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ESCHENBACH PRINTING COMPANY
1919

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AT EASTON, PA.

Volume XI

JANUARY 1, 1919

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EDITORIALS

ELECTION RESULTS

The following have been elected officers of the AMERICAN CHEMICAL SOCIETY for the term of office beginning January 1, 1919.

President: William H. Nichols.

Directors: W. D. Bigelow,

W. R. Whitney.

Councillors-at-Large: E. C. Franklin,

B. C. Hesse,

G. N. Lewis,

Geo. D. Rosengarten.

SPECIAL MEETING OF THE COUNCIL

On Saturday afternoon, December 14, 1918, there assembled in Rumford Hall, Chemists' Club, New York City, one of the most largely attended meetings of the Council ever held. In response to the stimulation of Dr. Hesse's article in the November issue of THIS JOURNAL and the call of the Secretary, it was evident from the outset that there was to be no dearth of suggestions from the Local Sections. The total number of these suggestions mounted to the high figure of one hundred and thirty-three. Plainly, it was physically impossible to give to each of these matters in one session of the Council the consideration it deserved. The proceedings therefore developed largely into a grouping of the suggestions and reference of these groups to appropriate committees for thorough consideration and report to the next meeting of the Council. Upon certain matters of general importance, however, definite action was taken.

The full value of the meeting, therefore, will depend ultimately upon the character of the committee work between now and the Spring meeting of the Council. Too often the committee work of the Society is not taken by the individual as a very severe requisition upon his time, thought and energy. To the committees to be appointed to handle the material presented to this special meeting of the Council there is given opportunity to perform a distinct national service, for the presentments of the AMERICAN CHEMICAL SOCIETY with its more than twelve thousand members should carry great weight in molding national thought as to chemistry as an integral part of the Nation's activities. With committee work carried out in this spirit, it can confidently be predicted that the spring meeting of the Council will be historic.

Following a continuous four-hour session, the president, Dr. Wm. H. Nichols, entertained the Council at a delightful dinner in the dining room of the Chemists' Club. Dr. Nichols proved an ideal host and his genial spirit pervaded the jovial gathering. At the conclusion of the dinner, he acted as toastmaster and with a perfect stream of railery and camaraderie called upon a number of the members for informal remarks. The responses demonstrated that all had caught the spirit of the occasion.

BUSINESS TRANSACTED

At the business session of the Council it was unanimously voted to hold a Spring meeting in 1919. The matter of time and place was referred to the Advisory Committee with power to act. Soon after adjournment it was evident that the committee would receive a number of invitations.

The attention of the Council was called to the important Report on Engineering Education issued by the Carnegie Foundation. In the compilation of that Report the Society was represented by Professor H. P. Talbot and Dr. Clifford Richardson. The President was requested to appoint a committee of three to act in cooperation with and to be advisory to the Society for the Promotion of Engineering Education in matters pertaining to the training of chemical engineers.

The Directors were requested to arrange, if finances justified it, for the annual publication in *Chemical Abstracts* of a formula index.

Following an interesting talk by Dr. John Johnston, secretary of the National Research Council, the Council favored cooperation with that body in the coordination of research. A committee of five will be appointed to work out the details.

The Council likewise voted for cooperation with British chemical organizations and with the National Research Council in the compilation and publication in the English language of standard reference works on chemistry. The committee charged with this matter was requested to report at the Spring meeting. In case of an emergency requiring prompt action the committee will report to the Directors.

Much interest was aroused by the report of the Committee on Duty-Free Importations by Educational Institutions. The Council expressed itself as heartily favoring the abrogation by Congress of this feature of the tariff legislation, confident that its presence on the statute books has retarded the development of American sources of supply of laboratory material, and equally confident that American manufacturers would respond in such manner as to insure our educational institutions against a repetition of such conditions as resulted in 1915 from the blockade of German ports.

The Committee on Cooperation between Universities and Industries made an informal report, calling attention to the imminent danger to both universities and industries from a continuation of the efflux of the best teachers from the universities to industrial research staffs, favoring industrial research fellowships and requesting the appointment of auxiliary sub-committees in Local Sections for the working out of specific local questions and for general cooperation with the main committee. The President was authorized to appoint such sub-committees.

Dr. W. R. Whitney made an impressive appeal for

endorsement of national aid to research. The Council expressed itself as favoring the principle of federal aid to scientific and industrial research and authorized the President to appoint a committee to cooperate in the allocation of federal grants, to investigate the several proposals now pending, and to make recommendations to the Advisory Committee, which in turn was given power to act.

The introduction of the metric system throughout the country as rapidly as possible was urged. The Society's Committee on Merchant Marine was requested to emphasize the importance of this change in our system of weights and measures as an aid in developing foreign commerce.

A prolonged discussion was held concerning the future of chemistry in the War Department. All were agreed that it would be a calamity if our future army should lack this invaluable aid to its military efficiency. The Advisory Committee was requested to consider the advisability of appointing a special committee to consider all phases of this matter and to confer with the officials of the War Department. To the Advisory Committee was also referred the matter of urging the War Department to compile a complete record of the researches conducted by the Chemical Warfare Service and, in so far as public interest permits, to publish this material.

Announcement was made of the action of the Directors in appointing Mr. John Walker Harrington to take charge for the Society of the important work of developing its policies as to popular presentation of chemistry to the daily press. Mr. Harrington is an experienced newspaper writer of high rank and his technical ability will prove of great value in connection with the popular bulletins contributed by the members of the Society.

Many of the suggestions of the Local Sections were grouped and referred to appropriate committees for report at the Spring meeting. Finally, in order to cover the whole ground, an Omnibus Committee, with Dr. A. D. Little as chairman, was appointed to consider the responsibilities of the Society in the many great questions of reconstruction now engrossing the attention of the Nation.

THE FRUITS OF SERVICE

This morning New York City was awakened by a din of noises from sirens and steam whistles welcoming back to America her soldiers returning from the battlefields of France. It was a joyous welcome to men who richly deserved it. In the midst of the tumult our mind turned to the many chemists in laboratories and plants throughout the country, some in uniform and some wearing not even this badge of distinction, whose scientific and technical skill had contributed so profoundly to the safety of the men at the front through perfected gas masks, smoke screens, flares, rockets, and similar devices, and to the preparation on so vast a scale of offense weapons such as propellants, high explosives, detonators, poison gases,

improved steel for guns, light metals and dopes for aeroplanes. And we wondered whether or not the country appreciated what these men of the laboratories had done. Did it realize how these men at the behest of leading men of the profession had voluntarily foregone their eager desire to join in the great movement to the western battle front while the military authorities were gradually being roused to the important part which they and no substitutes must perform in this war? These men had worked on the production of toxic gases during the experimental days; many a lifelong scar will bear its silent witness of the risks incurred, while others of this number made the supreme sacrifice.

To all of these men, American chemists, who more than "made good" in a chemical war, all honor be given! Through the conservation of trained men, resulting from their sacrifice of personal inclination, this country was enabled to assemble and utilize efficiently the greatest corps of chemists in any of the allied countries, as is abundantly attested by foreign official representatives whose timely warnings, however, were of greatest aid in effecting this conservation of trained men.

It was our good fortune to be present at the dinner tendered Major General Sibert by the commissioned officers of the Chemical Warfare Service. It was a jolly affair, redolent with good fellowship. The spontaneous tributes to the commanding officer bore eloquent witness to the affectionate ties which had been formed.

These men had matched their wits against the Germans and had prepared material which rendered the enemy's efforts harmless and insured to our armies the means by which he would be overwhelmed. Some day when the full story of the war is told, the facts will become known as to why this mighty mass of material for offense was not delivered at the front where our men were calling for it; and when the tale is told there will be no discredit to the chemist for he was more than ready with his part.

But these rollicking chemists at the dinner tables knew that the end of their work was in sight. Soon they would return to normal duties. As we watched the riot of fun, thoughts flew in upon us.

Is this branch of the Service to be discontinued?

None present desired or seemed to have any idea that he would be expected to continue in the Service. In the curtailment of army activities and in the rapid progress of demobilization of forces not needed for occupation of enemy territory, it is to be hoped that this strong branch of our permanent army will not be totally abolished. Even though the elimination of poison gas warfare be agreed upon at the peace conference, there is vital work still to be conducted on chemical lines for both army and navy. If we are to have military and naval adjuncts to our Government, they should be supported by the best of chemical intelligence. Secretary Baker has called attention in his annual report to the desirability of making permanent the Chemical Warfare Service. He should

act promptly in perfecting the permanent organization, for it will be difficult to gather together again the picked men of this Service after they have returned to civil life. General Sibert can perform a distinct national service before his announced retirement by urging the same speed in action as he urged upon his own men in the manufacture of mustard gas.

Another thought came as we watched the diners. What about the return of these men to civil life? Will the way be easy or hard? For many of them former positions are waiting. For others the path is not so clear, for substitutes have been employed, at least for the year. Particularly is this true in many universities where finances are sadly cramped because of decrease in tuition fees and earnings from invested funds. Certainly we all should join hands in making this return involve as little as possible of sacrifice on the part of these men who have done their full part by our country in a time of great national stress.

To the undergraduates and the men drawn from graduate student ranks we would urge a return at all costs to their universities for the completion of their scientific training. This training has been sharply interrupted by the call of the war period, but the experience gained by both professors and students in connection with war work should infuse a fresh and even more vigorous spirit into educational work and should give to the country eventually a class of men into whose hands the future development of chemistry should worthily fall. In this connection the situation presents an admirable opportunity for the display of the spirit of cooperation on the part of the industries toward the universities by the establishment of a large number of scholarships and fellowships, even though these be only temporary, which will enable the immediate refilling of university ranks.

To those returning chemists who had previously completed their university courses, it need only be pointed out that practically no recruits have come into the ranks during the past year, and that the chemical industry of the country, with all strictly war work ended, will be greater than before the war.

Doubtless some hardships will be endured during the next six months of readjustment. This is to be deplored, but it is by no means a misfortune confined to chemical ranks. It is a part of the price. Certainly this country will need in the great program of peace days every chemist whose training is sound, whose judgment is well balanced, and whose faith in his country is an unquenchable flame.

NOTES

A new use is suggested for the ultramicroscope—to find a chemist among the host of American specialists who accompanied to Paris our official representatives charged with the responsibility of formulating a treaty of peace with that country which makes of chemistry its strong right arm in times of peace and war. This suggestion is sympathetically passed on to the president

of the Chemical Alliance, Inc., for reflection during his leisure moments.

Welcome to *The Octagon*, the official organ of the Lehigh Valley Section, and also to *The Blast Lamp*, published by the Kem Klub of Hunter College (for young women), New York City! That women are entering the field of chemistry in dead earnest is shown by the following extract from the latter publication.

The preparation is long and difficult. Chemistry alone is not sufficient. One must have a working knowledge of calculus and one must know a good deal of physics.

As to women in research this naïve confession is made:

It is said that the true spirit of research is natural curiosity, and certainly women possess that.

Knowing the delightful personality and inherent modesty of Mr. Charles H. MacDowell, of the War Industries Board, we are confident that he blushed with confusion when he read in a recent Washington press story the following:

Experts headed by Charles H. MacDowell, chief of the Chemicals Division of the Board, Mr. Baruch said to-day, are meeting with success in the development of new processes of manufacture of standardizing present processes. At the same time they are fostering the use of German formulas for obtaining in America soluble potash, aniline dyes, optical glass, and chemical apparatus, fine and pharmaceutical chemicals, and clay for graphite crucibles.

The Committee has voted the award of the Perkin Medal this year to Dr. F. G. Cottrell of the U. S. Bureau of Mines, for his work on electrical precipitation. This decision will be unanimously acclaimed.

The Nichols Medal, awarded for the most noteworthy contributions appearing during the year in the publications of this Society, will not be awarded this year. Too much of the best research is still locked up for reasons of war. The contest for this medal next year should be a hummer.

The recent great gathering of business men at Atlantic City expressed itself in no uncertain terms on the subject of pivotal industries, as follows:

Conditions brought upon us by the European War at its beginning, as well as our national necessities after we entered the war, made it of the highest importance that a number of industries should at once be developed in the United States. Large investments, both of capital and skill, have since been placed in these enterprises. Upon the production of some of them, relatively small in themselves, the continuation of some of our largest industries has depended. Some of the recently developed industries have national importance in fields much broader than the markets of their products; for they may serve, for example, to promote scientific research, which will add to national efficiency, resources, and wealth in many distinct ways.

It becomes essential, therefore, that the Government should at once proceed to ascertain the industries which have been developed during the European war and ascertain those the maintenance of which is indispensable for the safety of our industrial structure and our military establishment.

When these pivotal industries have been ascertained, means suitable in view of their nature and situations should at once be provided for their encouragement and preservation.



FIG. 2—GENERAL VIEW OF PHOSGENE PLANT

taking. Surrounded by a staff of competent officers and infusing his spirit into soldiers and civilians alike, he brought to completion in less than a year, one of the greatest chemical establishments ever constructed in this country.

Colonel Walker received the degree of B. S. from Pennsylvania State College in 1890. In 1892 he obtained his doctorate at the University of Göttingen, and in 1894 he accepted a professorship of industrial chemistry at the Massachusetts Institute of Technology, later becoming director of the Institute's course

in chemical engineering. Before entering the war service of the Government, Colonel Walker was in charge of the highly successful experiment in the education of chemical engineers, the School of Chemical Engineering Practice of the Massachusetts Institute of Technology.

HISTORICAL

When the United States entered the war, although it was known that poison gas had been used by the enemy and was also used by our Allies, very little information was obtainable in America as to what materials were employed and how they were prepared. The Ordnance Department was at this time charged with the responsibility of procuring all materials for the combatant departments of the Army. The Quartermaster's Department procured clothing, bedding, transportation facilities, etc., which had nothing to do with the actual fighting. In November 1917 it was decided to establish on Gunpowder Neck, Maryland, which was then a part of the Aberdeen Proving Ground property, a small shell-filling plant. This was designed under the direction of Lt. Col. Edwin M. Chance, who took

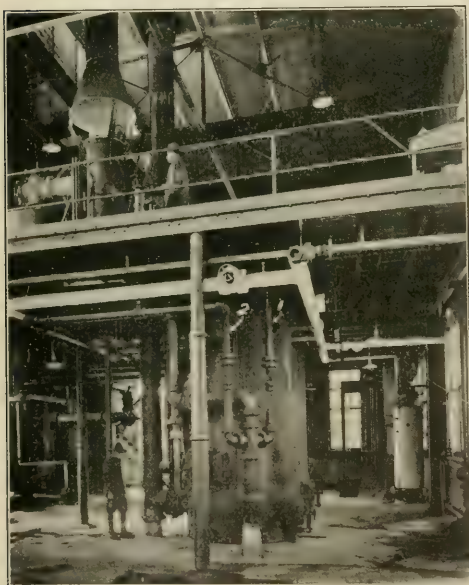


FIG. 3—CARBON MONOXIDE PRODUCER UNIT

1—Oxygen inlet 2—Carbon dioxide inlet

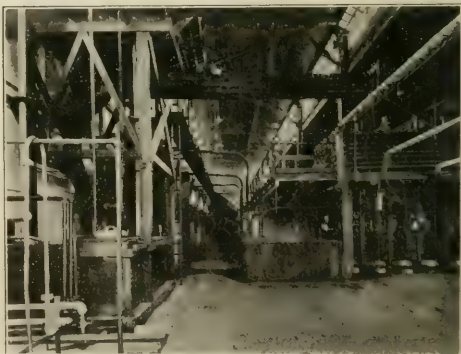


FIG. 4—PHOSGENE MIXER UNIT, 20 TONS PER DAY CAPACITY, COMBINING PURE CHLORINE AND CARBON MONOXIDE TO FORM PHOSGENE AND CONDENSING PRODUCT

charge of the construction work at Gunpowder Reservation, breaking ground early in November. The property taken for this purpose was at that time planted in wheat for the spring crops, and no provision for housing men or for transportation of any kind existed. Railroad facilities were extended to the Reservation from the Pennsylvania Railroad, and bunk-houses for a construction force were erected.

It was then the intention to have the toxic gas itself manufactured by chemical manufacturers throughout the country and shipped to Gunpowder Neck for filling. Owing to the facts, first, that the poison gas materials were new in the sense of not being an established industry; second, that no one would want to manufacture them after the war and therefore the plant would be obsolete; and third, the inherent danger of manufacturing toxic materials, it was soon determined that toxic materials could not be obtained throughout the country, however attractive were the offers, from a financial point of view, which the Government made. Early in December 1917, therefore, it was decided to erect on the site of the shell-filling plant such chemical plants as would be necessary to furnish the toxic materials required for filling the shell. Designs for the chemical plants were ready late in December 1917, and construction was started, notwithstanding the difficulties incident to a very severe winter. A water supply for manufacturing purposes was obtained by constructing two 36 in. mains from the Bush River. The capacity of the system is 24,000 gal. per min. A dock was erected, and industrial railroads throughout the Reservation were built.

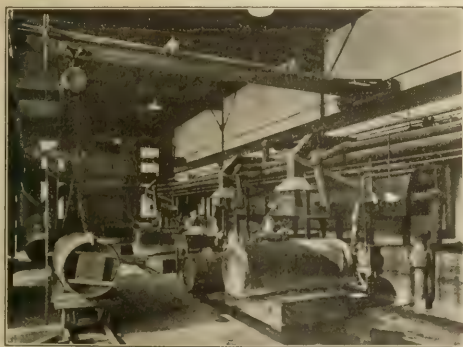


FIG. 5—FILLING LIQUID PHOSGENE INTO 1700-LB. CONTAINERS FOR OVERSEAS SHIPMENT

Adequate shipping facilities were provided by tapping the Pennsylvania Railroad on the one side, and on the other by water transportation through the Bush River to Chesapeake Bay. A 12 ft. channel about a quarter of a mile in length, was dredged through Bush River to the Bay. In order to obtain the greatest speed in the development of the processes necessary, the aid of such manufacturing concerns as were willing to undertake large-scale investigation was accepted. The two gases which it was then obvious would be required in large quantities were chlorpicrin and phosgene. The manufacture of chlorpicrin was begun on a relatively small scale at the plant of the American Synthetic Color Co., Stamford, Conn., while the manufacture of phosgene was undertaken at the plant of the Oldbury Electrochemical Company, at Niagara Falls, N. Y. The Trench Warfare Section of the Ordnance Department, under Lt. Col. E. J. W. Ragsdale (then Captain), assumed responsibility for these developments. Associated with him were Lt. Col. Wm. McPherson, Major D. J. Demorest, Major Wm. L. Evans, and Major Orland R. Sweeney, all of Ohio State University. Majors

Francis C. Frary and Sterling N. Temple, who were, previous to entering the Army, connected with the Oldbury Electrochemical Company, at Niagara Falls, had charge of the develop-



FIG. 6—LIQUID PHOSGENE READY FOR SHIPMENT OVERSEAS

ment of phosgene. Between October 1917 and the first of February 1918, gas warfare had assumed much greater importance in Europe. Representatives of the French and British Governments were sent to America and were of the greatest possible help, not only with the information as to methods which they supplied, but also in furnishing an incentive for the work. By this time it was obvious that the Government would be compelled to erect a large chlorine plant in order to supply this important raw material.

In January 1918 things were not going as satisfactorily as desired, so Colonel Walker, who was at that time Chief of the Chemical Service Section and Assistant Director of Gas Service (the office of Director of Gas Service and the Chemical Service Section are now both absorbed in the organization of the Chemical Warfare Service), was asked to take charge of the Gunpowder Neck project. He was immediately transferred to the Ordnance Department and made Commanding Officer of Gunpowder Reservation (now Edgewood Arsenal). The entire project was taken out of the Trench Warfare Section and was made a separate bureau of the Ordnance Department.

Under the leadership of Colonel Walker, things began to hum. At this time, the railroad transportation system of the country went to pieces. Nothing daunted, however, military guards were sent out to accompany each carload and shipment of materials, these guards seeing to it that the cars were constantly headed towards Edgewood Arsenal, and in case of breakdown,

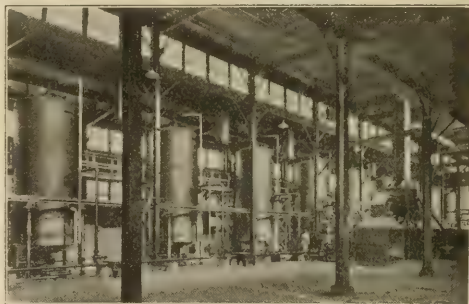


FIG. 7—CHLORPICRIN PLANT. MIXER IN LOWER RIGHT-HAND CORNER AND LINE OF TEN STILL

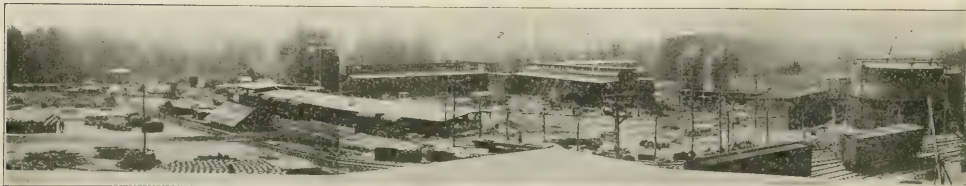


FIG. 8—GENERAL VIEW OF MUSTARD GAS PLANT

1—Ethylene holders

2—Reactor houses

3—Sulfur chloride and mustard gas storage tanks

that repairs were quickly made. Later this practice had to be discontinued as it did not meet the approval of the Inland Traffic Service.

In July 1918, Edgewood Arsenal was withdrawn from the Ordnance Department and made a part of the Chemical Warfare Service under the able direction of Major General Wm. L. Sibert.

ORGANIZATION

Edgewood Arsenal was organized with the following departments:

1—Chemical plant, complete, for manufacturing caustic soda and liquid chlorine.

2—A chemical plant for the manufacture of toxic materials.

3—A filling plant for filling the shell, Stokes mortar bombs, Livens projector drums, hand grenades, incendiary bombs, etc.

4—Construction, maintenance, and stores division.

5—Headquarters military organization.

6—Military medical hospital with ample facilities.

7—Executive office. This was moved from Washington to Baltimore, taking the two upper stories of McCoy Hall, one of the old Johns Hopkins University buildings. This executive office consists of sections for administration, purchase, finance, property, contracts, personnel, traffic, etc.

In addition to the officers in charge of the individual plants mentioned below, the following officers were in charge of general features of the work: Lt. Col. George Chahoon, Jr., assistant to the Commanding Officer and in charge of Administration and Contracts; Lt. Col. Wm. G. Gallowhur, executive officer in charge of Edgewood Plant; Lt. Col. E. B. Ellicott, Construction, Maintenance and Stores; Major Frank J. Wagner, Military Administration; Lt. Col. G. E. Lewis, in charge of Hospital.

While the plant at Edgewood was being completed, and in order to avoid having all the eggs in one basket, such manufacturing firms as were willing to enter into the production of toxic materials were utilized.

In general charge of these outside plants was Lt. Col. Wm. McPherson, assisted by Majors E. E. Free, C. R. Wraith, H. H. Hanson, and Capt. J. D. Rue.

The experimental plant for the manufacture of chlorpicrin at Stamford, Conn., was rented, enlarged, and operated by the Government with Lt. V. E. Fishburn in charge.

A plant for the manufacture of phosgene was built at the works of the Oldbury Electrochemical Company, Niagara Falls, N. Y., under the charge of Dr. F. A. Lidbury and Government officer in charge, Major Adrian Nagelvort. Another plant for phosgene was erected at the plant of Frank Hemingway, Inc., at Bound Brook, N. J. Manufacturing here was in charge of Mr. Frank Hemingway and Government officer in charge, Lt. Wm. R. Chappell.

A plant for bromine was erected at the plant of the Dow Chemical Company, Midland, Michigan, Major M. G. Donk in charge.

A plant for chlorine was erected at the Charleston Chlorine Company's plant at Charleston, West Virginia. This plant was in charge of W. A. Guile, Jr., and Government officer, Lt. M. R. Hoyt.

Later, there were added the plant of Zinsser and Company, at Hastings-on-Hudson, N. Y., Major F. G. Zinsser in charge; the National Aniline and Chemical Company at Buffalo, N. Y., Mr. C. P. Hugo Schoellkopf in charge and Government officer Capt. A. W. Davison; and the Union Dye and Chemical Corporation, Kingsport, Tenn., Lt. E. M. Hayden in charge.

CHEMICAL PLANTS

Plants for phosgene, chlorpicrin, and mustard gas are all in operation, producing an amount of toxic material far in excess of that used in the shell-filling plant. European shipments of toxic gases in bulk began in June, and have been continued up to the present. The chemical plants are under the general charge of Major Dana J. Demorest, with Captain William E. Hoffman as constructing engineer.

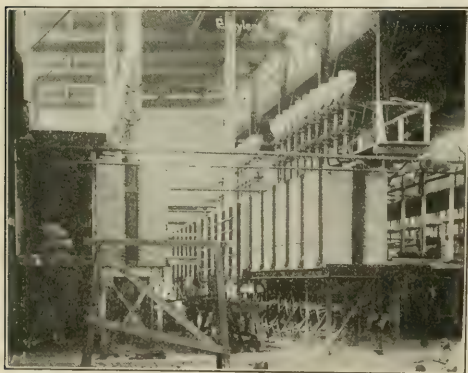


FIG. 9—ETHYLENE FURNACES



FIG. 10—SULFUR CHLORIDE PLANT



FIG. 11—FIRST MUSTARD GAS PRODUCER. IT OPERATED ON AN EXPERIMENTAL AND SEMI-COMMERCIAL SCALE

PHOSGENE

Phosgene is a lethal gas of high toxic power. It has a very severe delayed action upon the heart which frequently proves fatal after the immediate effects have apparently disappeared.

The method of manufacturing phosgene as used at Edgewood was worked out in the laboratory of the Oldbury Electrochemical Company under the immediate supervision of Dr. F. A. Lidbury by Dr. (now Major) Francis C. Frary and Mr. F. A. Stamps. The design of the plant at Edgewood as it now exists is the fruit of the efforts of Majors Frary, Temple, and Demorest. Instructions from Europe were to the effect that the carbon monoxide could be made best by first producing oxygen from liquid air and using pure oxygen in a small water-cooled producer to make pure carbon monoxide. Obviously the great heat of reaction of oxygen and carbon must be carried away by the water rapidly enough to insure life of the converter. By combining the endothermic reaction of carbon dioxide and carbon

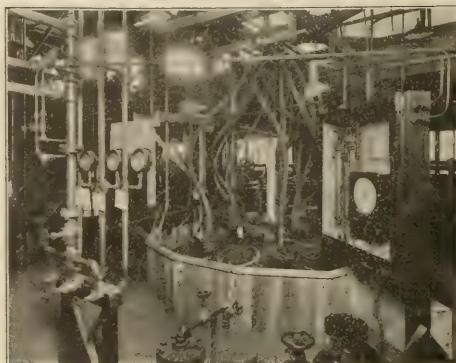


FIG. 13—DETAIL OVERHEAD VIEW OF LATEST MUSTARD GAS UNIT

with this exothermic reaction of oxygen and carbon, a standard U. G. I. gas producer can be employed and carbon monoxide made in very large quantities of high purity. The temperature of the reacting zone can be maintained as desired by regulating the relative amounts of oxygen and carbon dioxide used. The phosgene plant consists, therefore, of a carbon dioxide plant, having a daily capacity of 125,000 cu. ft. of pure carbon dioxide, an oxygen plant with a capacity of 200,000 cu. ft. of oxygen per day, which when used with four producers gives a daily production of 400,000 cu. ft. of carbon monoxide. When carbon monoxide and chlorine are passed over a carbon catalyst, phosgene is produced with the generation of much heat. It is necessary, therefore, to maintain by cooling a definite temperature. The reaction is practically complete and the phosgene is liquefied by passing through condensing coils immersed in refrigerated brine. At present phosgene is employed in filling the standard caliber gas shell, Stokes mortar bombs, and Livens projector bombs. It is also shipped to the Allies in large quantities in wrought iron drums containing 1700 lbs. The demonstrated capacity of the plant as it exists at present is 40 tons per 24-hour day. Two additional units are almost complete which will bring the total capacity to 80 tons per day. Phosgene is manufactured also in the government plant operated by the Oldbury Electrochemical Company, where the carbon monoxide issuing from the phosphorus furnaces is utilized. The capacity of this plant is 10 tons per day and used partly in filling projectiles at the plant, and partly in containers for shipping abroad. The Bound Brook, N. J., plant of Frank Hemingway, Incorporated, has a capacity of 5 tons per day. This product goes almost exclusively to the Allies in bulk.

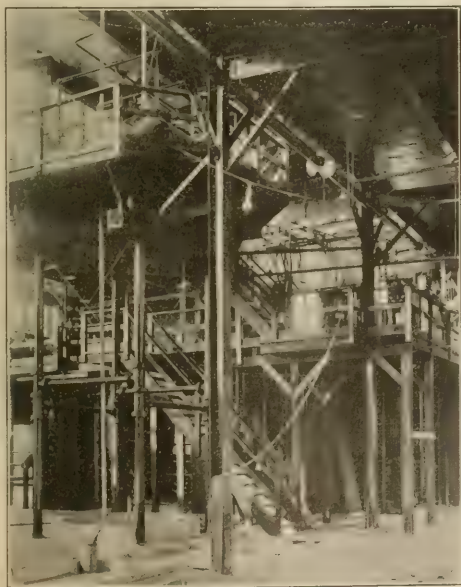


FIG. 12—GENERAL VIEW OF LATEST MUSTARD GAS UNIT. IT HAS PRODUCING CAPACITY OF 12 TONS OF GAS PER DAY

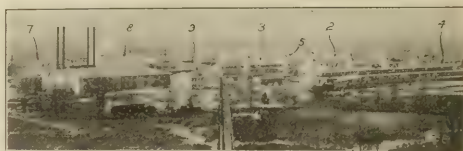


FIG. 14—GENERAL VIEW OF CHLORINE PLANT

- | | |
|-----------------------------|---|
| 1—Salt preparation building | 6—Chlorine gas pipe line to sulfur chloride, chlorine liquefaction, and chemical plants |
| 2—Sub-station | 7—Boiler and evaporator house |
| 3—Cell house No. 1 | 8—Caustic fusion |
| 4—Cell house No. 2 | 9—Drum-making shop |
| 5—Chlorine drying towers | |

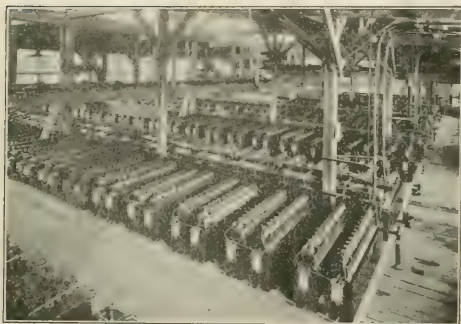


FIG. 15—ONE OF THE EIGHT CELL ROOMS. EACH OF THESE ROOMS IS EQUIPPED WITH GENERATOR, DRYING TOWER, AND NASH PUMP TO FORM A COMPLETE UNIT

CHLORPICRIN

Chlorpicrin is a strong lethal gas and is also a strong lachrymator. Being a liquid at normal temperature and pressure, a somewhat higher explosive charge is required in projectiles thus filled than when a real gas such as phosgene is employed. Chlorpicrin is produced by reacting upon calcium picrate with bleaching powder in wrought iron digesters furnished with condensers. The reaction proceeds evenly when the temperature is maintained within very definite limits in which the chlorine of the bleaching powder reacts with the calcium picrate. If, however, the proper conditions are not maintained, the bleaching powder reacts with a liberation of oxygen, instead of chlorine, and the entire mass foams into the condenser. The chlorpicrin distills from the reaction mass and is separated from the accompanying water by standing for two or three days in settling tanks. At the plant at Stamford, picric acid is produced from phenol and used directly in making chlorpicrin. At the Edgewood plant, the picric acid is provided from other government producing plants. A great portion of the picric acid thus employed has been that rejected by both the U. S. and the Allied Governments on account of excessive lead content. Chlorpicrin is employed for filling all types of projectiles either by itself, or mixed with stannic chloride or phosgene.

MUSTARD GAS

Mustard gas, dichlorodiethylsulfide, is an intense vesicant as well as being very toxic when inhaled. It has a marked action upon the eyes, causing temporary blindness, and quickly pro-



FIG. 16—CHLORINE LIQUEFACTION, 40 TONS PER DAY

duces intense hoarseness, followed by inflammation of the lungs. It penetrates clothing readily, producing a flesh wound of much the same character as the burn from phosphorus.

Mustard gas is produced by passing dry, pure ethylene into sulfur chloride at a temperature maintained within very narrow limits. The reaction vessel can be either cast iron or wrought iron lined with lead. The reaction is highly exothermic and a large cooling surface must be maintained. The reaction is a cranky one and is accompanied by destructive side-reactions which are difficult to control. When a batch "goes wild" great volumes of hydrochloric acid are given off, accompanied by highly toxic gases of an unknown composition. As the gas is strongly lachrymatory, such accidents produce great discomfort. Under certain conditions free sulfur is deposited which usually appears as a eutectic with mustard gas, giving a viscous mixture which is mechanically very difficult to handle.

Mustard gas is filled into shell of all calibers and has been sent to the Allies in bulk in large quantities. Starting with $1\frac{1}{2}$ tons per day in July, the production has constantly increased, until to-day the plant has a demonstrated capacity of somewhat over 30 tons per day. Other units to be completed within the month would bring the capacity of this plant to 80 tons per day. In order that other sources of mustard gas could be available in case of accident at Edgewood, or were a greater supply demanded, this Arsenal has constructed a plant with a capacity of 25 tons per day at the plant of Zinsser and Company, Hastings-on-Hudson. A second plant of 50 tons capacity is nearing completion at the works of the National Aniline and Chemical Co., Buffalo, N. Y.



FIG. 17—GENERAL VIEW OF FILLING PLANTS

1—Shell-filling group No. 1 (filling shell and Livens drums) and Power Plant No. 1

2—Shell-filling group No. 2 (filling 155 mm. shell and Stokes bombs)

3—Shell-filling group No. 3 (filling 75 mm. shell)

4—Stannic chloride grenade-filling plant

5—White phosphorus grenade-filling plant

6—Incendiary drop bomb-filling plant

7—Plant under construction for filling 9.2 in. and 240 mm. shell

CHLORINE PLANT

A chlorine plant with a capacity of 100 tons per day and an equivalent amount of caustic soda was designed by the Samuel M. Green Company, of Springfield, Mass., and built under the personal direction of Mr. Green. The electrolytic apparatus employed is that designed by Mr. H. R. Nelson. The cell is known as the "Nelson Cell." Ground was broken for this plant on May 11, 1918, and it was ready to begin operation in August. The entire plant was constructed from first to last without any material change in design and without occasion to tear down and rebuild any part or detail of it—an unusual experience in plant construction.

The chlorine is dried with sulfuric acid and conveyed in a steel-pipe line to the chemical plant where a portion is converted into phosgene, a portion to sulfur chloride, and a portion is liquefied. This liquefying plant has a capacity of 40 tons per 24 hours, compression being effected by a falling column of sulfuric acid. This liquid chlorine goes almost exclusively to the Allies as raw material for further manufacture, although a portion is mixed with phosgene to be filled into cylinders for gas-cloud attacks. The sulfur chloride plant has a capacity of 35 tons per day and furnishes a high grade of material without difficulty.



FIG. 19—FILLING SHELL WITH MUSTARD GAS
1—Empty shell 2—Filled shell



FIG. 18—FILLING LIVENS DRUMS WITH PHOSGENE

Lt. Col. C. F. Vaughn (formerly of the Mathieson Alkali Works, Niagara Falls, N. Y.) is in charge and is assisted by Captains R. A. Hungerford, C. J. Frankforter, and A. U. Wetherbee. The erection of the cells is in charge of Lt. R. G. Brown.

CHEMICAL LABORATORY

Major Wm. L. Evans was placed in charge of organizing a laboratory. He assembled a strong organization, and at the outset, in lieu of a laboratory, placed his force in borrowed laboratory space throughout the country, principally at Johns Hopkins University, Bureau of Standards, Washington, and at Ohio State University. A splendid chemical laboratory, equipped with all modern appliances, has now been provided at Edgewood Arsenal and has been productive of most far-reaching results. It has been under the able direction of Major Evans, assisted by Captains J. A. Wilkinson, R. E. Hall, and W. O. Robinson. Here all of the control processes necessary for the operation of the plants have been worked out, as well as the research incident to factory operation, and results of great value

have been obtained. Major Evans has charge also of the Inspection Department, and upon him rests the responsibility of seeing that all shell-filling material is in accordance with specifications, that shell are filled to the proper weight and void, that they are properly painted, marked, and tested.

SHELL-FILLING PLANT

The shell-filling plant is constructed to care for the filling of all caliber of shell from the small 75 mm. to the large 240 mm. Inasmuch as phosgene must be maintained in liquid condition at atmospheric pressure, refrigeration is provided for reducing the temperature both of the phosgene itself and the projectile into which it is to be filled. Conveyors carry the empty shell through rooms held at a temperature of 0° F., discharging the same in front of the filling machines at a temperature far below the boiling point of the toxic gas. The shell are filled to a constant void by an automatic machine in which six shell are handled at one time. They are closed by motors actuated by compressed air and which, in the closing process, are driven until they stall. In this way a uniform closing torque is obtained. Industrial railroads bring the shell from the incoming dump where they are unpacked, inspected, and classified, and carry the filled shell to the outgoing dump where they are weighed, inspected for leak,



FIG. 20—SHELL-FILLING MACHINE FILLING 75 MM. SHELL WITH MUSTARD GAS

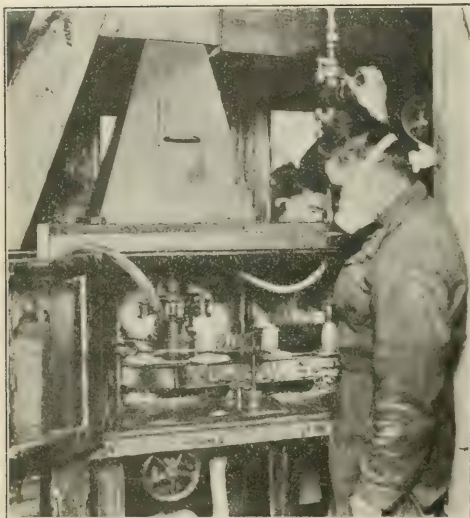


FIG. 21—FILLING HAND GRENADES ON ENDLESS CHAIN WITH STANNIC CHLORIDE

painted, marked, and boxed for shipment. Each unit is ventilated with great care, and the tail gas is washed in stoneware towers. In the construction of these towers a standard type of silo was employed. In the combined units there can be filled in one 24-hour day 80,000-75 mm. shell, 10,000-4.7 in., 50,000-155 mm., and 4,000-8 in. shell. The capacity for filling 6 in., 9.2 in., and 240 mm. shell has not yet been demonstrated. A separate plant is provided for filling smoke shell with phosphorus, and there are also separate plants for filling hand grenades with both gas- and smoke-producing material, and for manufacturing incendiary bombs and darts.

Lt. Col. E. M. Chance is in charge, assisted by Majors F. W. Mack, E. B. Van Keuren, A. M. Heritage, and T. M. Chance. Shell dumps are in charge of Capt. B. B. Gill, phosphorus shell and incendiary bombs, Capt. W. J. Taylor.



FIG. 22—FILLING HAND GRENADES WITH WHITE PHOSPHORUS

HEALTH AND RECREATION

Gunpowder Neck is devoid of substratum water, so, for domestic purposes, a sanitary water system was installed supplying two million gallons per day, the water being pumped from the Highlands back of Edgewood through a storage reservoir with ample capacity. This domestic supply is filtered and chlorinated.

The construction of the plant and other facilities was done by civilian labor, while the operation is exclusively in the hands of enlisted men, of whom there are now 6200. They are divided in complete military organization, are housed in standard type barracks, and are subjected to the discipline and drill which obtains in the best army camps. Both the commissioned and enlisted men working at Edgewood Arsenal and at the branch plants situated in other parts of the country deserve all of the honor and credit bestowed upon the enlisted men who have been sent to France to go "over the top." At Edgewood he carries hard manufacturing duties and is subjected to poison gas in all of its forms and conditions. While every precaution is taken to preserve the health of the men and to protect them, accidents do happen and casualties occur. A hospital of 250 beds is maintained and is provided with every facility for the most modern scientific treatment of accidents and disease. In each cantonment there are fine Y. M. C. A. and K. of C. buildings, baseball diamond with bleachers, and at the central cantonment a fine athletic field, with running tracks, etc. The Y. M. C. A. assembly halls are provided with moving picture machines, and in the summer time an open air moving picture theatre is largely attended. The camp is enlivened by a band of 42 pieces made up of enlisted men at the plant.



FIG. 23—PAINTING AND STRIPING FILLED GAS SHELL ON ENDLESS CONVEYOR. LIVENS DRUMS IN LEFT REAR

CONCLUSION

Here is a mammoth plant, constructed in record time, efficiently manned, capable of an enormous output of toxic material, and just reaching its full possibilities of death-dealing at the moment when news is hourly expected of the signing of the armistice. What a pity we did not possess this great engine of war from the day American troops first sailed for France, for had we been so prepared how many of our boys who "have gone West" could have returned for the welcome home! Shall we forget this lesson of preparedness? Is this great plant to be scrapped? Possibly wise heads may find a solution of the problem which will add this great resource to American chemical industry, at the same time preserving its value to the Nation as a greater asset, in case of future war, than a standing army.

C. H. H.

THE WORK OF THE TECHNICAL DIVISION CHEMICAL WARFARE SERVICE, A. E. F.

By Col. RAYMOND F. BACON, Chief of the Technical Division, C. W. S., A. E. F.

The importance of gases in the present war has been universally recognized as extremely great. In proportion to the amount of gas shell used the casualties produced thereby have been far in excess of those caused by any other form of ammunition. To enable protection against these casualties and to employ gases with desirable effect upon the enemy has required investigation and experiment of a most comprehensive nature, both in the laboratory and in the field. Then, too, initiative and ingenuity have had every opportunity for their display in the tactical use of gases to neutralize activity or to produce casualties. The military use of the term "gas" obscures the fact that the substances so designated have great differences in properties and effects, and it has required systematic military instruction to demonstrate the variety of results obtainable by their employment in warfare—that two gases may be as different in their tactical possibilities as H. E. differs from shrapnel, and that this variety of behavior affords a vast number of possible combinations with other means of modern warfare.

The experience of the past three years has shown that many unique effects can be obtained by the use of gases (chlorine, carbonyl chloride) readily dissipated by wind; liquids (chlorpicrin, diposgene, dichlorethylarsine) moderately persistent; liquids (brombenzyl cyanide, dichlorethyl sulfide) highly persistent; and solids (diphenylchlorarsine, diphenylcyanarsine). To illustrate, it was found early in the practice of chemical warfare that "gas" harassed to an unprecedented extent—far beyond any other known shell filling. Unlike H. E., shrapnel, etc., the effects of the "gases" were not completed immediately upon the explosion of the shell, but persisted for greater or less time, imposing upon the enemy the necessity of wearing a mask, a source of discomfort, impairment of vision, and extreme fatigue. The psychological effects on troops of the different gases with their various and alarming symptoms of poisoning were of even more serious consideration. "Gases" were, moreover, ascertained to be capable of penetrating certain means of defense, such as trenches and dugouts, frequently more effectively than other forms of ammunition, and were especially effective in silencing enemy batteries.

The Gas Service, American E. F., was organized at a time (September 1917) when broad study of the possibilities of both gas and anti-gas warfare had become exigent. Following the arrival of the first overseas contingent of the Chemical Service Section, in January 1918, a research laboratory was established at Puteaux, near Paris, and later, in March, arrangements were concluded for an experimental field for proving and field-investigation purposes. Until the organization of the Chemical Warfare Service (General Order, War Dept., No. 62),¹ the Chemical Service Section in France reported to the Chief of the Gas Service, A. E. F., but also had charge of relating chemistry to warfare in the entire expeditionary forces. Not only did the Section act in a research and consultative capacity in all the numerous technical phases of gas warfare, but it also conducted the investigation of emergency problems for all branches of the service in France. The results of these inquiries have been recorded in a series of reports.

The Chemical Warfare Service, A. E. F., has continued the functions of the Gas Service, A. E. F., with increased authority. As at present constituted, this Service, the European Division²

¹ THIS JOURNAL, 10 (1918), 675.

² This Division includes personnel assigned to all divisions, corps and army headquarters, in addition to those required for the supply of material in the field in France. For a list of its commissioned personnel, see THIS JOURNAL, 10 (1918), 681.

of the Chemical Warfare Service, U. S. A., has the following organization plan:

CHIEF

Brig. Gen. Amos A. Fries

STAFF

Medical Adviser: Col. H. L. Gilchrist, M. C.

Adjutant: Maj. C. E. Richardson, C. W. S., in direct charge of office administration.

Assistant Adjutants, Capt. J. D. Law, C. W. S.

1st Lieut. J. M. White, C. W. S.

HEADQUARTERS ORGANIZATION

ASSISTANT CHIEF

Col. E. N. Johnston, C. W. S.

To act for the Chief in his absence; in charge of Offense Division and new field projects.

PERSONNEL OFFICER

Lieut. Col. R. B. Clark, C. W. S.

In charge of procurement and assignment of commissioned and enlisted personnel of the Chemical Warfare Service, A. E. F.

DEFENSE DIVISION

Chief: Lieut. Col. G. N. Lewis, C. W. S.

In charge of material for use in the defensive, the training of anti-gas officers and all other instruction of a defensive nature, and the defensive operations in the field.

Assistants

Lieut. Col. R. N. Maddux, C. W. S. 1st Lieut. N. F. Hall, C. W. S.

Maj. J. G. Barry, C. W. S. 1st Lieut. J. J. Hast, C. W. S.

1st Lieut. R. W. Austin, C. W. S.

OFFENSE DIVISION

Chief: Col. E. N. Johnston, C. W. S.

In charge of material for use in offensive gas warfare, the training of officers for the field work of the Division and all other instruction of an offensive nature, and the offensive operations in the field.

Assistants

Artillery Officer: Lieut. Col. L. R. Dice, C. W. S.

Ordnance Officer: Maj. A. M. Prentiss, C. W. S.

Engineer Officer: Maj. Henry Adams, C. W. S.

TECHNICAL DIVISION

Chief: Col. R. F. Bacon, C. W. S.

In charge of all investigations in chemical warfare, the research laboratory at Puteaux, near Paris, and the study of defensive and offensive problems at the Experimental Field, near Chaumont; also acts in an advisory capacity on all technical matters pertaining to gas warfare, and collaborates with other Divisions in the development of material to the point of proving.

Assistants

Maj. W. A. Hamor, C. W. S. 1st Lieut. A. R. Norton, C. W. S.

1st Lieut. L. H. Greathouse, C. W. S.

PURCHASE AND SUPPLY DIVISION

Chief: Lieut. Col. R. Mayo-Smith, C. W. S.

In charge of estimates, programs, appropriations and allotments of material and property; the maintenance and operation of dumps and salvage plants; and the purchase and supply of all material required by the other Divisions.

INTELLIGENCE DIVISION

Chief: Maj. J. L. Clarkson, C. W. S.

In charge of the procurement and distribution of military intelligence, reports and other documents relating to chemical warfare, the preparation of bulletins of information, and the issuance of instruction brochures for use in the training of gas officers and for the confidential information of the Service.

Assistants

Capt. O. J. Noer, C. W. S.

2nd Lieut. L. E. Roberts, C. W. S.

2nd Lieut. W. J. Harper, C. W. S.

FIELD ORGANIZATION

The Defense, Offense, and Purchase and Supply Divisions maintain field organizations, including personnel assigned to army divisions and corps. That of the Defense Division is particularly elaborate, embracing the Gas Defense Schools and Gas Defense Officers on duty with the armies.

TECHNICAL DIVISION

Director, Research Laboratory: Maj. F. G. Keyes, C. W. S.

This Laboratory, also known as the "Paris Laboratory," has a staff of 20 officers and 45 soldiers, all of whom are chemists qualified to conduct original investigations; its accomplishments will be presented below.

Director of Experiments, Hanlon Field: Maj. J. H. Hildebrand, C. W. S.
Maj. Hildebrand's section has been charged with the duty of proving the efficiency of material under field conditions and with the conduct of research into all matters pertaining to gas warfare under conditions obtaining at the "front."

Liaison Officer with the French: Lieut. Col. J. E. Zanetti, C. W. S.

Liaison Officer with the British: Lieut. Col. J. F. Norris, C. W. S.

In direct charge of obtaining special information, reports and other documents relating to chemical warfare from the Allies; the material procured is distributed by the Intelligence Division.

WORK OF THE TECHNICAL DIVISION

A large variety of chemical and physical problems, mainly of an emergency character, has been studied, and, for the most part, solved, at the Paris Laboratory of the Technical Division. The results of these investigations are presented in the weekly progress and special reports of the Technical Division, of which about 90 have been issued (C. W. S., A. E. F., Serial B); copies of all these reports have been distributed by the Intelligence Division to the Chemical Warfare Service, U. S. A., to the Allies, and to certain officers of the C. W. S. on duty in the field. More recently, since July 1918, a number of important inquiries have been carried out by the technical staff at Hanlon Field; and, while serious handicaps have frequently been encountered because of the need of certain equipment, not a few results of decided military value have been obtained. The successful outcome of most of the work of the Technical Division is to be attributed to the splendid spirit of the specialists engaged in research at Paris and Hanlon Field.¹

The laboratory equipment was not received from this side until in May, although it had been purchased four months before, and accordingly work was begun with such necessary apparatus and chemicals as could be obtained abroad because of the pressing importance of the problems submitted to the Division. Enthusiasm, ingenuity, and team-work enacted prominent rôles in the essential productivity of the Laboratory during that semester of military life, when it became urgent to provide immediate protective measures for our fighters against Boche "blue cross" and "yellow cross," when it became all-important to develop a suitable fighting mask, and when it became clear that satisfactory procedures must be developed for recognizing and destroying persistent "gases" in the field. These and other problems were attacked and solved.

Following the receipt and installation of the American laboratory equipment, the Paris establishment rapidly assumed the fore-front of those laboratories engaged in chemical warfare research in Europe. Indeed, it will interest the American chemical profession to learn that the equipment of this laboratory excelled even that of any of the permanent laboratories in the Allied countries. Additional personnel then came and the growth enabled the formation of definite sub-sections, with a consequent general expansion in activity. Maj. J. H. Hildebrand served as Director until his transfer to Hanlon Field as Director of Experiments there, and Maj. W. A. Hamor, his successor, was enabled, during June and July, to place the Labora-

tory upon its present conspicuously high plane, both from a scientific as well as a military standpoint. When Major Hamor assumed the office of Acting Chief of the Technical Division during the writer's absence on a military mission to the United States, Maj. F. G. Keyes followed the standard which had been established, and he has continued the productivity with admirable energy and resourcefulness.

At the present time, this section of the Technical Division has the following departments, or sub-sections:

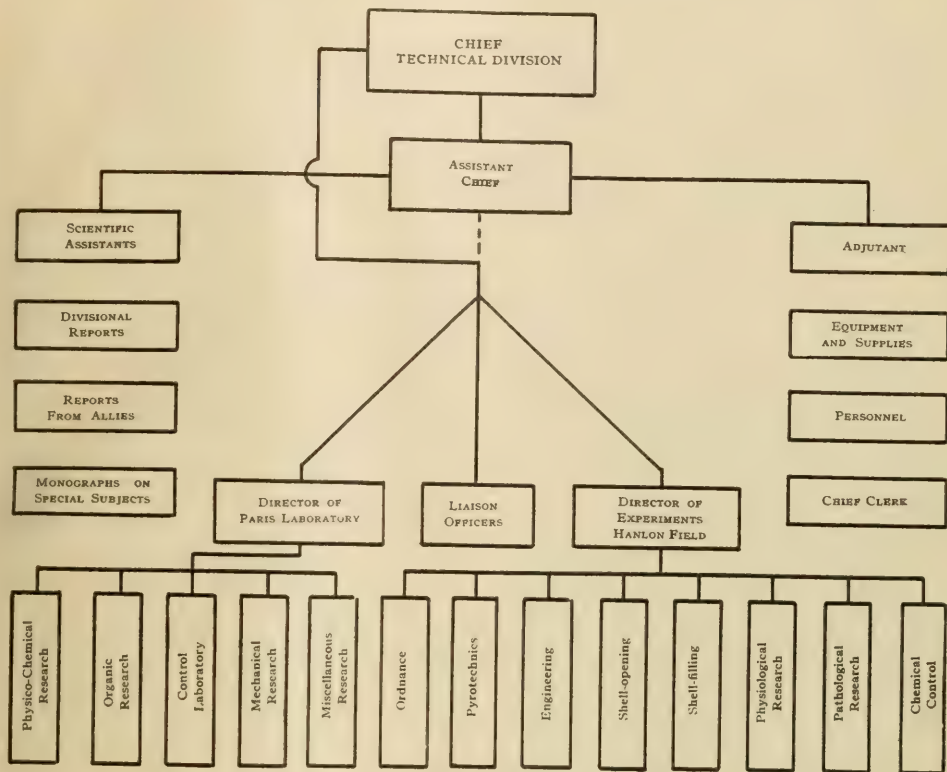
SUB-SECTION	CHIEF
Physico-Chemical Research...	Maj. F. G. Keyes
Organic Research.....	Capt. B. H. Nicolet
Control Laboratory.....	Sgt. Leo. Finkelstein
Mechanical Research.....	Maj. F. G. Keyes
Miscellaneous Research.....	1st Lieut. A. R. Olsen

The physico-chemical investigations have largely centered on the determination of the physical constants of the various "gases" in use—information much needed in connection with the formulation of gas-shell programs—and marked progress has been recorded by Major Keyes and his principal assistant, Sergeant Weisberg. This sub-section has recently completed a physico-chemical study of charcoals and their absorptive powers, and has also participated in the development of a practical detector for the recognition of "mustard gas" in the field. The organic researches have included the following: Development of systematic procedures for the examination of gas-shell contents, contaminated water supplies, and earth infected with "gases;" development of compounds suitable for use in "camouflage gases;" and the preparation of new "gases" for use in warfare. The gas-camouflage is of particular interest. It has been found that malodorous compounds (butyl mercaptan, dimethyl trithiocarbonate, etc.) are useful to mask the presence of other "gases" or to force the enemy to wear respirators when no other "gases" are present. As in the case of lachrymators, such "stink gases" must frequently be accompanied by other "gases," in order that the enemy may never know when toxic gases are actually absent. Camouflage gases are also useful in that they save "mustard gas" and the highly lethal gases. Their value has been demonstrated in trials at Hanlon Field and also at the front. The control laboratory has been charged with the examination of anti-gas appliances and equipment, new, defective, and used under varying conditions, and with the development of protective appliances and fabrics. Its canister testing facilities are excellent, and usually 150 canisters per month have been received from gas officers for examination; the necessity for knowing at all times the actual condition of the masks and canisters used by our fighting troops is, of course, obvious. The mechanical researches, conducted in the experimental engineering laboratory, have culminated in a field detector for "mustard gas," an automatic fire-extinguisher for airplanes, a gas-proof pigeon container, and certain improvements in shell-filling. The sub-section on miscellaneous research attends to the study of the various problems submitted by other arms of the service in France. It has been of special assistance to the Air Service and Signal Corps, A. E. F.

Hanlon Field, the experimental ground, has an area of approximately 20 square miles and is provided with the required laboratories (chemical, physiological, and pathological), shops, shell-opening, shell-filling and gaine-filling plants, meteorological station, ranges, trenches, etc. Here also are located the Gas Defense and Gas Offense Schools, at which the gas officers of the Service are trained for field duty. Hanlon Field compares very favorably in layout and equipment with the experimental field of the British at Porton, England, from which many suggestions were received at the inception of the Technical Division's work.

¹ For an earlier expression of appreciation of the work of the personnel of the Technical Division, see Hamor, *This Journal*, 10 (1918), 495.

TECHNICAL DIVISION, CHEMICAL WARFARE SERVICE,
A. E. F.



Among the investigations successfully concluded and reported upon by the staff at Hanlon Field, mention may be made of the following: A method of firing Livens projectors without "digging-in;" the development of a practical base-plate for Livens projectors; the effects of H. E. in Livens drums; the design of a practical airplane bomb for gases; the value of fumigens when employed in conjunction with gases; and the character of gas clouds and the persistence of gas clouds, especially of chlorpicrin and dichlorethyl sulfide, when formed by the bursting of shell under different explosive charges. Important findings have also emanated from the Field chemical laboratory (1st Lieuts. J. L. Crenshaw, C. W. S., and H. I. Cole, C. W. S.), where, in collaboration with the shell-opening plant (1st Lieut. H. E. Stump, C. W. S.), examination is made of enemy "duds" and their fillings, in order to maintain constant familiarity with the types of shell in use, their markings, and the "gases" employed therein. The needed protective measures are determined at the Paris Laboratory in the case of every filling possessing novel characteristics, and prompt dissemination of this information has invariably been arranged for through the Defense and Intelligence Divisions. The Field physiological laboratory (Maj. A. N. Richards, C. W. S., and 1st Lieuts. Samuel Goldschmidt and D. W. Wilson, C. W. S.) has been

largely concerned with the study of the effects of various gases on different animals and the degree of protection afforded by certain proposed preparations, while the pathological laboratory (Maj. H. C. Clark, C. W. S.) has established liaison with the Medical Department, studying considerable material obtained from the hospitals.

It has been impossible, in this résumé, to discuss at any informative length the varied and numerous investigations conducted for the American Expeditionary Forces by the Technical Division during the past year. The general character of its chemical warfare work has, however, been described as the maintenance of an intimate knowledge of conditions at the front, the planning and supervision of researches at the Paris Laboratory and Hanlon Field, the interpretation and application of the results of these investigations, as well as those conducted at American University and by the Allies, and recommendations regarding what gases and what types of masks, protective clothing, and other anti-gas equipment to issue. The research and advisory work of an offensive nature has required constant consideration of the tactical aspects of gas warfare, while the anti-gas activities have been the results of sojourns to a more familiar field—the chemistry of vocational hygiene.

THE TWO HUNDRED AND FIFTIETH ANNIVERSARY OF CHEMICAL INDUSTRY IN AMERICA

By C. A. BROWN, New York Sugar Trade Laboratory, New York City

Dr. Bernhard C. Hesse, in his excellent address upon "Our Preparation for After the War" printed in the November 1918 issue of *THIS JOURNAL*, made the very pertinent suggestion that the Fiftieth Anniversary of the AMERICAN CHEMICAL SOCIETY, which comes in 1926, be celebrated by a Jubilee Volume, which shall give a compact and complete account of what American chemists have done. The suggestion is a most admirable one and should be acted upon immediately. It is only seven years to the anniversary date of our Society and fully this amount of time will be needed for collecting, editing, and printing the material which shall do credit to such a volume.

Some of the readers of Dr. Hesse's address may have wondered, however, why he should date the origin of chemistry in America from the year 1768. This year antedates the Declaration of Independence and if we are going back to colonial times, as we very properly should, let our Jubilee Volume describe the origins of American chemistry from the very beginning. The writer has collected a considerable amount of material upon the development of chemical industries during the early days of our country's history and in the present communication wishes to call attention to the first origins of chemistry in America and to the man, who, in point of time, should have the honor of being called the first American chemist.

The importance of colonial manufactures was realized in England at the very beginning of the movement to found American settlements, and it is interesting to know that some of the earliest enterprises in which the English settlers engaged belonged to what are now termed chemical industries. The London Company, the year after they founded the Jamestown Settlement, sent eight Poles and Germans to the new colony to make pitch, tar, glass, and soap-ashes. No sooner were these workmen landed than they began operations, with the result that the settlers soon afterward shipped to London a cargo which consisted of lumber and what Captain Smith called "trials of pitch, tar, glass, frankincense, and soap-ashes." From this small beginning in 1608 we must date the commencement of chemical industries in America. The glass-house used for these trials stood in some woods about a mile from Jamestown. In the words of Dr. J. L. Bishop, "though probably very unpretending in its dimensions and appointments, it was doubtless the first manufactory ever erected in this country."

The scope of industrial activities at Jamestown was rapidly widened. In 1620 Sir Edwin Sandys, treasurer of the London Company, reported that 150 workmen had been sent to set up three iron works, that the efforts to make pitch, tar, potashes, and soap-ashes were being developed, and that the salt works, which had been suffered to go to decay, were restored with hopes of such plenty as not only to serve the needs of the colony but also to supply the great fisheries on the Atlantic Coast. The iron works mentioned in this report were at Falling Creek on the Jamestown River and the salt works at Cape Charles on the Eastern Shore.

Attempts were being made to extend the activities of the colony to lead smelting and to other fields when all industrial efforts were paralyzed by the Indian massacre of 1622. The iron works, glass-house, and other establishments were not only entirely demolished, but the courage to begin new enterprises which were under contemplation, such as the development of mineral resources, the distillation of walnut oil, the preparation of gums, drugs, dyes, and other plant products, was completely crushed. The Virginia settlers, after the failure of these early enterprises, turned from manufacturing to the more congenial and lucrative

pursuit of agriculture for which, after all, the natural resources of the colony were better adapted. More money could be made in growing tobacco than in the uncertainties of glass and iron. The colonists, henceforth, came to depend exclusively upon the Mother Country for their iron, leather, earthenware, and other commodities, to the grief of the historian Beverley who in 1705 complained bitterly of the sad relapse of his countrymen from the self-reliance of the early settlers. This appeal, however, was without effect. Virginia became a colony of planters, and the chemical industries, which the Jamestown settlers had the honor of commencing, were obliged to look elsewhere for a home.

Chemical industries in the New England colonies were destined to run very much the same course as in Virginia. We find the same attention being given to the manufacture of such necessities as iron and salt, the same difficulties from Indian wars in the way of exploiting mineral resources, and the same, although much slower, decay of these industries owing to lack of natural resources. The first development of many important industries, such as those of oil, soap, candles, and distilling, took place in New England as a result of the whaling, fishing, and commercial activities of its early settlers.

As a matter of special interest, in view of present war conditions, mention should be made of the birth of our ammunition industries. On June 6, 1639, the General Court of Massachusetts made a grant of 500 acres of land at Pecoit to Edward Rawson, "so as he goes on with the powder, if the saltpeter comes." The uncertainty of depending upon outside supplies of saltpeter caused this Court to issue in June 1642 the following order for promoting the public safety. In order to raise and produce "such materials amongst us as will perfect the making of gunpowder, the instrumental means that all nations lay hold on for their preservation... every plantation within this Colony shall erect a house in length about 20 or 30 foote, and 20 foote wide within one half year next coming, . . . to make saltpeter from urine of men, beastes, goates, hennes, hogs and horses dung."

Lack of space prevents our touching upon the origin of other chemical industries in New England except as they concern the life of the earliest American chemist.

In the beginning of 1669, just 250 years ago, Henry Oldenburg, secretary of the newly founded Royal Society, wrote the following words to John Winthrop, Jr., fellow member of the Society, and Governor of the Colony of Connecticut: "Give me leave, I pray, to inquire what chymists you have in your parts and whether they have written anything considerable."

This attempt to determine the names and status of American chemists may be regarded as the prototype of the questionnaire which our Chemical Warfare Service recently sent through the length and breadth of the land. It is not known what answer, if any, Governor Winthrop made to the request of Oldenburg. Probably modesty forbade his replying to the Honorable Secretary that excepting himself there was at that time probably no other man in the American colonies who could claim the title of chemist.

The name of John Winthrop, the younger, is so firmly associated with the political and military history of the English settlements that his services in the field of science and industry have been overlooked. Excepting a few curious-minded antiquarians, probably no chemists of the present generation ever have occasion to refer to the early records of the Royal Society, otherwise Winthrop's contributions to various chemical subjects would have been more frequently mentioned. All American chemists know of Sir Robert Boyle, discoverer of Boyle's law and author

of "The Skeptical Chymist," yet few of them, probably, are aware of his intimate friendship with Winthrop and of the association of these two men, not only in chemical matters, but in subjects which had a more immediate bearing upon the material and spiritual welfare of the early colonial settlements.

John Winthrop¹ was born at Groton, England, February 12, 1606. After studying at the Free Grammar School at Bury St. Edmunds, he spent several years at Trinity College, Dublin, and then finished by studying law in London, where he was admitted to the bar in 1625. The next five years were spent in adventure and travel, Padua, Venice, Constantinople, and many other European cities being visited. It was during this period, no doubt, that Winthrop formed an acquaintance with many of those scientists and scholars with whom in after years he corresponded in Latin.

In 1630 Winthrop's father sailed for the new colony at Massachusetts Bay and the succeeding year the son followed. Young Winthrop entered immediately into all the activities of his new life. In March 1633, he planted a settlement at Agawam, the present Ipswich, but the death of his wife and daughter caused a change in his plans and the following year he sailed for England on an errand in the interest of the colony. It was during this visit that young Winthrop was granted authority by Lords Say and Brook to begin a plantation in Connecticut for which they gave him men and means with an official commission as Governor. Winthrop, who had meantime remarried, sailed again for America and in November 1635 built a fort at Saybrook in his future colony.

Winthrop's connection with the Massachusetts Bay Colony did not, however, definitely cease until 1650, and during this interval he was constantly engaged in many activities of an official and private nature. In June 1638 he obtained permission to set up a salt factory at Ryall-Side, in what is now Beverly, and in 1641 he sailed for England to obtain funds and men for the erection of iron works. Among the papers of Winthrop is an interesting memorandum upon "Considerations concerning Ironworks" in which he tells how after making a search for ore in Maine and New Hampshire, he finally decided to locate his iron furnace at Braintree, Mass., at which place the General Court in 1644 gave him and his partners a grant of 3000 acres. He obtained the same year a grant to start similar works in the Pequot country, a section which in 1647 was transferred to Connecticut.

In 1646 Winthrop made his home in New London and in 1650 severed his official connection with the Massachusetts Bay Colony, in order to devote his time entirely to the welfare of Connecticut. His interests in the material resources of his colony is shown by an act of the General Assembly for 1651:

Whereas in this rocky country, among these mountains and rocky hills, there are probabilities of mines of metals, the discovery of which may be of great advantage to the country in raising a staple commodity; and whereas John Winthrop, Esquire, doth intend to be at charges and adventure for the search and discovery of such mines and minerals: for the encouragement thereof, and of any that shall adventure with the said John Winthrop, Esquire, in the said business, it is therefore ordered by the Court that if the said John Winthrop, Esquire, shall discover, set upon and maintain such mines of lead, copper, or tin, or any minerals, as antimony, vitriol, black lead, allum, stone-salt, salt springs, or any other the like, within this jurisdiction, and shall set up any work for the digging, washing, and melting, or any other operation about the said mines or minerals, as the nature thereof requireth, that then the said John Winthrop, Esquire, his heirs, associates, partners or assigns, shall enjoy forever said mines, with the lands, wood, timber, and water within two or three miles of said mines, for the

necessary carrying on of the works and maintaining of the works, and provision of coal for the same.

It is doubtful if a greater or more unlimited monopoly for the production of chemical products was ever granted to a man than this. The unsettled condition of the country and troubles with the Indians (to say nothing of the non-existence of any such mines of wealth) prevented Winthrop from enjoying the slightest part of the fruits of this ambitious program. He did, however, establish salt-works at New London and made plans for the erection of iron works near New Haven, to which place he moved in 1655.

In order to obtain a Royal Charter for his colony, Winthrop, in the autumn of 1661, went again to London, where he resided until the spring of 1663 before his diplomatic errand was finished. It was during this interval that he joined the Royal Society (organized in 1660), his name being proposed December 18, 1661, and his admission taking place January 1, 1662. During the fifteen months of his participation in the meetings of the Society he took a most active part in all that was said and done. Winthrop's love for chemical and scientific pursuits had always been strong and he was now able, for the first and only time in his life, to satisfy these tastes by associating with interested and congenial friends.

In the Society meeting for March 5, Winthrop was appointed to a committee to investigate the refining of gold. On April 23 he gave a demonstration of a self-feeding tin lamp "burning high like a candle" of which a diagram was made and registered. At this same meeting he exhibited a specimen of malleable mineral lead and other samples. On April 30 he exhibited other mineral specimens. On June 25 he was asked to prepare a paper upon pitch and tar. This subject was reported upon July 9, and on July 16 his completed paper, "Of the Manner of Making Tar and Pitch in New England," was registered in the *Proceedings of the Society* (Register Book, Vol. 1, p. 179). The title and date are important, for it marks the first contribution from an American before a scientific society, and it is a satisfaction for chemists to know that the subject relates to industrial chemistry. In this paper Winthrop describes in detail the method of collecting pitch-pine knots and subjecting them to heat, the tar being recovered by what he calls a *distillatio per descensum*. Other subjects reported upon by Winthrop during the 1662 meetings of the Royal Society related to black lead, the manufacture of potashes, and the exhibition of various mineral and vegetable products.

On January 7, 1663, Winthrop was asked by the Royal Society to undertake an experiment upon brewing beer from maize. The research was a rather elaborate one as we can see from references contained in the minutes of subsequent meetings. Finally on March 11 he made his report, presenting the members as a result of his experiments some bottles of beverage which was pronounced to be "a pale, well-tasted, middle beer." In this experiment eight gallons of beer were brewed from about half a bushel of maize.

Winthrop's report upon the brewing of maize was included in a paper upon the "Description, Culture and Use of Maize" which appeared in the *Philosophical Transactions of the Society* for 1678 (No. 142, pp. 1065-1069). In this paper Winthrop calls attention to the possibility of making syrup and sugar from cornstalks: "A syrup as sweet as sugar may be made of it, as hath been often try'd. And meats sweetened with it have not been distinguished from the like sweetened with sugar. Trial may easily be made, whether it will not be brought to crystallize, or shoot into a saccharine powder, as the juice of the sugar cane." It was over 150 years before this suggestion of Winthrop was carried out.

Winthrop was asked by the Society to keep some of the beer which he exhibited in order to see how it would stand ageing but this part of the experiment was interrupted by other duties.

¹ For the main facts in this article pertaining to Winthrop's life use was made of T. F. Water's excellent biography, published by the Ipswich Historical Society. For Winthrop's relations with the Royal Society, Birch's History of the Royal Society, the Proceedings of this Society, and the letters of Winthrop, published in the Massachusetts Historical Society's Proceedings, Series I, Vol. XVI, Pp. 206-251, were consulted.

On March 18 he notified the Society that he was about to return to New England. His final attendance at the meetings was on March 25 when he was given a commission to execute some experiments upon sea-sounding and was provided with apparatus to procure samples of water from the bottom of the ocean. This last commission, owing to defects in the apparatus and the roughness of Winthrop's homeward voyage, could not be carried out.

The chemists whom Winthrop met at the meetings of the Royal Society were among the celebrities of the day and comprised men of every shade of opinion. There were old-time alchemists, such as Elias Ashmole and Kenelm Digby, practical technologists, such as Robert Moray, and skilled experimenters, such as Robert Boyle. It was a transition period between the old order of things and the new, and remnants of old beliefs crept into the meetings on more than one occasion. A smile is provoked now upon reading that at one meeting, after Winthrop had exhibited the tail of a rattlesnake, a doctor who was present took the rattles home "to make some trial of the powder of it," yet the incident is recorded with all seriousness. No mention was afterwards made of the powder's medicinal value.

The short time spent by Winthrop among the members of the Royal Society has been called the happiest period of his life and his return to the wilds of Connecticut, in spite of the desire to see his family again, was no doubt attended with feelings of regret. The separation from the comradeship of the Royal Society was somewhat alleviated, however, by correspondence, although months and years, in some cases, elapsed before mail was delivered. All too frequently the letters, communications, and specimens which Winthrop sent to the Royal Society were lost at sea either from capture by Dutch privateers or from shipwreck. In the same way letters and books sent to Winthrop by his European friends often failed to reach their destination.

The modern chemist, in the comforts of his club or in the fellowship of his society meeting, does not always appreciate the benefits of his position. There is no better way of bringing this truth home than by contrasting these advantages with the desolation of Winthrop's surroundings. We can form some idea of his longing for scientific companionship from a letter which he wrote to Sir Robert Moray from Hartford, September 20, 1664.

I had sad and serious thoughts about the unhappiness of the condition of a Wilderness life so remote from the fountains of learning and noble sciences... when I was greatly revived with the special favour of your honor's letter. . . .

After telling Sir Robert about his attending the surrender of New York by the Dutch to the English the previous August, Winthrop next answers some of his correspondent's questions regarding the industries and mineral resources of Connecticut.

Matters of public concernment have been so many and difficult since I came over and several occasions preventing that, though I have had men at work about some preparations for a salt worke, yet could never have time to goe to the Sea Side (which is about 60 miles from this place) to make triall of the businesse, but am waiting some good opportunity for it, of which I may give your honor some account afterwards.

I had a piece of Marcasite, which seemed to containe copper, an Indian brought from up in the country, but there have bene such warres amonge the heathen in these parts that there could be no travelling that way upon such discoveries, but time I hope will give better opportunities. I heare there is peace like to be made amongst those Indians shortly, which before the Dutch suffered not whilst that land was in their power. I should be glad there could be found any minnerall matters of real worth.

I must be bold to crave the favor of my humble service to the President and the gentlemen of the Royall Society.

The difficulties and dangers of prospecting retarded the de-

velopment of chemical industries in the early colonies at least a hundred years. In a subsequent letter (August 18, 1668) to Sir Robert Moray, Winthrop alludes to this:

I shall not now repeat what was mentioned in former letters except some little about minneralls, though I may be assured that all which were sent came not to your hands. I have been very inquisitive after all sorts of minneralls, which this wilderness may probably afford; but indeed the constant warres, which have continued amongst the Indians since I came last over, hath hindered all progresse in searching out such matters, for some of them which have formerly brought any specimens of that kind were kild in the warre, and others, who pretend to know places of likely appearance, dare not goe up into the country, without strong parties: those places which have bene for present of most hopes for J and H^1 are best knowne to the Honble. Colonnell Nicolls... Better tymes may promote better discoveries, for which we must waite. Those shewes of minneralls, which we have from the Indians, doe only demonstrate that such are in reality in the Country, but they usually bring but small pieces, which are found accidentally in their huntings, sticking in some rock or on the surface of the earth, or the side of some hill, or banke of a river: but they seldom speake of any great quantity where they finde it, nor can they in likelihood meet with a solid vein of good metall, which usually lyeth deepe in the earth, never opened by them, nor have they meanes to do it, therefore cannot know what is in those bowells, except where an earthquake hath shaken downe the side of an hill, or made some rent amonge the rocks....

Concerning the Iron stone of these parts and the Iron works, I forbear to mention anything againe now about those matters, having written largely formerly, as also concerning lead and something about copper and some considerable expenses bestowed rashly upon trialls of a stone that holdeth (as is supposed) some small quantity of that metall: as also what trialls have bene made by digging into the earth and through some rocks, in hope of good metalls, of all which I may hope againe to recollect my thoughts about those particulars of which I have formerly written.

Winthrop's faculty for making and holding friends had probably as much to do with the correspondence between him and the members of the Royal Society as a mutual desire to gather knowledge. Wherever this faculty exists it seems always to be accompanied by a certain liberality and tolerance of opinion—traits which, as exemplified in such men as Franklin and Priestley, are usually found to go with a love for science. The harsh, intolerant spirit, which characterized so many New England Puritans, was entirely absent in Winthrop. "I rejoice," wrote Roger Williams, "that your name is not blurr'd, but rather honor'd, for your prudent and moderate hand in the late Quaker trialls amongst us," and again in a letter written to Winthrop the year before his death, "You have bene noted for tendernes towards the bodies and infirmities of poor mortalls. You have bene tender too toward the estates of men in your civil steerage of government and toward the peace of the land, yea, of these wild savages."

The same attachment to Winthrop is shown in the letters of his English and Continental friends. One of the latter, when about to send some works of Glauber and other chemists to Winthrop, wrote to an English acquaintance in quaint German, "Herr Winthrop wolle der Herr meinert wegen hertzlich grüssen. Ich bin seiner nit vergessen, dencke noch oft an Ihn und bisweilen wünsche Ich mich bey Ihn auff $\frac{1}{2}$ oder gantzen tag."

But of all these friends none was more faithful than Henry Oldenburg, who must always rank as the model for a scientific secretary. "You will please to remember," he writes Winthrop, "that we have taken to taske the whole Universe and that we were obliged to doe so by our Dessein, . . . We know your ingenuity, experience and veracity, the best qualities of a man and philosopher and we doubt not but you will let us share in the happy fruits and products thereof. And, since you have now been from us several years, give us at least a visit by a Philosophicall letter. . . . The Royal Society, who retains still a particular

¹ The alchemistic symbols for silver and mercury.

respect and kindnesse for you, will receive what shall come from you...with no ordinary affection and thankfulness."

Oldenburg not only urges Winthrop to contribute papers upon the mineral resources of his colony and upon his new method for manufacturing salt, but he sends him at the same time copies of the Society's transactions with chemical books by Boyle and other authors. He also keeps him posted upon the latest researches which the Society had under way. "Since you went," he writes again, "the Society hath made, among others, the Torricellian Experiment in a glass-tube of 40 feet high which costed much trouble but gave contentment." He then describes with considerable detail another experiment which seemed to contradict Boyle's theory of "the spring and weight of the air."

In every letter Oldenburg pressed his friend to write a book upon the natural resources of New England but the cares of office allowed Winthrop no time for such a project. He longed for leisure and the opportunities for research and study and wished to resign the Governorship but the General Assembly refused to give their consent. In performance of his duties as Governor he attended a meeting of the Colonial Commissioners at Boston in the winter of 1675-1676, and it was while absent upon this mission that he contracted his final sickness. He died at Boston, April 6, 1676, and was buried in King's Chapel cemetery.

The objection may be raised against the claim that Winthrop was our first American chemist by saying that he was not a professional chemist but only an amateur. Without denying this, it may be said that the same objection would apply to all chemists for the next hundred years after Winthrop's death. They were not chemists by vocation, but by avocation. The great Priestley was not a chemist by profession, but a Unitarian minister.

In support of the claim for Winthrop we have not only his own letters and the records of the Royal Society but we have the testimony of his contemporaries. In a tribute by the colonial poet Benjamin Thompson the dedication is addressed "to the Honourable Dust of that most Charitable Christian, Unbiassed Politician and Unimitable Pyrotechnist, John Winthrop, Esq.: A Member of the Royal Society and Governor of Connecticut Colony in New England, who expired in his Country's Service, April 6, 1676."

In this tribute Thompson mentions little about Winthrop's

political achievements but devotes nearly half the poem to his chemical pursuits.

Projections various by fire he made
Where nature had her common Treasure laid.
Some thought the tincture Philosophick lay
Hatch by the Mineral Sun in Winthrop's way,
And clear it shines to me he had a Stone
Grav'd with his Name which he could read alone.

Sometimes Earth's veins creeping from endless holes
Would stop his plodding eyes : anon the Coals
Must search his Treasure, conversant in use
Not of the Mettals only but the juice,
Sometimes his wary steps, but wandering too,
Would carry him the Chrystal Mountains to,
Where Nature locks her Gems, each costly spark
Mocking the Stars, sph'r'd in their Cloisters dark.
Sometimes the Hough, anon the Gardners Spade
He deigned to use, and tools of th' Chymick trade.

Winthrop's death may be said to mark the close of the first epoch in the history of industrial chemistry in America, the epoch which was mostly devoted to what were called "trials." The future of chemical industries in America was destined to remain neither in Virginia nor in New England. With the founding of another colony by William Penn, six years after Winthrop's death, a new era was to begin when undiscovered mineral resources, of an extent and character hitherto undreamed, were to make the Middle Atlantic Section the future center of chemical industry.

But the period when our ancestors made trials of pitch, tar, glass, salt, powder, and iron ought not to be forgotten and it should be commemorated at the fiftieth anniversary of the AMERICAN CHEMICAL SOCIETY. The occasion would be fitting, for it has the sanction of a commemoration in more ways than one.

Winthrop died on April 6, 1676, and on April 6, 1876, exactly two hundred years later to the day, the AMERICAN CHEMICAL SOCIETY had its birth.

As the origin of our Society dates back to a meeting of chemists about the grave of Priestley, we can celebrate its fiftieth anniversary in no better way than by meeting in Boston in 1926 about the grave of Winthrop, the man who first brought chemistry into the wilderness, who labored to apply his chemical knowledge to the service of his fellowmen, and who, in spite of his own failures, had unbounded faith and confidence in the future.

CHEMICAL MARKETS OF THE WEST INDIES

By O. P. HOPKINS, Washington, D. C.

It is a fact not generally appreciated that the West Indies are second only to Europe as a market for American goods. During the fiscal year 1916 these islands imported nearly as much from America as the continent of South America, two-thirds as much as was taken by all Asia and the East Indian Islands, or seven times the total sold to China. Cuba, of course, takes the bulk of the trade, but some of the other islands are worth-while customers and constantly becoming more attractive; in fact, the opportunities for future expansion throughout the Archipelago are quite as promising as in any other quarter. The extraordinary natural resources of the islands have not nearly been fully developed.

The wealth of the West Indies lies in agricultural, forest, and mineral products which are exported in the main as crude or partly manufactured materials. Imports, on the other hand, consist of manufactured

goods and foodstuffs, of which the United States is the chief source of supply because of favorable location and superior knowledge of the markets.

All of the islands are covered in this article except a few of the very smallest, which have no trade to speak of, and the American possessions, Porto Rico and the Virgin Islands, which are usually included in studies of the American possessions. The table showing the chemical trade as a whole is in each case compiled from the official statistics of the country, while the tables showing the trade with the United States are made up from published statistics of the United States Bureau of Foreign and Domestic Commerce.

CUBA

Sugar is the principal source of Cuban wealth, followed by tobacco. The elimination of the competition from European beet sugar during the war has

stimulated the Cuban industry and brought prosperity to the whole country, so that the market for imported articles is even more attractive than it was before the war. Other agricultural products of minor but growing importance are cacao, coffee, winter vegetables, pineapples, citrus fruits, bananas, and other tropical fruits. Hennequen and malva blanca are two fibers that are grown in increasing quantities to meet the demand for sugar bags.

The mineral resources of the island have not been extensively exploited, but iron and copper ores have been taken out in quantity, especially under the stimulation of war prices.

The only important manufacturing industries are carried on in connection with the cane and tobacco crops. American capital is heavily invested in the sugar mills. The minor manufacturing industries are unable in any case to meet the domestic demands, and the great bulk of manufactured goods is imported.

The purchases of chemical products are rather heavy, as "Salts not elsewhere specified" were imported to the extent of more than three and a half millions during the fiscal year 1917, while "Pharmaceuticals not elsewhere specified" were imported to the value of more than two millions, and fertilizers to the extent of a million. It is unfortunate that more details as to the items included under these classes are not available, but there seems to be a dearth of information on the matter.

The merits of chemical fertilizers have only recently been recognized, but the results obtained with them by the more progressive cane and tobacco growers have had their effect upon the others, and the demand is rapidly growing. American packers, Chilean nitrate concerns, and German fertilizer agencies have been active in the market, and American capital has erected a plant for the manufacture of complete fertilizer from imported materials. This market will continue to expand.

The products imported are for the most part such as the United States can furnish to good advantage, and this country now has the lion's share of the trade in most lines. French manufacturers have always done a good business in proprietary medicines, pharmaceuticals, and perfumes, but the Germans have not been particularly successful.

The following Cuban statistics for the fiscal years 1914 and 1917 show the extent of the imports of chemicals and allied products and the manner in which the principal competing countries have participated:

CUBAN IMPORTS OF CHEMICALS AND ALLIED PRODUCTS

ARTICLES	1914	1917
CHEMICALS, DRUGS, DYES, MEDICINES		
Acids.....	\$ 213,832	\$ 308,301
Belgium.....	18,304	
United States.....	166,839	300,236
Alcohol.....	827	353
Alkaloids.....	16,807	12,186
France.....	3,863	5,772
United States.....	2,804	5,649
Calcium carbide.....	328,539	276,032
United States.....	328,492	276,032

CUBAN IMPORTS OF CHEMICALS AND ALLIED PRODUCTS (Continued)

ARTICLES	1914	1917
CHEMICALS, DRUGS, ETC. (Continued)		
Chemicals, n. e. s.....	\$ 212,192	\$ 286,389
Germany.....	22,968	
United States.....	143,311	263,476
Dyes, natural and artificial.....	5,572	6,714
Germany.....	5,476	
United States.....	2,303	5,936
Fertilizers, chemical.....	504,713	1,014,833
Germany.....	140,202	
United States.....	250,590	1,014,833
Glycerin, olein.....	113,650	333,767
Belgium.....	16,773	
United States.....	80,769	353,767
Medicines, patent or proprietary.....	547,535	415,876
France.....	175,203	152,782
United Kingdom.....	28,417	9,657
United States.....	302,803	232,652
Opium.....	66,933	97,293
China.....		47,570
United States.....	2,226	19,061
Oxides.....	130,227	234,575
United Kingdom.....	34,824	
United States.....	94,409	232,775
Pharmaceutical products, n. e. s.....	1,214,844	2,127,623
France.....	639,018	666,779
Germany.....	16,390	
Spain.....	49,501	125,740
United Kingdom.....	16,948	40,259
United States.....	469,716	1,240,165
Quinine.....	3,006	6,836
United States.....	549	2,770
Roots, herbs, etc.....	76,649	245,091
Spain.....	10,675	112,570
United Kingdom.....	14,293	6,936
Saccharine.....	1,689	3,146
Salts, n. e. s.....	2,919,691	3,632,270
Chile.....	2,519	285,313
United Kingdom.....	527,696	256,825
United States.....	2,355,135	3,060,585
Seeds.....	6,838	21,463
Mexico.....	6,730	21,285
Vanilla.....	5,456	5,550
EXPLOSIVES		
Cartridges.....	72,677	137,218
United States.....	63,199	137,218
Dynamite (U. S.).....	128,956	340,402
Fireworks.....	4,938	3,867
Gunpowder (U. S.).....	22,868	20,192
Hunters' powder.....	6,681	10,260
United States.....	6,681	9,653
Miners' fuses (U. S.).....	8,787	19,433
Other explosives (U. S.).....	45	6,840
OILS:		
Animal:		
Cod-liver oil.....	8,679	4,154
Norway.....	3,010	220
United States.....	4,289	2,655
Other animal oils.....	2,323	7,430
United Kingdom.....		5,891
United States.....	1,336	1,539
Mineral:		
Crude.....	678,040	1,470,431
United Kingdom.....	812	3,186
United States.....	677,209	1,467,245
Refined.....	711,809	1,610,396
United Kingdom.....	6,768	528
United States.....	701,300	1,602,345
Benzine.....	690	198,455
Gasoline.....	26,357	310,509
Naphtha.....	24,993	101,879
Oil for cordage works.....	19,266	12,713
Refined petroleum.....	63,086	56,173
Other refined oils.....	577,420	930,667
Vegetable:		
Cottonseed oil.....	346,013	1,046,113
Spain.....	40,348	
United States.....	305,665	1,046,113
Olive oil.....	1,104,941	1,880,653
Spain.....	1,012,556	1,725,041
United States.....	63,369	137,359
Oil for manufacture of soap.....	21,801	195,222
United States.....	21,801	195,222
Other vegetable oils.....	176,025	313,576
Portugal.....		78,887
United Kingdom.....	98,353	29,283
United States.....	43,689	200,946
PAINTS, PIGMENTS, COLORS, VARNISHES:		
Colors, natural.....	14,698	10,103
Spain.....	3,115	3,602
United States.....	5,893	5,892
Colors, metallic base.....	622,172	1,041,861
Belgium.....	57,361	
United Kingdom.....	177,496	112,566
United States.....	378,165	904,603
Other colors and paints.....	94,375	94,344
Germany.....	13,727	
United Kingdom.....	6,049	6,279
United States.....	64,947	83,440
Varnishes.....	76,769	75,250
United Kingdom.....	4,810	2,957
United States.....	67,214	70,706

CUBAN IMPORTS OF CHEMICALS AND ALLIED PRODUCTS (Concluded)

ARTICLES	1914	1917
PERFUMERY AND ESSENCES.....	606,450	805,654
France.....	454,045	598,308
United States.....	82,459	145,665
SOAP AND CANDLES		
Candles.....	\$ 173,965	\$ 222,825
Spain.....	85,802	44,654
United States.....	171,995	169,569
Soap, common, in cakes.....	376,191	596,738
Spain.....	203,508	140,681
United States.....	149,739	414,265
Soap, fine.....	89,956	142,912
France.....	43,918	76,263
Spain.....	1,523	60,896
United States.....	38,087	41,361
Soap, other.....	72,559	82,994
United States.....	51,385	61,507
Soap greases.....	217,849	475,547
United States.....	217,055	467,358
GLASS AND GLASSWARE.....	1,577,972	2,064,183
Germany.....	466,581	265
United States.....	361,558	1,518,919
Belgium.....	217,112	
Spain.....	139,964	230,566
PAPER AND CARDBOARD.....	1,942,922	3,827,533
United States.....	1,021,099	3,249,388
Germany.....	300,782	
Spain.....	289,786	362,600

That the American share in the trade has increased substantially for nearly every item since the war started is clearly shown in the next table. This increase is to be attributed in part to the elimination of European competition, but an even more important factor has been the increased purchasing power of the country. The immediate problem before the American exporter is not how to further expand this trade, but how to maintain his present share in it.

There seems to be a discrepancy between the Cuban figures for imports of fertilizer from the United States and the American figures for exports of fertilizer to Cuba, the probable explanation being that the Cuban returns for "Salts not elsewhere specified" include some items that might have been classified under "Fertilizers." The statistics in this table are for the fiscal years 1914 and 1917:

AMERICAN PRODUCTS SOLD IN CUBA

ARTICLES	1914	1917
Aluminum.....	\$ 3,748	\$ 33,497
Asphaltum.....		
Unmanufactured.....	119,008	455
Manufactured.....	21,305	
Babbitt metal.....	16,280	68,828
Blacking, shoe paste, etc.....	35,055	57,258
Candles.....	70,723	188,910
Cement, hydraulic.....	1,011,720	1,282,818
Chemicals, drugs, dyes, medicines:		
Acids.....	6,956	40,439
Sulfur.....	90,490	244,037
Al other.....	12,714	16,232
Baking powder.....	13,692	19,132
Bark extract for tanning.....	367,578	280,982
Calcium carbide.....	4,014	7,549
Copper sulfate.....	670	24,412
Dyes and dyestuffs.....	524,438	1,019,805
Medicines, patent or proprietary.....	3,568	13,032
Petroleum jelly, etc.....	(a)	588,578
Soap, salts and preparations.....	5,452	60,101
Sulfur (brimstone).....	23,882	29,356
Washing powder and fluid.....	771,394	1,748,468
All other.....	3,441	23,488
Cement, hydraulic.....	4,750	28,565
Clays.....		
Explosives.....		
Cartridges, loaded.....	173,169	240,959
Dynamite.....	134,936	262,827
Gunpowder.....	5,837	17,255
All other.....	41,967	129,541
Fertilizers.....		
Phosphate rock.....		21,329
Land pebble.....		18,698
All other.....	389,622	3,738,222
Flavoring extracts and fruit juices.....	6,808	31,158
Glass and glassware.....	267,944	1,317,286
Glue.....	23,896	88,066
Glucose.....	14,839	50,216
Grease.....	109,769	205,603
Lubricating.....	443,071	1,314,503
Soap stock and other.....	414,733	1,920,572
India-rubber manufactures.....		
Ink.....	30,962	90,222
Printers.....	16,008	36,315
All other.....	17,774	77,738
Leather, patent.....	409	
Matches.....	10,214	30,280
Metal polish.....		

AMERICAN PRODUCTS SOLD IN CUBA (Concluded)

ARTICLES	1914	1917
Naval stores:		
Rosin.....	\$ 127,886	\$ 207,747
Tar, turpentine, and pitch.....	18,940	14,470
Turpentine, spirits of.....	31,748	41,612
Nickel, nickel oxide, and matte.....	543,148	16,704
Oilcloths and linoleum.....	65,930	78,583
Oils:		
Animal.....	1,924	21,832
Crude mineral.....	429,810	1,303,774
Refined mineral.....		
Gas and fuel.....	43,989	84,084
Illuminating.....	84,411	163,766
Lubricating and heavy paraffin.....	543,148	925,987
Gasoline.....	61,587	466,440
Other light oils.....	2,502	223,252
Vegetable:		
Corn.....	8,388	24,286
Cottonseed.....	382,390	1,158,123
Linseed.....	17,968	68,587
All other fixed.....	10,173	163,187
All other oils.....	17,070	42,278
Paints, pigments, etc.:		
Dry colors.....	8,951	98,029
Ready-mixed paints.....	223,459	241,856
Varnish.....	48,748	77,467
Whitewash.....	8,083	24,805
Zinc oxide.....	5	9,058
All other (including crayon).....	147,716	537,307
Paper:		
Board.....	12,851	20,312
(a).....	(a)	301,346
Printing:		
News.....	266,257	478,601
Acid other.....	263,157	1,117,523
Wrapping.....	44,391	645,672
Writing and envelopes.....	114,775	340,166
All other.....	223,416	315,538
Paraffin and paraffin wax.....	9,403	41,478
Paste.....	10,758	24,697
Perfumery, cosmetics, etc.....	41,983	172,902
Photographic goods:		
Motion picture films.....	14,699	46,432
Other sensitized goods.....	62,476	80,186
Plaster of Paris.....	8,143	12,161
Plumbago and manufactures.....	165,029	187,211
Salt.....		
Soap:		
Toilet.....	60,772	148,881
All other.....	137,073	372,752
Starch.....	3,683	73,552
Stearin:		
Animal.....	39,190	241,110
Vegetable.....	(a)	15,262
Sugar, refined.....	103,775	222,467
Wax, manufactures of.....	1,886	8,509
Yeast.....	15,386	22,103

(a) Not stated separately in 1914.

The principal Cuban product sold in the United States is cane sugar; in fact, this is now the most valuable item imported from any country. There are very few countries whose total exports to the United States equal in value our purchases of Cuban sugar.

CUBAN PRODUCTS SOLD IN THE UNITED STATES

ARTICLES	1914	1917
Asphaltum and bitumen, crude.....	\$ 4,600	\$ 32,846
Bones, hoofs, horns, and manufactures.....	48,605	50,982
Cacao, crude.....	326,642	149,447
Chemicals, drugs, dyes, medicines:		
Glycerine, crude.....	27,431	106,776
Potash salts.....		9,868
Vanilla beans.....	30	
All other.....	7,210	9,753
Copper:		
Concentrates.....	1,270,182	5,824,698
Matte, regulus, etc.....		469,168
Old and clippings.....	162,709	101,004
Dyedwoods, in crude state:		
Logwood.....		19,253
All other.....		3,381
Fertilizers:		
Guanos.....	1,250	8,846
Potash, sulfate.....	2,675	735
All other.....	1,133	5,291
Glass and glassware.....	21,689	26,945
Hide cuttings and other glue stock.....		
India rubber:		
India rubber.....		74,444
Scrap.....	12,426	37,507
Iron ore.....	3,717,975	1,913,804
Manganese oxide and ore.....		461,853
Oils:		
Mineral.....		15,647
Coconut.....		3,184
All other.....	2,014	8,634
Starch.....	129	3,987
Sugar and molasses:		
Molasses.....	1,474,200	10,381,816
Sugar, cane.....	98,394,782	204,521,160
Waxes, paraffin.....	168,691	217,563
Zinc, block and old.....	7,293	19,865

The only other important imports suitable for inclusion in this list are molasses, copper ore, and iron ore, the first two of which have been greatly increased since the war started. The preceding table contains details of our imports from Cuba for the fiscal years 1914 and 1917.

DOMINICAN REPUBLIC

The Dominican Republic's output of sugar was valued at \$5,000,000 in 1914, cacao at \$4,000,000, tobacco at \$400,000, and coffee at \$350,000, and these are the principal products of the country. The war has greatly stimulated the output of sugar and has also led to some exploitation of the immense dyewood resources, which had previously been neglected. The forests contain an abundance of tropical woods, and agriculture could be much extended. There is very little manufacturing, and the mineral resources have not been surveyed. The population is estimated at about 800,000.

To date there has not been much of a demand for chemicals, although the market for patent medicines and pharmaceuticals is not altogether unattractive. Before the war Germany had a good share of the business in paper and glass, and France sold most of the perfumes, but in all other lines the United States has practically no competition.

The following table will give some idea of the extent to which chemicals and allied products are imported:

IMPORTS OF CHEMICALS AND ALLIED PRODUCTS INTO THE DOMINICAN REPUBLIC

ARTICLES	1913	1917
CHEMICALS, DRUGS, GUMS, RESINS, FATS, AND WAXES.....	\$320,194	\$476,237
France.....	38,361	38,187
Germany.....	22,881	
United States.....	228,37	411,468
Calcium carbide.....	(a)	35,662
Caustic soda.....	(a)	8,755
Tallow and greases.....	(a)	36,211
Other oils, fats, waxes.....	(a)	367,012
Vegetable juices and extracts.....	(a)	6,463
Gums, resins, and caustic soda for the manufacture of soap.....	103,989	(b)
RUBBERS.....	3,371	12,407
All other chemicals.....	212,834	9,727
PERFUMERY AND COSMETICS.....	43,776	77,350
France.....	28,963	39,083
United States.....	6,827	31,273
OILS, ALL SORTS.....	448,384	786,956
Spain.....	30,078	14,809
United States.....	384,082	743,045
Oils for table use.....	(a)	268,458
Spain.....	(a)	14,809
United States.....	(a)	230,708
Oils, mineral:		
Crude.....	(a)	45,324
Gasoline.....	(a)	117,450
Illuminating oil.....	(a)	217,811
Lubricating oil.....	(a)	69,339
All other.....	(a)	68,574
SOAP.....	86,884	248,902
United States.....	82,583	240,915
EXPLOSIVES.....	(a)	10,872
United States.....	(a)	10,436
PAINTS, PIGMENTS, VARNISHES.....	56,073	140,852
Germany.....	6,467	4,967
United Kingdom.....	41,415	133,982
United States.....	125,683	248,381
PAPER AND MANUFACTURES OF.....	52,898	
Germany.....	54,764	
United States.....	55,350	72,360
GLASS AND GLASSWARE.....	22,189	
Germany.....	29,144	63,867

(a) Not shown in 1914. (b) Not shown in 1917.

it will be seen that demands for practically all lines have expanded since the war started.

AMERICAN PRODUCTS SOLD IN THE DOMINICAN REPUBLIC			
ARTICLES			
	1914	1917	
Blackening, shoe paste, etc.....	\$ 6,270	\$ 10,726	
Candles.....	6,449	66,465	
Celluloid and manufactures.....	5,665	5,803	
Cement, hydraulic.....	77,733	146,129	
Chemicals, drugs, dyes, medicines:			
Acids.....	1,970	15,292	
Calcium carbide.....	22,597	30,996	
Medicines, patent and proprietary.....	80,523	153,134	
Soda salts and preparations of.....	(a)	18,293	
All other.....	51,121	175,506	
Cheewing gum.....	9	7,725	
Explosives:			
Cartridges, loaded.....	59,932	508	
Dynamite.....	12	3,045	
Gunpowder.....	12	216	
All other.....	4,169	4,450	
Flavoring extracts and fruit juices.....	710	9,287	
Glass and glassware.....	14,852	52,019	
Glue.....	310	4,127	
Grease:			
Lubricating.....	7,012	13,788	
Soap stock and other.....	20,669	6,110	
India-rubber manufactures.....	27,131	80,026	
Rosin.....	24,865	54,632	
Leather, patent.....	15,027	14,286	
Lime.....	6,088	6,656	
Matches.....		5,606	
Naval stores:			
All other.....	14,688	18,339	
Oleicloth and linoleum.....	1,974	2,565	
Oleicloth and linoleum.....	4,854	8,178	
Oils:			
Mineral:			
Crude.....		10,705	
Gas and fuel.....	8,442	17,885	
Illuminating.....	105,101	134,646	
Lubricating and heavy paraffin.....	24,865	54,632	
Gasoline.....	25,442	107,256	
All other (including residuum).....		72,858	
Vegetable:			
Corn.....	28,307	113,994	
Cottonseed.....	134,595	151,178	
Lined.....	3,266	16,911	
All other fixed.....	2,445	7,383	
Essential.....	460	2,196	
Paints, pigments, etc.:			
Dry colors.....	3,184	7,128	
Ready-mixed paints.....	14,613	27,833	
White lead.....	1,218	3,609	
All other (including crayon).....	16,937	46,079	
Paper and manufactures.....	54,130	204,262	
Paraffin and wax.....	51	11,391	
Perfumery, cosmetics, etc.....	4,510	22,636	
Photographic goods, sensitized.....	2,197	6,336	
Soap:			
Toilet.....	8,040	30,692	
All other.....	72,735	194,868	
Starch.....	855	3,301	
Sugar, refined.....	56,932	135,607	

(a) Not stated separately in 1914.

The Republic's chief contributions to the United States are now cacao and sugar, as the next table shows. As a source of cacao it is second only to Ecuador. The sudden development of the logwood industry is shown by the jump in exports to the United States from four thousand to two hundred thousand dollars in three years.

DOMINICAN REPUBLIC PRODUCTS SOLD IN THE UNITED STATES			
ARTICLES			
	1914	1917	
Cacao, crude.....	\$3,187,006	\$7,202,747	
Chemicals, drugs, dyes, medicines:			
Glycerin, crude.....		1,883	
All other.....	3,308	42,328	
Copper:			
Matte, regulus, etc.....		32,690	
Dye and clippings.....	1,813	27,799	
Dyewoods, in crude state:			
Logwood.....	4,410	221,718	
All other.....	8,221	4,669	
Coconut meat (copra).....		13,723	
Sugar and molasses:			
Molasses.....	8,590	161,029	
Sugar, cane.....	86,761	5,242,315	
Tanning materials: Mangrove bark.....		13,834	
Wax: Beeswax.....	19,894	142,354	

HAITI

Imports of American goods, according to the American classification, are shown in the next table, by which

Agricultural and forest products comprise Haiti's contribution to international trade. There are said

to be mineral resources, but little is known of them, and there is practically no manufacturing. Coffee is the principal product and was exported to the extent of seventy-nine million pounds in 1914. Other exports are cacao, cotton, logwood, fustic, and other woods, gum guaiacum, honey, orange peels, and hides and skins. Sugar and indigo were once exported in large quantities, but these products are now unimportant. The United States is the principal purchaser of the island's goods and easily the chief source of supply for manufactured goods. The coffee trade suffered by the cutting off of the markets in Germany, Belgium, and Holland, but the increased demand for logwood and other dyewoods has brought prosperity to many of the inhabitants. There are very few white persons in the country.

Haitian statistics are notoriously incomplete and unreliable; in fact, there have been no detailed official trade figures in recent years, and it has consequently been impossible to compile a table that would present the trade in chemicals and allied products as a whole. The table that follows shows the imports from the United States as given in the statistical publications of our own Government, and as the trade is very largely American it gives a fairly definite idea of the importance of the market.

The chief imports are soap and mineral oil, both of which are purchased almost exclusively from the United States. The bulk of the soap is a cheap grade of yellow laundry soap that comes in bars. The importance of this item, as compared with totals for other countries of similar standing, is probably to be accounted for by the fact that even this simple industry is not well developed in the country.

AMERICAN PRODUCTS SOLD IN HAITI

ARTICLES	1914	1917
Blacking, shoe paste, etc.	\$ 7,484	\$ 12,097
Candles	4,861	4,914
Cellulose and manufactures	85	3,170
Cement, hydraulic	25,574	63,185
Chemicals, drugs, dyes, medicines:		
Medicines, patent or proprietary	7,863	16,534
All other	22,823	53,252
Glass and glassware	9,019	17,805
India-rubber manufactures	8,525	10,654
Leather, patent	7,492	18,445
Matches	5,277	5,627
Naval stores	2,702	13,078
Nickel, nickel oxide, and matte		3,038
Oilcloth and linoleum	6,544	6,156
Oils:		
Mineral:		
Gasoline	1,358	3,415
Illuminating	112,307	82,338
Lubricating, etc.	6,305	6,799
All other	0	2,010
Vegetable:		
Corn		5,623
Cottonseed	13,298	28,895
Linsed	218	11,675
All other fixed	5	3,672
Essential	95	558
Paints, pigments, etc.:		
Dry colors	1,715	3,860
Ready-mixed paints	5,545	13,799
All others (including crayons)	8,860	19,624
Paper and manufactures	17,347	44,011
Perfumery, cosmetics, etc.	1,271	10,658
Soap:		
Toilet	1,519	27,901
All other	455,524	420,732
Sugar, refined	40,342	38,609

Logwood is the only material of interest to the chemical industry that is imported into this country from Haiti in large quantities, as the following table shows.

HAITIAN PRODUCTS SOLD IN THE UNITED STATES

ARTICLES	1914	1917
Cacao, crude	\$218,947	\$ 384,739
Chemicals, drugs, dyes, medicines:		
Gums	416	2,200
All other		90,363
Copper, brass, and clippings	491	8,085
Dyewoods, in crude state:		
Logwood	95,609	1,800,397
All other	687	1,476
Fertilizers:		
Guano		
All other		2,166
India rubber:		
Balata		1,546
All other		37
Oils, vegetable:		
Cottonseed		15,261
All other		1,244
Seeds, castor		2,993
Sugar, cane		144,600
Wax:		
Beeswax	17,287	16,365
Vegetable		167

BRITISH WEST INDIES—BARBADOS

Cane is practically the only source of wealth in Barbados, and from this crop are obtained the sugar, molasses, rum, and alcohol that make up the rather important trade with Canada. There are deposits of manjack, an almost pure bitumen that is shipped to some extent to the United States for use in manufacturing a good grade of black insulating varnish. The total population is less than two hundred thousand, the great majority of whom are colored. The only imports of chemicals and allied products totaling more than one hundred thousand dollars are fertilizers and soap, Canada and England furnishing most of the former and England the bulk of the latter, as the following table shows:

IMPORTS OF CHEMICALS AND ALLIED PRODUCTS INTO BARBADOS

ARTICLES	1912
CHEMICALS AND DRUGS	\$ 61,104
United Kingdom	30,824
United States	20,283
SULFATE OF AMMONIA	252,591
Canada	199,653
OTHER FERTILIZERS	244,590
United Kingdom	108,421
Chile	3,528
United States	92,590
SOAP	89,247
United Kingdom	14,419
United States	4,346
PAINTS AND VARNISHES	27,661
United Kingdom	21,632
United States	2,326
OILS, EDIBLE	17,631
United States	11,008
KEROSENE	51,926
United States	51,877
OILS, OTHER	46,577
United States	21,456
PAPER AND STATIONERY	52,398
Germany	6,341
United Kingdom	20,795
United States	12,862
EARTHENWARE AND GLASSWARE	32,469
Germany	2,686
United Kingdom	26,118

Details of the imports from the United States are shown in the next table, for the fiscal years 1914 and 1917:

AMERICAN PRODUCTS SOLD IN BARBADOS

ARTICLES	1914	1917
Cement, hydraulic	\$ 940	\$ 1,973
Chemicals, drugs, dyes, medicines:		
Medicines, patent or proprietary	10,770	14,359
Soda salts and preparations	12,985	24,051
All other	2,246	5,750
Glass and glassware	6,524	22,323
India-rubber manufactures		
Oils:		
Mineral:		
Gasoline	13,089	12,741
Illuminating	41,838	60,847
Lubricating	5,632	10,595
All other		1,421
Vegetable:		
Corn	1,267	30,409
Cottonseed	6,376	10,506
Linsed	79	2,532
All other	115	523
Paints, pigments, etc.	3,049	10,072
Paper and manufactures	9,526	40,224
Perfumery, cosmetics, etc.	6,575	8,632
Soap (except toilet)	78	5,460
Sugar, refined	8,948	15,565

(a) Not shown in 1914.

Imports of sugar from Barbados have increased as a result of the war, but the total is not impressive. The "Asphaltum and bitumen," as given in the official statistics, is probably all manjack. The following table is for fiscal years:

PRODUCTS OF BARBADOS SOLD IN THE UNITED STATES			
ARTICLES			
	1914	1917	
Asphaltum and bitumen.....	\$ 3,241	\$ 3,385	
Copper, old, and clippings.....		7,115	
Oils:			
Fish and other animal.....		269	
Sugar and molasses:			
Molasses.....	178,553	254,903	
Sugar, cane.....	15	290,750	

BRITISH WEST INDIES—JAMAICA

Bananas overshadow all other products as a source of wealth in Jamaica in normal times. The disastrous hurricane in 1915 gave the industry a severe setback. Normal exports of bananas approximate seven million dollars. No other article was exported in excess of a million dollars in 1914, but the following were shipped in excess of half a million: sugar, logwood extract, coffee, cacao, coconuts, and logwood. Other and characteristic products are rum, ginger, and annatto. The mineral and forest resources have not been much developed and there is no manufacturing to speak of. The United States takes about half the exports and furnishes about half the imports, England, the mother country, being second in importance in both respects. Of the total population of more than 800,000, only about 16,000 are white.

There is naturally only a very limited market for chemicals and allied products. The next table shows that the principal import, soap, comes almost exclusively from England. The United States has an equal or better share in the other lines.

JAMAICA IMPORTS OF CHEMICALS AND ALLIED PRODUCTS			
ARTICLES			
	1912	1914(a)	
CHEMICALS.....	\$ 41,511	.....
United Kingdom.....	22,882	.....
United States.....	17,339	.....
DRUGS AND MEDICINES.....	183,983	\$153,961	
United Kingdom.....	81,324	.....
United States.....	90,468	.....
OILS, MINERAL.....	38,518	.....
Naphtha and gasoline.....	38,294	.....
United States.....	179,087	232,891	
Petroleum.....	175,836	.....
United States.....	108,611	74,920	
OILS, VEGETABLE.....	70,744	.....
Cottonseed oil (U. S.).....	47,507	.....
PAINTERS' COLORS AND MATERIALS.....	20,904	.....
United Kingdom.....	62,048	.....
United States.....	6,555	.....
PERFUMERY.....	22,318	.....
Germany.....	30,873	.....
United Kingdom.....	19,957	.....
United States.....	205,142	168,673	
SOAP, COMMON.....	203,780	.....
United Kingdom.....	20,084	.....
United States.....	39,604	.....
SOAP, FANCY.....	4,745	.....
PAPER, PRINTING.....	34,859	.....
United Kingdom.....	82,575	.....
United States.....	19,597	.....
PAPER, OTHER; MANUFACTURES OF.....	124,159	.....
United States.....	37,662	.....
GLASS AND GLASSWARE.....	20,084	.....
Germany.....	12,809	.....
United Kingdom.....	27,754	.....
United States.....	24,196	.....

(a) Statistics available for only a few classes.

More details of the trade in American goods are shown in the table that follows, which is a compilation from our own statistics for the fiscal years 1914 and 1917.

AMERICAN PRODUCTS SOLD IN JAMAICA			
ARTICLES			
	1914	1917	
Blacking, shoe paste, etc.....	\$ 3,788	\$ 7,071	
Celloloid and manufactures.....	26	2,124	
Cement, hydraulic.....	25,400	60,766	
Chemicals, drugs, dyes, medicines:			
Aceticum.....	3,022	4,698	
Calcium carbide.....	2,448	3,543	
Medicines, patent or proprietary.....	48,485	52,191	
Petroleum jelly.....	7,761	9,240	
Soda salts and preparations.....	(a)	24,300	
All other.....	36,709	90,635	
Explosives:			
Cartridges, loaded.....	2,726	3,265	
Dynamite.....	1,046	3,855	
All other.....	1,369	5,168	
Fertilizers.....	1,281	13,894	
Flavoring extracts and fruit juices.....	1,392	5,105	
Glass and glassware.....	15,922	40,810	
Grease:			
Lubricating.....	4,920	10,894	
All other.....	375	951	
India-rubber manufactures.....	71,882	135,076	
Ink.....	2,032	3,628	
Linseed.....	333	5,986	
Naval stores.....	3,761	5,409	
Oilcloth and linoleum.....	3,731	5,365	
Oils:			
Mineral:			
Gasoline.....	45,222	105,768	
Illuminating.....	196,765	139,011	
Lubricating.....	13,409	43,362	
Vegetable:			
Corn.....	.....	120,137	
Cottonseed.....	162,232	73,625	
Linsed.....	333	5,986	
All other.....	696	27,348	
Paints, pigments, etc.:			
Ready-mixed.....	6,728	8,763	
White lead.....	19	3,093	
All other (including crayons).....	10,046	30,615	
Paper and manufactures.....	89,162	185,713	
Perfumery and cosmetics.....	16,807	26,851	
Photographic goods:			
Motion-picture films.....	7,223	22,210	
Other sensitized goods.....	3,326	7,291	
Salt.....	.....	3,157	
Soap:			
Toilet.....	14,784	17,387	
All other.....	1,454	13,092	
Sugar and molasses:			
Molasses.....	51	4,793	
Sugar, refined.....	25,970	46,305	

(a) Not shown in 1914.

Logwood is now an important import from Jamaica, but it is the only one. The imports of essential oil are interesting, but the official statistics do not throw any light on the kind or kinds included in this total. There is a small plant or two for making oil from orange peels.

JAMAICA PRODUCTS SOLD IN THE UNITED STATES			
ARTICLES			
	1914	1917	
Cacao, crude.....	\$102,660	\$ 322,997	
Chemicals.....	54,879	116,982	
Coconut meat (copra).....	12	65,423	
Dyewoods, in crude state:			
Logwood.....	269,272	1,118,334	
All other.....	29,920	18,210	
India-rubber scrap.....	703	2,044	
Oil, Essential.....	54,501	147,690	
Sugar, cane.....	17	197,373	
Tanning materials: Mangrove bark.....	15	26,339	
Wax: Beeswax.....	.....	763	

BRITISH WEST INDIES—TRINIDAD AND TOBAGO

Statistics of trade and production always lump the returns from Trinidad and Tobago, the latter island being of comparatively little importance. The population of Tobago is only about twenty thousand as compared with the three hundred and fifty thousand of Trinidad. Negroes and East Indians predominate.

The principal products are sugar, cacao, petroleum, asphalt, coconuts, and mangrove bark. Manjack is mined to some extent. The sugar production in 1915 amounted to more than five million dollars, all of which went to England. Cacao is a very important product, more than six million dollars worth being sold to the United States, the principal customer, in 1917. The product of the famous asphalt lake is well known

in the United States, as most of the output comes to this country. The petroleum fields are also a prime source of wealth.

In spite of the comparative wealth of the islands, however, there is not much of a market for chemicals or allied products, as the first table following shows, although later figures, if available, would probably show an increase in this respect. Soap, the most important item, is imported chiefly from England.

IMPORTS OF CHEMICALS AND ALLIED PRODUCTS INTO TRINIDAD AND TOBAGO

ARTICLES	1912
MEDICINES (Non-Alcoholic).....	\$ 72,925
United Kingdom.....	33,155
United States.....	26,279
OPIUM AND GANJA.....	25,861
British West Indies.....	12,677
FERTILIZERS.....	92,113
United Kingdom.....	67,070
United States.....	9,855
SOAP.....	194,251
United Kingdom.....	172,985
United States.....	8,258
CANDLES.....	39,360
United Kingdom.....	26,581
United States.....	3,494
PAINTS AND PAINTERS' COLORS.....	41,998
United Kingdom.....	29,895
United States.....	4,550
PETROLEUM.....	119,249
United States.....	119,220
OLIVE AND OTHER EDIBLE OILS.....	74,229
France.....	4,185
United States.....	13,203
PAPER AND STATIONERY.....	125,809
Germany.....	6,502
United Kingdom.....	2,167
United States.....	17,553
GLASSWARE.....	49,453
Germany.....	13,183
United Kingdom.....	23,381
United States.....	12,629

In the next table, which shows imports from the United States, it will be seen that there has been an increased demand for chemicals from this country since the war started, but the total is relatively insignificant.

AMERICAN PRODUCTS SOLD IN TRINIDAD AND TOBAGO

ARTICLES	1914	1917
Blacking, shoe paste, etc.....	\$ 2,173	\$ 3,841
Candles.....	7,254	14,530
Cement, hydraulic.....	19,543	80,373
Chemicals, drugs, dyes, medicines:		
Acids.....		
Sulfuric.....	23	8,432
All other.....	403	5,185
Calcium carbide.....	480	5,378
Medicines, patent or proprietary.....	30,841	34,755
Petroleum jelly.....	1,338	3,008
Soda salts, and preparations of.....	(a)	23,923
All other.....	23,131	107,184
Explosives.....		
Cartridges, loaded.....	2,961	6,571
All other.....	2,038	2,604
Glass and glassware.....	6,396	44,043
Grease.....	2,964	8,710
India-rubber manufactures.....	32,455	82,039
Naval stores.....	4,634	7,352
Oilcloth and linoleum.....	5,111	6,548
Oils.....		
Mineral.....		
Illuminating.....	116,816	132,759
Lubricating, etc.....	17,759	46,125
Naphthalene.....		
Gasoline.....	21,673	4,420
All other.....	66	
Vegetable.....		
Corn.....	7,777	18,236
Cottonseed.....	331	25,475
Linsed.....	1,187	3,688
All other.....	1,187	2,743
Paints, pigments, etc.....		
Ready-mixed paints.....	2,789	5,560
Varnish.....	1,900	4,398
All other (including crayons).....	4,572	10,067
Paper and manufactures.....	28,405	112,060
Perfumes and cosmetics.....	9,629	19,438
Photographic goods: Motion-picture films.....	223	6,225
Soap.....		
Toilet.....	4,847	9,346
All other.....	544	23,175
Sugar, refined.....	7,942	37,664

(a) Not stated separately in 1914.

The next table shows that our purchases of asphalt from Trinidad, although looming large in the popular

imagination, are a very poor second to our takings of cacao, which are really of prime importance. The item "Chemicals, etc." is large enough to be interesting, but it is not to be accounted for by a study of the products of the islands, and probably gets its importance from the fact that some products of the mainland are shipped by way of Port of Spain, Trinidad. Tonka beans, which are included under chemicals in American statistics, have been imported from Venezuela for many years, cured, and then reshipped.

TRINIDAD AND TOBAGO PRODUCTS SOLD IN THE UNITED STATES

ARTICLES	1914	1917
Asphaltum and bitumen.....	\$ 433,208	\$ 565,960
Cacao, crude.....	4,891,574	6,311,496
Cherubs, etc.....	635,290	188,722
Copper ore.....		5,955
Coconut meat (copra).....	493	165,051
Glass and glassware.....	4,225	950
India rubber:		
Latex.....	24,555	2,318
India rubber.....		1,258
Scrap.....		407
Oil: Crude mineral.....	297,603	146,429
Sugar, cane.....	36	210,653
Tanning materials: Mangrove bark.....		226

DUTCH WEST INDIES

The Dutch West Indies consist of the island of Curacao and five smaller islands, the total population of which is not more than sixty thousand, mostly colored. There are no products of great importance, although the exports of straw hats to the United States have reached as high as one hundred and fifty thousand dollars. There is small exportation of aloes for chemical use, divi-divi, and gold.

The very limited importation of chemicals and allied products is shown in the following table for 1913, the latest year for which statistics are available:

IMPORTS OF CHEMICALS AND ALLIED PRODUCTS INTO THE DUTCH WEST INDIES

ARTICLES	THE NETHERLANDS	IMPORTS FROM OTHER COUNTRIES
CHEMICALS AND DRUGS.....	\$1,214	\$13,162
COLORS AND DYES.....	3,312	7,815
PERFUMERY.....	787	17,741
SOAP.....	380	13,855
STEARIN CANDLES.....	4,030	4,204
OTHER CANDLES.....		790
OILS.....		
Gasoline.....		8,938
Petroleum.....		19,968
Linsed.....	2,842	3,963
Other sorts.....	1,118	11,206
MATCHES.....		2,171
GLASS AND GLASSWARE.....		4,260

The next table shows that there has been an increase in the imports from the United States since the war started:

AMERICAN PRODUCTS SOLD IN THE DUTCH WEST INDIES

ARTICLES	1914	1917
Cement, hydraulic.....	\$ 4,704	\$46,337
Chemicals, drugs, dyes, medicines:		
Medicines, patent or proprietary.....	4,562	4,561
All other.....	6,074	15,389
Explosives.....	1,128	7,205
Glass and glassware.....	2,366	14,062
India-rubber manufactures.....	2,070	13,283
Naval stores.....	958	2,563
Oils.....		
Mineral.....		
Illuminating.....	20,650	28,946
Lubricating.....	1,649	4,122
Gasoline.....	12,094	57,525
Vegetable.....		
Corn.....	2,140	7,139
Cottonseed.....	3,228	6,815
Linsed.....	273	5,357
All other.....	637	1,827
Paints, pigments, etc.....	2,723	7,829
Paper and manufactures.....	3,057	14,120
Perfumes, cosmetics, etc.....	1,557	4,872
Soap.....		
Toilet.....	3,252	4,858
All other.....	905	10,937
Sugar, refined.....	3,377	16,841

The table that follows shows the character of materials imported into this country from the colony. It is an interesting fact that the liqueur called "Curacao" is really manufactured in Holland, although the orange peel that gives it its peculiar flavor is supplied only from Curacao.

DUTCH WEST INDIES PRODUCTS SOLD IN THE UNITED STATES		
ARTICLES	1914	1917
Cacao, crude.....	...	\$ 15,449
Chemicals, drugs, dyes, medicines:		
Gums.....	\$56,051	87,498
All other.....	102,897	
Copper, old, and clippings.....	246	2,904
Dyewoods in a crude state:		
Logwood.....	...	...
All other.....	12,515	5,002
Fertilizers.....	6,683	9,414
Salt.....	12,287	8,854
Sugar, cane.....	...	4,300
Tanning materials: Mangrove bark.....	...	6,256

FRENCH WEST INDIES

These French possessions consist of Guadeloupe, with a number of much smaller islands, and Martinique.

The total population of Guadeloupe is not more than thirty-five thousand, and sugar and rum are the only products normally exported to the value of more than a million dollars. Imports of chemicals are not important. In the following table the items "chemicals" and "cottonseed oil" are the only ones exceeding a hundred thousand dollars in value, the former probably including fertilizers, which are used to some extent in the cane fields. These are the latest official figures from the authorities of the islands:

IMPORTS OF CHEMICALS AND ALLIED PRODUCTS INTO GUADELOUPE AND DEPENDENCIES		
ARTICLES	1913	1914
CHEMICALS.....	\$142,714	\$203,605
United States.....	688	549
DYES, PREPARED.....	988	130
EXPLOSIVES.....	1,661	1,404
MEDICINES, PREPARED.....	10,607	30,448
United States.....	623	20
ROOTS, HERBS, SEEDS.....	1,107	224
PAINTS, COLORS, VARNISHES.....	12,344	9,232
United States.....	615	429
PERFUMERY.....	5,635	22,681
SOAP, COMMON.....	35,891	36,163
CANDLES.....	27,353	30,602
OLS, MINERAL.....	42,437	52,218
United States.....	38,679	51,455
OLS, VEGETABLE:		
Cottonseed oil.....	140,132	132,821
United States.....	140,132	132,821
Other oils.....	35,364	58,023
PAPER, CARDBOARD, AND MANUFACTURES OF.....	23,300	26,327
United States.....	296	483
GLASS AND GLASSWARE.....	20,892	15,555
United States.....	893	318

The population of Martinique is nearly two hundred thousand, of which comparatively few, however, are whites. The cane products, sugar and rum, are of considerable importance, the exports of the former amounting to four and a half million in 1915 and of the latter, three million. Cacao is exported to the extent of about a quarter of a million annually. War prices have brought prosperity to the island.

"Chemicals" and cottonseed oil are the principal exports that can be considered in this article. "Chemicals" undoubtedly include the important imports of fertilizers, which comprise ammonium sulfate, potash, superphosphate, and guano. Ordinarily France

furnishes somewhat more than half the total imports, with the United States second, but this condition has been reversed since the war started. The following table contains such details as are available for 1913 and 1914:

IMPORTS OF CHEMICALS AND ALLIED PRODUCTS INTO MARTINIQUE		
ARTICLES	1913	1914
CHEMICALS.....	\$424,377	\$467,639
United States.....	83,897	30,126
DYES, PREPARED.....	162	183
EXPLOSIVES.....	1,520	2,027
MEDICINES, PREPARED.....	18,790	12,906
United States.....	60	93
ROOTS, HERBS, SEEDS.....	1,311	1,082
PAINTS, COLORS, VARNISHES.....	14,798	12,123
United States.....	319	452
PERFUMERY.....	8,069	7,204
SOAP, COMMON.....	30,187	32,508
CANDLES.....	21,424	13,279
OLS, MINERAL.....	50,373	45,489
United States.....	45,371	40,055
OLS, VEGETABLE:		
Cottonseed oil.....	132,449	163,926
United States.....	131,486	163,926
Other oils.....	24,630	29,284
PAPER, CARDBOARD, AND MANUFACTURES OF.....	26,492	29,685
United States.....	51	574
GLASS AND GLASSWARE.....	19,830	16,137
United States.....	506	869

In the American statistics the French possessions in the West Indies are grouped together, and the next table shows the imports of American chemicals and allied products into Guadeloupe and dependent islands, and Martinique. The most important items are cottonseed and corn oil, "All other chemicals," and fertilizers. It will be seen that the American share of the fertilizer trade is increasing.

AMERICAN PRODUCTS SOLD IN THE FRENCH WEST INDIES		
ARTICLES	1914	1917
Candles.....	\$ 173	\$ 8,520
Cement, hydraulic.....	7,167	31,140
Chemicals:		
Acids:		
Sulfuric.....	6,400	2,000
Other.....	...	378
Medicines, patent or proprietary.....	731	1,215
Soda salts, and preparations of.....	(c)	8,168
All other.....	4,429	11,678
Explosives.....	828	104
Fertilizers (except phosphate rock).....	26,683	92,376
Glass and glassware.....	1,091	11,304
Glucose.....	8	4,876
Grease.....	785	4,409
India-rubber manufactures.....	2,334	27,976
Matches.....	...	12,095
Naphthalene.....	...	2,592
Oilcloth and linoleum.....	382	4,260
Oils:		
Mineral:		
Gas and fuel.....	436	5,048
Gasoline.....	7,433	61,695
Illuminating.....	51,827	71,903
Lubricating.....	5,865	20,652
Vegetable:		
Corn.....	5,526	121,875
Cottonseed.....	266,887	374,382
Linsced.....	52	11,332
Other fixed.....	126	3,031
Paints, pigments, etc.:		
White lead.....	...	4,485
All other (including crayons).....	1,461	13,088
Paper.....	773	14,674
Soap (except toilet).....	263	49,333
Sugar and molasses.....	505	28,870

(c) Not shown in 1914.

Of the imports from the islands, vanilla beans alone are of sufficient importance to merit attention, as the following table, for fiscal years, shows:

FRENCH WEST INDIAN PRODUCTS SOLD IN THE UNITED STATES		
ARTICLES	1914	1917
Chemicals, drugs, dyes, medicines:		
Vanilla beans.....	\$42,346	\$76,338
All other.....	2,332	1,294
Oils, essential.....	2,823	6,090

ORIGINAL PAPERS

EFFECT OF PHOSPHINE AND HYDROGEN SULFIDE ON THE OXIDATION OF AMMONIA TO NITRIC ACID¹

By GUY B. TAYLOR AND JULIAN H. CAPPS

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In a recently published paper² it has been shown that acetylene gas derived from commercial carbide has a marked deleterious effect on the oxidation of ammonia to nitric acid by catalytic platinum. Further experiments have shown that this effect is to be ascribed to impurities in the acetylene rather than to acetylene gas itself. Lunge and Keane³ state that the common impurities present in acetylene are hydrogen sulfide, phosphine, ammonia, carbon monoxide, hydrogen, methane, nitrogen, and oxygen. Silicon hydride may also be present in minute quantity. Captain G. A. Perley and Mr. J. D. Davis, of this Bureau, from experiment and observation on commercial ammonia converters oxidizing cyanamide ammonia, strongly suspected phosphine as the active poisoning agent. As a result, the present investigation was undertaken to secure data on the effects of phosphine and of hydrogen sulfide.

The apparatus and experimental methods have been previously described.⁴ Thoroughly activated, pure platinum gauzes were used, 0.0026 in. diameter wire, 80 wires to linear inch.

PURIFIED ACETYLENE

To free acetylene from impurities the gas was passed through a train of wash bottles containing solutions as follows: Copper sulfate, acid cuprous chloride, 50 per cent nitric acid, alkaline sodium hypochlorite, and sodium hydroxide. The purified gas was collected in a large bottle and allowed to stand over night in contact with sodium hypochlorite solution. Thiosulfate was added to take care of any free chlorine that might have been evolved, and copper sulfate to precipitate hydrogen sulfide derived therefrom. This purified acetylene was used in a short run of about 2 hrs., during which the concentration in the ammonia-air mixture was gradually raised to about 0.4 per cent. There was no noticeable effect on the gauze except a rise in the temperature, and the yields were quite satisfactory. Examination of the gauze after the run showed it had suffered no change and had the characteristic gray appearance of an active gauze.

PHOSPHINE

Phosphine was prepared by heating yellow phosphorus with sodium hydroxide solution. The gas was collected in bottles in which it was treated with hydrochloric acid to free it from the self-inflammable variety. The acid was then neutralized with strong alkali.

In the preliminary experiments a gas was used containing 23 per cent PH_3 as determined by absorption

in a solution of copper sulfate. The rest was presumably hydrogen. This was fed into the ammonia-air mixture at a rate of about 10 cc. a minute for 2 min., corresponding to about 25 parts PH_3 per million. The electrically heated gauze blackened immediately. After shutting off the phosphine the gauze cleared in 5 min. The rate was then varied and it was found that 10 parts per million was sufficient to cause black areas to appear on the gauze. A total of 590 cc. of the phosphine-hydrogen mixture was fed into the system, reaching a final concentration of 0.07 per cent in the gases passing to the oxidizer. The gauze was black nearly all over most of the time. Examination of the gauze after the run showed in a pronounced way the same appearance as the gauze that had been run with impure acetylene. It was brittle and pulled apart even though carefully handled.

Quantitative experiments were then undertaken, using another gauze from the same sheet, in order to determine the limit concentration of phosphine allowable.

Phosphine, PH_3 , prepared as above, was diluted with air in a small metal gas holder which was water-sealed. This gas mixture was led into the ammonia-air feed line through 6 ft. of brass tubing, which formed the delivery pipe of the gas holder, at rates which should have added phosphine in amounts between 0.4 and 4 parts per million of the gas entering the oxidizer. The efficiency of oxidation was not modified by this to the extent that the preliminary tests had indicated.

On examination, however, it was found that the phosphine in the gas holder decreased rapidly on standing over water. Furthermore at the conclusion of the tests, the brass delivery tube of the gas holder was corroded and it seemed certain that a further portion of the phosphine was destroyed in passing through it. On account of these known sources of error, the rather inconsistent results of these tests were discarded.

The phosphine mixtures always contained hydrogen. While it did not appear probable that hydrogen could have any deleterious effect, preliminary of the above tests, electrolytic gas from electrolysis to sodium hydroxide solution was introduced and found to be without effect up to one-tenth per cent hydrogen in the ammonia-air feed.

At about this time actual trials with added phosphine made by Lieut. Brush at Captain Perley's direction, showed that even two or three parts of phosphine per hundred million of mixed gases were serious in plant operation.

Therefore, a second series of tests was made using special precautions to insure the phosphine added actually reaching the gauze. The metal gas holder was varnished inside, a glass delivery tube arranged, and the phosphine-air mixture confined with an oil seal. The gas came in contact with no metal or water and did not vary in phosphine concentration from day to day. About 200 cc. of 20 per cent PH_3 was diluted in the gas holder to about

¹ Published by permission of Director, U. S. Bureau of Mines.² THIS JOURNAL, 10 (1918), 547.³ "Technical Methods of Chemical Analysis," [I], 2, 587.⁴ Taylor and Capps, *Loc. cit.*

60 liters. This was diluted twice during the tests with an equal volume of air.

TABLE I—EFFECT OF PHOSPHINE

Tsqr No.	Date	Time	Cu. ft.		PH ₃ -air mixture		Composition of NH ₃ -air mixture		Yield HNO ₃ per cent
			per hr.	min.	per cent	per cent	P. p. m. per cent		
...	July 16	10:55	170	0	..	..	0	..
458	July 16	11:25	170	0	..	9.74	0	91.5	
...	July 16	11:30	170	55	0.05	..	0.3	..	
459	July 16	11:35	180	60	0.05	9.80	0.3	9.5	
...	July 16	11:47	180	0	..	..	0	..
460	July 16	12:45	180	0	..	9.22	0	92.4	
...	July 16	1:47	180	25	0.05	..	0.14	..	
461	July 16	1:05	170	25	0.05	9.22	0.14	53.0	
...	July 17	12:50	170	0	..	..	..	..
...	July 17	1:00	170	25	0.024	..	..	..
462	July 17	1:30	170	25	0.024	10.5	0.07	71.0	
...	July 17	1:35	170	12	0.024	..	0.03	..	
463	July 17	2:10	180	12	0.024	10.15	0.03	87.5	
464	July 17	3:00	185	12	0.024	9.73	0.03	85.8	
465	July 17	3:35	165	12	0.024	9.80	0.03	85.2	
...	July 18	2:00	185	..	..	..	..	..
...	July 18	2:08	185	25	0.024	..	0.06	..	
466	July 18	2:35	185	25	0.024	10.25	0.06	74.5	
...	July 18	2:40	180	12	0.024	..	0.03	..	
467	July 18	3:15	200	12	0.024	9.85	0.03	86.5	
468	July 18	3:35	165	12	0.024	9.95	0.03	86.2	
...	July 19	9:45	165	0	..	..	..	..
469	July 19	10:20	165	0	..	10.3	..	89.5	
...	July 19	10:25	165	25	0.013	..	0.035	..	
470	July 19	11:08	165	29	0.013	9.80	0.04	80.3	
...	July 19	11:10	165	50	0.013	..	0.07	..	
471	July 19	11:45	170	50	0.013	9.30	0.07	76.5	

The gas in the holder was analyzed every day in duplicate by oxidation of 2 liter samples with sodium hypochlorite. The hypochlorite solution was strongly acidified with nitric acid and boiled down to a small volume to eliminate chlorine. The phosphate was then precipitated with ammonium molybdate and determined volumetrically with $N/20$ NaOH, taking all the usual precautions in this well-known procedure. The alkali was standardized against a known phosphate solution. We feel confident that the calculated phosphine concentrations given in parts per million in Table I were actually present in the ammonia-air mixture to ± 10 per cent.

The rate of flow of the ammonia-air mixture was about 90 liters a minute. The phosphine-air mixture, less than 0.1 per cent PH_3 , was fed in at rates from 0 to 60 cc. a minute.

During these tests the electric current of 115 to 140 amperes was never cut off, even momentarily, while phosphine was being admitted.

In connection with these tests, an attempt was made to determine the phosphine concentration in the ammonia-air mixture directly by application of the nephelometric reagent of Kober and Egerer,¹ molybdate strychnine solution, for phosphates. By oxidation of a 2-liter sample with hypochlorite we were able to detect 1 part in a million where silver nitrate test paper showed nothing. Quantitative results could hardly be expected.

Fair results were obtained nephelometrically² in the analysis of acetylene and gas containing above 0.02 per cent PH_3 .

The results presented in Table I show that 2 or 3 parts phosphine in a hundred million undoubtedly reduce the yield. The results are consistent throughout. The gauze, which had been used in previous

tests, was undoubtedly not in the best of condition, as shown by efficiencies taken when no phosphine was present. This points to cumulative poisoning of the platinum.

Several nephelometric analyses of the acetylene gas generated from the same lot of carbide used in our experiments with this gas, showed 0.02–0.03 per cent PH_3 . These analyses were confirmed by passing 23 liters of acetylene through sodium hypochlorite solution in a Friedrich spiral wash bottle in 16 hrs. The phosphate was determined gravimetrically and calculated 0.0226 per cent PH_3 . Assuming a value of 0.02 per cent PH_3 in the acetylene used in the earlier experiments where 0.02 per cent acetylene in the ammonia-air mixture caused a drop of 2 or 3 per cent in the yield and 0.1 per cent a drop of 25 or 30 per cent, corresponding to 4 and 20 parts PH_3 per hundred million, respectively, the results with acetylene are accounted for on the basis of phosphine alone.

HYDROGEN SULFIDE

Hydrogen sulfide generated in a Kipp from ferrous sulfide and dilute sulfuric acid was measured into the feed line through a water wash bottle and the flowmeter. The results are given in Table II and show that H_2S has no deleterious effect in concentrations approaching 0.1 per cent. Tests were made on the same gauze used with phosphine.

TABLE II—EFFECT OF HYDROGEN SULFIDE ON AMMONIA OXIDATION

Test No.	Time	Date	Cu. ft. air mixture		Intake NH ₃ per cent	Gas H ₂ S per cent	Yield HNO ₃ per cent
			per hr.	Amperes			
...	1:30	June 20	165	130	..	0	..
447	1:46	June 20	165	130	10.12	0	91.5
...	1:48	June 20	160	130	..	0.02	..
448	2:00	June 20	160	130	10.07	0.02	93.0(a)
...	2:02	June 20	160	130	..	0.04	..
449	2:33	June 20	155	140	9.66	0.04	94.3(a)
...	2:35	June 20	160	130	..	0.07	..
450	2:47	June 20	160	130	9.62	0.07	95.0(a)

(a) Not corrected for H_2SO_4 formed.

SUMMARY

I—Pure acetylene has no effect on the catalytic action of platinum in oxidizing ammonia to nitric acid.

II—Hydrogen sulfide in small concentrations has no immediate toxic effect.

III—Phosphine to the extent of 2 or 3 parts per hundred million in the ammonia-air mixture affects the yield several per cent; 20 to 30 parts are ruinous.

IV—It has been shown that phosphine is a sufficiently active poison to account for previous results obtained with crude acetylene. It seems certain that the difficulty of oxidizing cyanamide ammonia with high efficiency is due to its phosphine content.

V—It seems probable that phosphine has to some extent a cumulative action, since the platinum appears to become less efficient with use.

ACKNOWLEDGMENT

The work described in this report was done under the general direction of the chief chemist of the Bureau of Mines, Dr. Chas. L. Parsons.

BUREAU OF MINES
WASHINGTON, D. C.

¹ J. Am. Chem. Soc., 37 (1915), 2373.

² The nephelometer was on the Richards principle adapted to a Duboscq colorimeter. This instrument was kindly placed at our disposal by Dr. W. M. Clark of the Department of Agriculture.

SOME NOTES ON ACETYSALICYLIC ACID

By HENRY L. DAHM

Received May 27, 1918

Recent publications¹ have brought to light the difficulty of obtaining true accurate melting points of bodies which decompose during the progress of the test, particularly in the case of acetylsalicylic acid.

The following modification of the method described in the *U. S. P.* has been used for the past year in this laboratory and gives consistent checking results by different operators.

A sketch illustrates the apparatus used. It consists of a 250 cc. CO₂ flask filled with paraffin oil, stirred by a small propeller, connected to a Rabe water turbine or a small electric motor. A standardized thermometer provided with an air jacket for protection against air current, graduated in 0.2° C. and calibrated for a 3-in. immersion, is adjusted permanently in the oil bath with a 3-in. immersion when the temperature is 130° C. The melting-point tube is carried on a separate movable rod which easily slides into position at the proper time. The melting-

point tube only is immersed in the oil, being drawn rather long for this purpose, the rod serving only as support, with 2 small rubber bands to hold the tube. The temperature is increased at the uniform rate of 1° per min. with constant stirring until the temperature has reached 130° C. when the melting-point tube is immersed in the oil.² With this method, samples of American- and foreign-manufactured aspirin were found to melt within the range of 133° to 135° C. (corrected).

Due to the rapid decomposition of acetylsalicylic acid on heating and lack of consistent results when lower temperatures were used, 130° C. was fixed as the proper point of immersion. Emery and Wright found a depression in the melting point of the pure substance of about 1° for every 5 min. heating just

below its melting temperature, so that heating at the rate of 1° per min. and starting, for instance, from 120° C. would mean a depression of about 2° in the true melting point.

An increase in the rate of heating is also not advisable, due to difficulty of control and possibility of overheating, especially with a thermometer having a considerable time lag. It is advisable to use a thermometer fixed permanently in the bath, as the introduction of a cold thermometer carrying the sample would tend to give low results, due to cooling effects. The thermometer used for this work is graduated from 74° to 150° C. in 0.2° intervals, is 15 in. long (Taylor Instrument Company, No. 1457 Precision Grade), and has a small expansion bulb which makes it impractical to immerse it with the sample and obtain rapid readings. But they are more accurate and sensitive than a longer thermometer with a wider range, large mercury bulb and no expansion bulb, as the stem correction will be less and barely noticeable. It is important that the propeller used have sufficient surface to thoroughly agitate the oil.

A set of color standards for determining the approximate amounts of free salicylic acid in aspirin were found quite useful in comparing the quality of various samples. The standards are very stable and when once adjusted can be relied upon for a long time. They were prepared as follows:

A 10 per cent solution of hydrated cobalt chloride was prepared by dissolving 10.000 g. CoCl₂ + 2H₂O in 50 cc. water + 5 cc. 10 per cent HCl and diluting carefully to 100 cc. in a calibrated flask. By using various dilutions, as outlined below, standards were prepared. The standards are preserved in small, square or round, glass-stoppered bottles of uniform size and holding about 25 cc. of liquid.

STANDARD SOLUTION	WATER	COCl ₂ + 2H ₂ O	COLOR	SALICYLIC ACID
Cc.	Cc.	Per cent	No.	IN EQUAL VOLS.
5.0	395	0.125	0	Gram
10.0	390	0.25	1	0.00005
10.0	390	0.50	2	0.0001
10.0	90	1.00	3	0.00025
10.0	75	1.50	4	0.0003
10.0	65	2.00	5	0.00035
10.0	40	2.50	6	0.0004

They were standardized by using a 0.1 per cent solution of sublimed salicylic acid, taking aliquots, adding 5 cc. of alcohol and diluting to a final volume of 25 cc. to which one drop of dilute ferric chloride solution (10 per cent soln., as per *U. S. P.*) was added. After standing for 5 min. in a flask similar to the standards, the color was matched to one of the standards and the per cent salicylic acid for that standard calculated. It is important to note that these results hold true only for similar quantities (25 to 30 cc.), after 5 min. time, and using the same amount of ferric chloride.

If 5 cc. of a 2 per cent solution of acetylsalicylic acid in alcohol, diluted with 20 cc. H₂O and placed in a similar bottle, are treated with 1 drop FeCl₃ solution and the color matched, the grams in the standard × 10 gives the per cent free salicylic acid in the acetylsalicylic acid.¹ If a colorimeter is available the same solution may be used, the volume ratios used giving the percentage ratio between sample and unknown.

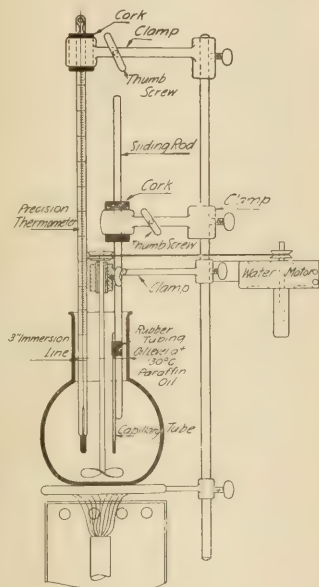
The following results were obtained on three well-known American brands and one foreign brand of acetylsalicylic acid:

¹ Color Standard No. 2 is the maximum limit allowable in a good sample of acetylsalicylic acid.

¹ *Proc. Assoc. of Agr. Chem.*, 1912

² The initial temperature of the bath, before immersing the melting point tube, should be 3° lower than the melting point of the sample. In my experience it is very rare that the initial temperature need be below 130° C.

³ Bureau of Chemistry, Dept. of Agr., Bulletin 162



MELTING-POINT APPARATUS

	1	2(a)	3	4
Melting Point	133.5°	134.5°	133.4°	133.6°
Color:	134.5° C.	134.5° C.	134.4° C.	134.8° C.
Odor.....	White crystals	White powder	White crystals	White powder
Sulfates.....	None	None	None	Acid
Chlorides.....	Very faint trace	Very faint trace	Very faint trace	Very faint trace
Heavy metals.....	None	None	Very faint trace	None
Reaction of aqueous soln.	Acid	Acid	Acid	Acid
Free salicylic.....	None	None	None	None
Ash, per cent.....	0.02	0.02	0.015	0.03
Assay.....	99.95	99.95	98.86	99.59

(a) Foreign product.

In carrying out these tests as well as others for the purity of various samples and brands of acetylsalicylic it can be stated that the same results and conclusions were obtained as those noted by Leech, with an exception in higher melting points, though comparative results were the same. There is no difference in quality and purity between various samples of American products now on the market and the much vaunted patented foreign brand formerly on the American market.¹

SUMMARY

A modification of the usual *U. S. P.* method of taking melting points, applicable to acetylsalicylic acid, is given.

A set of permanent color standards for use in determining the approximate amounts of salicylic acid in acetylsalicylic acid, with directions for preparation, is described.

Results of previous investigators as to quality and purity of American and foreign aspirin were confirmed, by tests made over a period of one year.

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THE VULCANIZATION OF RUBBER AT CONSTANT TEMPERATURE AND BY A SERIES OF INCREASING TEMPERATURES²

By G. D. KRATZ AND ARTHUR H. FLOWER

It has long been known that when the vulcanization of rubber is effected by heating for a period of time at a definite and constant temperature, the rate of combination of the sulfur with the rubber decreases with the time. In this particular instance, however, as is recorded in the experimental part of this paper, we have endeavored to maintain a constant rate of combination of the sulfur and rubber by a variation in the temperature. Our efforts have been confined primarily to devising a method for calculating a series of temperatures by the use of which the rate of vulcanization might be accurately controlled. With this possible, we desired to make a comparison of the physical characteristics of a rubber mixture vulcanized to the same point by both methods.

Although it is not within the scope of this article to review in its entirety the literature upon the subject or to draw conclusions from the results previously obtained by others, certain of these should be briefly recalled.

¹ *J. pharm. chim.*, [7] 5 (1917), 213, P. N. Leech, *THIS JOURNAL*, 10 (1918), 288.

² Presented before the Rubber Section at the 56th Meeting of the American Chemical Society, Cleveland, September 10 to 13, 1918.

The vulcanization of rubber at constant temperature was regarded by Weber¹ as consisting in a chemical reaction between the rubber and sulfur. Later, Skellon² also recorded results which tend to show that the combination of sulfur with rubber is strictly a chemical reaction, which is first preceded by the melting of sulfur and its solution in the rubber. Likewise he maintains that the rate of combination for unit time and constant temperature decreases with the decrease in the active mass of the sulfur present. Ostwald,³ on the contrary, has regarded the vulcanization phenomenon as due to an adsorption of the sulfur by the rubber, the rate of which, when expressed graphically, follows the typical adsorption isotherm. Spence⁴ and his co-workers, however, have demonstrated that Weber's vulcanization curves, on which Ostwald based his calculations, are subject to correction. They⁵ have also shown almost conclusively that the vulcanization phenomenon is the resultant both of an adsorption and a chemical interaction of the sulfur with the rubber, so that the views of others are probably not entirely free from need of modification.

Furthermore, from the results obtained by Spence it is quite obvious that when vulcanization is effected at constant temperature, the major portion of the sulfur combines with the rubber during the early stages of the reaction. And it is equally apparent that a lowering of the initial temperature and subsequent increasing of it at regular intervals would tend to make the reaction proceed more uniformly.

In fact, for many years it has been common technical practice to employ this method, popularly known as a "rising cure," but as King⁶ has recently pointed out, the use of the "rising cure" has been based mainly upon the fact that it affords a means whereby the low heat conductivity of the rubber may be minimized rather than for the above reason, for it is well established that in the case of large bulky articles, unless the vulcanizing temperature is exceedingly low, or unless it is initially low and gradually increased as the reaction proceeds, the outside surface may be over-vulcanized before the heat has thoroughly penetrated to the interior of the mass.

With the former idea in mind it appeared to us that by employing slabs of a thickness such that they would not be subject to King's contention, a series of increasing temperatures could be previously calculated which would effect the combination of a unit amount of sulfur in unit time throughout the period of vulcanization. The vulcanization-time curve thus would appear as a straight line. A mixture vulcanized in this manner might have widely different physical properties from those of the same mixture vulcanized at a constant temperature.

One of us⁷ has already shown that there is a distinct and readily measurable relationship between the time

¹ "Chemistry of India Rubber," 1906 edition, pp. 85-88.

² *India Rubber J.*, 46 (1913), 723; *Rubber Ind.*, 1914.

³ *Kolloid-Z.*, 6 (1910), 136.

⁴ *Ibid.*, 11 (1912), 28; *Chem.-Ztg.*, 36 (1912), 1162; *Kolloid-Z.*, 11 (1912), 274.

⁵ *Ibid.*, 8 (1911), 304; 11 (1912), 28; 13 (1913), 265.

⁶ *Met. and Chem. Eng.*, 18 (1918), 5.

⁷ G. D. Kratz, *India Rubber Review*, 16 (1916), 225.

required for vulcanization and the temperature at which it is effected, although there is hardly sufficient evidence to warrant its expression as a law as previously formulated by Bourne.¹ Based on our previous observations we have been able to calculate with accuracy the relative rates of vulcanization for various temperatures and to apply these different temperatures so that the vulcanization-time curve did actually take the form of a straight line. The satisfactory results obtained were remarkable in that the degree of vulcanization was measured not by chemical but by physical means, which is shown later to be a dangerous procedure.²

In the application of the above, however, although the accuracy of our calculations and the control obtained over the rate of combination of the sulfur with the rubber exceeded our expectations, the differences noted in the physical characteristics of a mixture vulcanized by the two methods were not widely different until a sulfur coefficient of 3.9 was obtained. At this point, vulcanization at constant temperature resulted in a product which was noticeably inferior to the same mixture when vulcanized by a series of increasing temperatures.

This was not entirely unexpected, as, in the case of a mixture containing 5 per cent of sulfur, vulcanized to the point of "technical cure"³ with a sulfur coefficient of 1.69, the vulcanization-time curve at constant temperature so closely approximated a straight line that, for all practical purposes, a unit amount of sulfur may be said to have combined in unit time by either method. In fact, the same statement may be made with reservation even up to a vulcanization coefficient of 2.9, although at this point both the tensile strength and elongation, particularly the latter, of the mixture vulcanized at constant temperature were found to be slightly inferior to those obtained when vulcanization was effected by a series of increasing temperatures.

Thus our results would tend to show that the values for the sulfur coefficient, as previously given by others, are in all cases high. Even the figures 2.8 to 3.0, recommended by Spence,⁴ appear to be excessive, while the values established by Eaton and Day⁵ are entirely out of question. Furthermore, it seems evident that, as has previously been stated by DeVries,⁶ changes in

the rubber-sulfur mixture which determine the physical properties of the mixture proceed independently of those which determine the vulcanization coefficient. Or in other words, the past history of the sample must be known if it is to be judged solely on the basis of its sulfur content. With such the case, certain qualifying statements should be made if it is to be assumed that a stoichiometric relationship exists between the rubber and sulfur at what is generally known as "optimum cure."

Likewise, it is obvious that whatever figure may be decided upon as the correct vulcanization coefficient for Hevea rubber, it is essential that, in order to obtain maximum physical results by vulcanization at constant temperature, restrictions be placed upon the minimum amount of sulfur and catalyst allowable in the original mixture. For best results at constant temperature there should be present in the mixture such quantities of both sulfur and catalyst that the active mass of the sulfur is not decreased to an extent that will slow up the rate of reaction before the desired sulfur content is attained. We have shown that if this is not taken into consideration the continued heating necessary to effect the combination of the latter fractions of the sulfur undoubtedly impairs the quality of the final product.

Summarizing briefly, under certain conditions we have found it possible to obtain a uniform rate of vulcanization for a rubber-sulfur mixture by employing a previously calculated series of increasing temperatures such that the vulcanization-time curve is reduced to a straight line.

By so doing we have shown that at comparatively high sulfur coefficients a better product is obtained by vulcanization with a series of increasing temperatures than with a constant temperature. We have also found the vulcanization coefficients previously recommended by others to be excessive, and that, unless the history of the vulcanization phenomenon is fully known, it is unsafe to judge samples solely on the basis of their sulfur content.

EXPERIMENTAL PART

In order that our calculations should be comparable with other work, our experiments were carried on with the same rubber mixture as previously employed,¹ not, however, using the same lot of rubber. This mixture consisted of the following proportions by weight:

First latex plantation crepe.....	100
Zinc oxide.....	100
Sulfur.....	5
Basic amine.....	0.33

The rubber used was of the best quality typical of its variety and, as before, it was subjected to the minimum amount of milling necessary to work in all of the ingredients. The basic amine (catalyst) was ground to 200 mesh and worked into the rubber before the pigment and sulfur were added.

After mixing, the compound was allowed to stand for 48 hrs. before any portion of it was vulcanized. This interval having been allowed for recovery, portions were vulcanized in a hydraulic platten press of

¹ *India Rubber J.*, **45** (1913), 120.

² This work is now being repeated; the rate of vulcanization being measured by both chemical and physical means.

³ The term "technical cure" is used to indicate that degree of vulcanization at which are found coincident maximum tensile strength and maximum elongation. This is not necessarily dependent upon the vulcanization coefficient, although a certain relationship does appear to exist between them. "Technical cure" is thus used in contradistinction to "optimum cure," as it has been our experience that what is generally known as "optimum cure" is, in most instances, for practical purposes an over-cure and that the previously established values for the correct vulcanization coefficient are for the most part high. Certainly it should not be in excess of 2.8 per cent for Hevea rubber. In connection with other work we have also determined the vulcanization coefficient of certain rubbers other than Hevea. These results show that although the coefficients for these rubbers are not necessarily constants, as suggested by Spence and Eaton, they should not be in excess of the following figures: Plantation Hevea, 2.8; Pine Hard Para, 3.2; Red Kassai, 3.4; and Ceara (Manihot), 4.4. Samples of these rubbers with higher coefficients were found to age quickly with rapid deterioration.

⁴ *India Rubber J.*, **52** (1916), 861.

⁵ *J. Soc. Chem. Ind.*, **36** (1917), 1116.

⁶ *India Rubber J.*, **53** (1917), 101.

⁷ Kratz, *India Rubber Review*, **16** (1916), 225.

the usual type. The molds used produced slabs or buttons $\frac{1}{8}$ inch thick. A recovery period of seven days was allowed before physical tests were made. Physical tests were made with a Scott testing machine (vertical type).

A button mold was used where sulfur estimations only were desired. By employing a ten-cavity mold it was possible to obtain a sample for analysis at any point during the vulcanization. It was previously determined that the momentary releasing of pressure on the platens, in order to partially withdraw the mold and remove a button, was without noticeable effect upon the final sulfur content of the other buttons in the mold.

All temperatures were maintained within 0.5° F. on either side of the figures given. In cases where a series of increasing temperatures was employed, each temperature change was made and established within one minute. This was accomplished by the use of a double system of steam regulators on the steam line to the press.

Throughout the following work, combined sulfur estimations were made by the method of Rosenstein-Davies,¹ each figure given being the average of at least two determinations checking within 0.1 per cent. In every instance the samples for analysis were previously subjected to 24 hrs. continuous extraction with acetone in a Soxhlet apparatus, dried in air, and then *in vacuo* at 100° C. to constant weight.

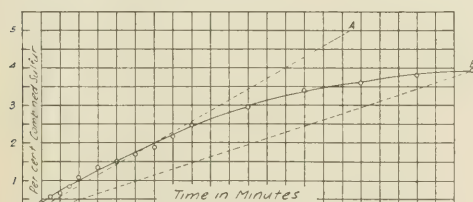


FIG. 1.—VULCANIZATION TIME CURVE AT CONSTANT TEMPERATURES

EXPERIMENT 1—Under this head, an investigation was made of the rate of vulcanization of the mixture at a constant temperature of 298° F. Our results, which confirm those previously obtained by others, are tabulated in Table I and are expressed graphically in Fig. 1. By this table and figure it is also shown that although 60 per cent of the sulfur present in the mixture combined with the rubber during the first two hours, less than 80 per cent had entered into combination at the end of 4 hrs.

In addition to this, it is seen in Table I that the "technical cure" for this mixture is obtained in about 60 min. at 298° F. with a vulcanization coefficient of 1.69. Further, while the general shape of the curve in Fig. 1 was found to be convex to the x-axis, that portion up to and including this 60 min. point very closely approximates the straight line OA drawn through this point. Thus in the case of this particular mixture "technical vulcanization" is attained before the active mass of the sulfur present is decreased to an extent

which would produce a marked decrease in the rate of vulcanization.

TABLE I.—VULCANIZATION AT A CONSTANT TEMPERATURE OF 298° F.

Time of Vulcanization Min.	Combined Sulfur Per cent	Tensile Strength Lbs. per Sq. In.	Elongation In. Per cent	Permanent Set Per cent
10	0.404	..	..	..
15	0.578	..	..	..
20	0.663	..	..	..
25	0.840	..	..	..
30	1.080	1527	725	14.32
40	1.330	1533	710	14.06
50	1.490	1930	707	15.23
60	1.690	2277	697	15.62
70	1.875	2015	685	17.97
80	2.170	2102	690	20.30
90	2.485	2055	680	21.09
120	2.945	2156	678	24.22
150	3.410	2060	685	25.78
180	3.600	1725	677	23.44
210	3.780	1538	680	23.44
240	3.920	1435	652	18.75

EXPERIMENT 2—It has been shown in Experiment 1 that at a coefficient of 1.69 our method was not applicable for the differentiation of the small variations in the quality of the mixture due to the method of vulcanization employed. For this reason it was decided to effect a comparison of the physical characteristics of the mixture when vulcanized to a coefficient of 3.9 at constant temperature and by a series of increasing temperatures.

The temperatures and times to be employed to effect vulcanization by the latter method may be readily obtained by applying the data given in Table I and Figs. 1 and 1a. First, the number of different temperatures to be used should be previously decided upon. Second, the number of minutes required to effect a "technical cure" at each of these temperatures may be obtained from Fig. 1a. Then, treating each temperature in the series individually, let

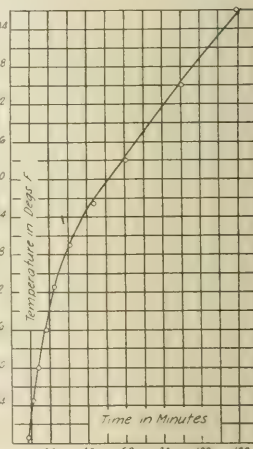


FIG. 1a.—TEMPERATURE-TIME CURVE FOR SERIES INDIVIDUALLY, let

t = time in minutes required to effect a "technical cure" at that temperature. (Fig. 1a.)

t' = time in minutes required to effect a "technical cure" at 298° F. (Table I.)

c = time in minutes required to attain the desired vulcanization coefficient at 298° F. (Table I.)

n = number of temperatures in the series.

$$t \times \frac{c}{t'} = T$$
 Then, $\frac{t \times c}{n} = T$, where T equals the number of minutes required for vulcanization at a given temperature when employed in the previously established series.

It is quite obvious that, if temperatures are chosen at random from the figure, the sum of the times for the complete series of temperatures may not be the same

¹ Chemist Analyst, 15 (1915), 4.

as the time required to effect the desired degree of vulcanization at a constant temperature of 298° F. On the other hand, it is easily possible to make a selection such that the total time of vulcanization is the same by either method. In order that our results might be strictly comparable, we chose the following series of four temperatures, the sum of the times of which was exactly equal to 240 min., the time required to obtain a coefficient of 3.9 at 298° F.

285.5° F.....	107 min.
298.0° F.....	60 min.
302.5° F.....	43 min.
307.0° F.....	30 min.
TOTAL.....	240 min.

Employing the foregoing series of temperatures and times, the mixture was vulcanized in a button mold for a total time of 240 min., samples being removed for combined sulfur estimation at hourly intervals and at each change in the vulcanizing temperature. These results are shown in the first four columns of Table II and expressed graphically by the solid line in Fig. 2.

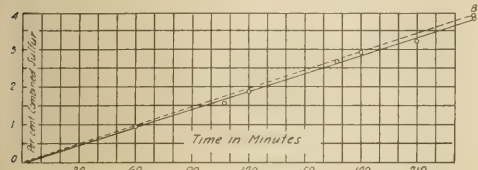


FIG. 2—VULCANIZATION-TIME CURVE FOR INCREASING TEMPERATURES

It is readily observed that the results obtained coincide almost exactly with the hypothetical straight vulcanization-time curve represented by the dotted line OB in Figs. 1 and 2.

Separate slab cures were then made for physical tests, at the temperatures and times required to produce vulcanization coefficients of 1.56, 2.96, and 3.86. The results of these tests are shown in the last three columns of Table II.

TABLE II—VULCANIZATION BY A SERIES OF INCREASING TEMPERATURES

Total Time of Vulcanization Min.	Time at the Different Temps. Min.	Temperature Deg. F.	Combined Sulfur Per cent	Tensile Strength Lbs. per Sq. In.	Elongation Per cent	Permanent Set Per cent
60	60	285.5	0.937	2168	715	17.97
107	107	285.5	1.567	...	...	...
120	13	298.0	1.879	...	...	...
167	107	285.5	2.702	...	...	...
180	60	298.0	2.963	2234	714	25.52
13	13	302.5	...	...	...	...
210	107	285.5	3.252	...	...	...
43	43	302.5	...	...	...	...
240	107	285.5	3.862	1944	705	25.00
43	43	302.5	...	...	...	...
30	30	307.0	...	...	...	...

To facilitate comparison, the results of these physical tests, together with those obtained at the same sulfur coefficient when vulcanization was effected at a constant temperature of 298° F., have been grouped together in Table III. From this table it is seen that there is very little difference in the tensile strength of the mixture at coefficients of 1.69 or 2.94 when vulcanized by either method. But in both instances a series

of increasing temperatures appears to produce a product of superior elongation. When the coefficient is increased to 3.9, however, it is seen that the product obtained by employing a series of increasing temperatures is markedly superior to that obtained at constant temperature, both as to tensile strength and percentage of elongation.

TABLE III		Tensile Strength		Elongation	
Constant Temp.	Increasing Temp.	Lbs. per Sq. In.	Constant Temp.	Per cent	Constant Temp.
1.690	1.567	2277	69	715	715
2.945	2.963	2146	2734	714	714
3.920	3.860	1435	1944	652	705

It is recognized that the results which have been recorded herein are not subject to indiscriminate or general application. This work has been confined to the investigation of one rubber-sulfur mixture only, and our calculations have been based on the correct or "technical cure" of the mixture as being obtained after vulcanization for 60 min. at 298° F. However, as the comparisons made are relative, and as the principle involved will apply to other mixtures and other vulcanization coefficients, we are warranted in drawing the following conclusions:

1—That it is possible to calculate and apply a series of increasing temperatures such that the vulcanization-time curve for any rubber-sulfur mixture may be made a straight line, the slope of which is dependent on the temperatures employed and the amount of catalyst present.

2—That in vulcanization at a constant temperature, in order to procure maximum physical properties, sulfur must be present in the mixture in such an amount that its active mass is not decreased to an extent which will appreciably slow up the rate of reaction before the desired vulcanization coefficient is attained.

3—That for rubber-sulfur mixtures containing 5 per cent or less of total sulfur, the physical properties of the mixture, when vulcanized by a series of increasing temperatures, are superior to those obtained by vulcanization at constant temperature; this is particularly true at vulcanization coefficients of 2.8 or above.

4—That the vulcanization coefficient for Hevea rubber is probably between 1.7 and 2.8.

5—That it is dangerous to evaluate samples of vulcanized rubber solely on the basis of their vulcanization coefficients.

THE FALLS RUBBER COMPANY
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THE DETERMINATION OF FREE CARBON IN RUBBER GOODS¹

By A. H. SMITH AND S. W. EPSTEIN

INTRODUCTION

The main object, perhaps, in the determination of free carbon in rubber goods is not the information gained directly, but the opportunity thus permitted of the determination of the rubber content by difference. For some time past the most widely used method for the determination of rubber has been to cal-

¹ Read before the Rubber Section at the 56th Meeting of the American Chemical Society, Cleveland, September 10 to 13, 1918.

culate it as the difference between 100 per cent and the total of the percentages of ash, total sulfur, and the various extracts. Recently refinements on this general method for the determination of rubber have been proposed and quite generally accepted, and it stands to-day the accepted standard of analysis. Obviously, this method is subject to wide error when free carbon is present and no correction is made for it.

This Bureau first became interested in this problem some months ago. At that time we were receiving relatively large numbers of rubber articles containing free carbon in which we were to determine the rubber content. In such cases we previously had determined the rubber directly by the nitrosite combustion method.¹ Admittedly, this method is a long one for routine work and we desired, if possible, to return to the method of determination by difference by correcting the ash figure for the amount of free carbon present. This of course necessitated a determination of the free carbon content of the goods and we finally arrived at the procedure which is here presented.

DISCUSSION OF PROPOSED METHOD

Our search of the literature on the subject revealed two general methods for such a determination: first, that in which nitric acid is used to decompose and remove the rubber and the carbon then determined in the residue; and second, that in which the rubber is dissolved in high-boiling solvents such as petroleum oils, nitrobenzene, aniline, etc., and the carbon then similarly determined in the residue.

Henry William Jones² proposes the use of nitric acid as a means of separating free carbon from vulcanized rubber and describes his process as follows: "A one- to two-gram sample is heated with concentrated nitric acid and then filtered cold on a Gooch crucible, washed with nitric acid to remove the mother liquors, and then with water to remove the acid and soluble metallic salts. The insoluble residue is then air-dried at ordinary temperatures, weighed, ignited, and weighed again."

W. A. Caspari³ also utilizes nitric acid to decompose the rubber but uses ammonia to remove the nitrous products formed.

We found the method of Caspari to give high results since there is no attempt to remove any organic compounds which may not be dissolved by nitric acid or ammonia. The method of Jones seemed, in general, to be satisfactory. In the report referred to, however, the details are somewhat lacking and the latter part is more or less confusing.

Our method as we first tried it was, first, primarily to remove organic matter with a nitric acid treatment and then filter on a Gooch crucible, leaving only fillers which were not attacked by nitric acid; and second, to remove by suitable treatment any possible remaining mineral fillers which might be reduced during ignition of the carbon. The carbon could then be determined by the difference in weight before and after ignition.

Our first experiments indicated the following:

1—The carbon itself was liable to attack by nitric acid.

2—The organic matter was not all removed by nitric acid.

3—Lead sulfate seemed to be the chief mineral ingredient which needed to be removed after the nitric acid treatment.

We treated samples of lampblack and gas black for various periods with concentrated nitric acid. In each case the mixture was heated on the steam bath for a definite length of time and then evaporated to dryness. The residue was always heavier than the original sample and the increase in weight varies with the time of heating. This increase was from 3 to 5 per cent for the minimum time taken to evaporate off the acid and from 5 to 8 per cent for 15 hrs. heating.

We then treated samples of lampblack and gas black for definite lengths of time with concentrated nitric acid, after which we filtered off the solution on a Gooch crucible, washed well with nitric acid, then with acetone, and finally with sodium hydroxide solution. The alkali invariably extracted material, the nature of which we did not investigate. The ignition loss of the residue, in proportion to the original amount of carbon taken, varied from 100 to 102 per cent in the case of gas black and from 101 to 105 per cent when lampblack was used.

As yet we have not made any effort to identify the products formed by the action of nitric acid on the variously made forms of amorphous carbon, but are inclined to believe that the action is an oxidizing one similar to the formation of graphitic acid by the prolonged heating of a mixture of graphite, potassium chlorate, and nitric acid. Therefore, one would expect to find here complex carboxylic compounds formed by the addition of hydrogen and oxygen to the carbon atoms.

There seem to be at least three classes of compounds formed, namely, the first soluble in nitric acid, the second insoluble in nitric acid but soluble in alkali, and the third insoluble in both. Our experiments indicated that the last named was the major product of the reaction.

Our first trials at completely removing the nitrated rubber with nitric acid showed that this was practically impossible. After filtration from the nitric acid solution, washing with acetone would invariably give an extract, in some cases the characteristic yellow of the nitrosite of rubber, in others a deep brown extract which persisted for several washings. With samples giving these deep brown extracts with acetone, a further washing with sodium hydroxide would result in a second brown extract. This showed that the nitric acid did not remove all of the nitrosite of rubber, nor some other organic matter which may or may not have been nitrated but which seemed to be soluble in acetone or sodium hydroxide solution. It was noted that the brown acetone and sodium hydroxide extracts were invariably obtained when mineral rubber was known to be present. All of the samples nitrated had previously been extracted with acetone and chloroform,

¹ Bureau of Standards method for the direct determination of rubber.

² Paper presented before the Fourth International Rubber Congress.

³ India Rubber Laboratory Practice.

so we were led to conclude that we were encountering that part of mineral rubber which after vulcanization, according to Caspari, becomes insoluble in the usual solvents.

B. D. Porritt¹ confirms Caspari's work, showing that during vulcanization some of the bitumen passes into an insoluble form much as rubber does. In the case of vulcanite, he says nearly half of the bitumen is rendered insoluble. He presented no information, however, as to whether or not any combination with sulfur takes place. He also found that nitric acid had no apparent action on bitumen. He treated a rubber mixture containing bitumen with nitric acid, and tried to determine, by extracting with carbon bisulfide, the bitumen left in the residue. He obtained results extremely low. From this he concluded that the preliminary treatment with nitric acid had rendered a portion of the bitumen insoluble in the solvents. If this were the case, carbon determined as we have proposed would give high results.

An experiment which we hoped might disclose the effect of mineral rubber on the determination was made as follows: Some mineral rubber was melted and stirred up with sulfur at 200° C. A vigorous reaction took place with considerable evolution of hydrogen sulfide. The brittle solid product obtained was extracted with acetone and chloroform, and gave a very large insoluble residue. This residue was found to be insoluble in all of the common organic solvents and unattacked by strong sodium hydroxide. When treated with hot concentrated nitric acid for a few minutes the acid became colored a deep brown, but the larger part of the material persisted as a black floating mass. It remained so even after a 24-hr. treatment. This residue, however, we found to be readily soluble in either acetone or strong sodium hydroxide solution. The effect of mineral rubber on the determination would then be as follows: The preliminary extractions with acetone and chloroform would remove the soluble portions; after nitration, acetone and sodium hydroxide solution would remove that part which had become insoluble through vulcanization.

We carried out a large number of determinations on compounds by treating directly with nitric acid. We compared these results with results obtained on the same samples which had been extracted with acetone and chloroform before nitration. The carbon content usually appeared a few hundredths of a per cent higher in the former. This we attributed to the difficulty in washing the filter pad free from the large quantities of extractable matter often present. Practical experience showed us that, after filtering off the nitric acid solution, filtration proceeded much more rapidly if we used solvents alternately.

Assuming that the organic matter has all been removed by the nitric acid, organic solvents, and sodium hydroxide solution, there remain with the carbon all of the mineral constituents which were not removed by the nitric acid. Among the latter lead is very often present, since part of it is usually converted into

lead sulfide during vulcanization and subsequently into lead sulfate during the nitric acid treatment. Any mineral matter remaining which is not attacked by carbon during ignition or which itself suffers no ignition loss, obviously need not be removed. If lead sulfate, however, is allowed to remain in contact with the carbon during ignition, it becomes at least partially reduced and perhaps volatilized with a subsequent loss in weight. Lead sulfate is therefore removed by washing with concentrated ammonium acetate solution until the filtrate shows the absence of lead.

Our attention was called by Mr. I. V. Stone, of the United States Rubber Company, to the fact that calcium sulfate would show an ignition loss. This was confirmed and so the presence of calcium sulfate at this point would lead to erroneous results. It must be considered, however, that calcium sulfate is practically only added along with sulfides of antimony, and that a combination of antimony sulfides and gas black and lampblack is very unusual.

In order to remove the last traces of sodium hydroxide previously used as a wash, the pad was washed well with a very dilute solution of hydrochloric acid. This cannot well be followed by a wash with water since the carbon is apt to go into colloidal solution. On attempting to dry the residue at 200° C., it was found that it gradually decreased in weight, probably owing to the very slow oxidation of the carbon at this temperature. Drying for 1½ hrs. at 150° C., however, removed all of the hydrochloric acid and gave a constant weight.

DETAILS OF METHOD AS FINALLY ADOPTED

As a result of these preliminary considerations and experiments, we devised the following procedure:

Extract a 1 g. sample for 6 hrs. with acetone and then for 3 hrs. with chloroform or carbon bisulfide. Transfer the sample to a 250 cc. beaker and heat on the steam bath until it no longer smells of chloroform. Add a few cc. of hot concentrated nitric acid and allow to stand in the cold for about 10 min. Add 50 cc. more of hot concentrated nitric acid, taking care to wash down the sides of the beaker. Heat on the steam bath for about one hour or until the disappearance of all bubbles or foam from the surface. Pour the liquid, while hot, into a Gooch crucible containing a fairly thick pad of ignited asbestos. Filter by applying gentle suction and wash well with hot concentrated nitric acid. Empty the filter flask, wash the filter alternately with acetone and benzol until the filtrate is colorless. Next wash it well with a hot 15 per cent solution of sodium hydroxide. Test for the presence of lead by running some warm ammonium acetate solution, containing an excess of ammonium hydroxide, through the pad into a solution of sodium chromate. If a yellow precipitate forms, the pad must be washed with the ammonium acetate solution until the washings no longer precipitate the sodium chromate solution. Next wash the residue well with warm 5 per cent hydrochloric acid solution. Remove the crucible from the funnel, taking care that the outside is clean, and dry it in an air bath for 1½ hrs. at 150° C. Weigh, burn off the carbon at a dull red heat, and re-weigh. The difference in weight represents approximately 105 per cent of the carbon originally present in the form of lampblack or gas black.

NOTE—It is recommended that 0.5 g. samples be taken for compounds containing over 10 per cent of free carbon and 1 g. samples be taken for compounds containing less than this amount.

¹ "Estimation of Bitumen in Rubber Mixings," Proceedings of Fourth International Rubber Congress.

It will be noted that we have taken the factor of 105 per cent as a ratio between the ignition loss and the amount of carbon present. This factor is arrived at from the results of a large number of determinations made at the Bureau of Standards. The results of gas black determinations ran from 101 to 106 per cent and lampblack determinations from 102 to 108 per cent. Results were obtained on different samples containing large amounts of mineral rubber, lead (both in the form of oxide and sulfate), reclaimed rubber of various kinds, glue, substitute, sulfides of antimony, talc, and others. In all cases the results came between 101 and 108 per cent of the carbon originally present, so by using a factor of 105 per cent, the maximum divergence would be 4 per cent and the usual divergence very small.

In our analysis of the gas black and lampblack used in our experiments, we determined the volatile loss at 100° C., the acetone extractable matter, and the ash, and assumed the remainder of our samples to be carbon. Our results have been calculated to this basis.

SUMMARY

I—It is necessary to correct the result as obtained by ignition loss to compensate for the error caused by the formation of compounds from the free carbon.

II—The attack of amorphous carbon by nitric acid renders an accurate determination by this method impossible; nevertheless the error caused thereby is sufficiently uniform and small in magnitude to allow of a practical determination.

III—Assuming the ignition loss to be 105 per cent of the weight of carbon, we feel that the results by this method justify its use at present as a routine method in the rubber laboratory.

BUREAU OF STANDARDS
WASHINGTON, D. C.

A RAPID AND ACCURATE METHOD FOR BUTTER ANALYSIS, SUITABLE FOR FACTORY CONTROL WORK

By EDWARD F. KOHMAN
Received July 11, 1918

Inasmuch as a fat standard for butter is advocated by many, it would be desirable to have some simple and rapid method for the determination of fat in butter to be used in creamery control work. We have found that with very little added time the fat can be determined in connection with the moisture test in the following manner:

The moisture is determined as usual over a small flame in a tall, rather narrow, lipped aluminum beaker with a capacity of about 100 cc., using a 10 g. sample. After the beaker is weighed to determine the loss of moisture, it is filled with petroleum ether and the contents stirred with a glass rod to secure a thorough mixture. It is then covered with a watch crystal and allowed to stand 2 or 3 min. for the mixture of curd and salt to settle, when the solvent is gently decanted off without disturbing the sediment. The beaker is then filled with fresh solvent. The curd and salt mixture settles rapidly in the fresh solvent and the liquid can be decanted off after a very short time. By gently heating the beaker now, either on a water bath, a hot plate, or directly over a small flame, but not so rapidly as to cause sputtering, the sediment can be completely freed of petroleum ether

by evaporation in a very short time. The per cent of fat is then determined by difference upon reweighing the beaker with its contents. The salt is now in ideal condition to be determined by titration, using a solution of such strength that the number of cc. used represents the per cent of salt.

No special practice is necessary in order to enable one to carry out this analysis successfully the first time. The writer has had no difficulty in assigning it to his students in dairy chemistry. In heating the butter to drive off the moisture, the slightest noticeable browning of the sample should be taken as the end-point. But it is surprising how little the results are affected if the sample is heated until it assumes a coffee-brown. Before trying to evaporate the petroleum ether from the mixture of curd and salt, it is well to loosen it from the bottom of the beaker by gently tapping it on the desk in order to lessen the tendency to sputter. When making duplicate determinations the two beakers can readily be held by one pair of tongs while being heated. We have thus been able to make duplicate analyses of butter in 20 min. or single determinations in 15 min., and the results are as accurate as those obtained by the A. O. A. C. methods, as the table given below will show. It is well to keep the petroleum ether from the second decantation in a separate container and use it for the first extraction in future analyses.

In the following table are a few typical results in which the moisture and fat content of butter as determined by the A. O. A. C. method and the method outlined above are compared.

ANALYSIS No.	A. O. A. C. METHOD Moisture Per cent	Fat Per cent	DECANTATION Moisture Per cent	METHOD Fat Per cent
1	14.22	81.97	14.27	82.13
	14.20	82.06	14.24	82.09
2	18.00	78.27	18.06	78.36
	17.93	78.38	18.08	78.35
3	19.72	77.46	19.72	77.50
	19.69	77.54	19.74	77.48
			19.78	77.50
			19.77	77.47
			19.74	77.47
			19.73	77.46
4	14.95	82.20	15.07	82.11
	15.00	82.06	15.11	82.08
			15.02	82.05
			15.08	81.99
5	20.98	76.29	21.07	76.26
	20.97	76.27	21.10	76.20
			21.05	76.22
			21.05	76.20
			21.06	76.21
			21.05	76.18
6	14.92	80.81	14.98	80.92
	14.98	80.82	15.00	80.83
			14.91	80.84
7	15.85	80.46	15.90	80.52
	15.82	80.49	15.90	80.46
			15.90	80.59
			15.91	80.57
8	15.36	81.08	15.40	81.14
	15.39	81.08	15.40	81.04
			15.37	81.10
9	15.83	80.62	15.92	80.65
	15.85	80.60	15.90	80.60
			15.93	80.73
			15.94	80.69
10	14.57	82.08	14.59	82.23
	14.59	82.05	14.62	82.09
			14.61	82.01
			14.63	82.01

The work embodied in the above table was done by the writer in 1916 while in the Department of Dairy Husbandry of the University of Illinois.

BUREAU OF CHEMISTRY
INDIANAPOLIS, IND.

UTILITY OF BLANCHING IN FOOD CANNING EFFECT OF COLD SHOCK UPON BACTERIAL DEATH RATES

By EVA M. BRUNET

Received July 29, 1918

The so-called process of blanching is used both by commercial packers and by the housewife in preparing many vegetables and fruits for preservation by canning. The physical advantages of dipping such food first into boiling water, then into cold, are probably sufficient to justify its use. However, there is a distinct impression prevalent among canners that the blanching is to some degree an essential part of the process of sterilization, and that products so treated are more readily processed. This report presents the results of a series of studies on the effect of cold shock upon bacterial death rates when organisms are subjected to subsequent high temperatures. It has been thought that the cold shock following a preliminary heating might so injure the vitality of the bacteria as to make them more susceptible to subsequent heating.

In a preliminary note presented in December 1917, at the meeting of the Society of American Bacteriologists,¹ the conclusion was announced that there is no evidence that heat and cold shock increase the susceptibility of bacterial spores to heat, for death rates of such bacteria are not increased during a second heating beyond the death rates of "unshocked" bacteria subjected to the same temperature.

In a recent paper, Bushnell² comes to a similar conclusion as a result of studies on the canned products themselves.

This paper presents data in support of the conclusion announced in our preliminary note, with certain inferences which may be drawn as to the utility of the blanching process in cold pack canning.

It is obvious that the times and temperatures used in both commercial and home canning processes are such that organisms other than those in the spore condition will be very quickly destroyed. It is necessary, then, to study the effect of cold shock upon the vitality or viability of bacterial spores.

The organism used in this study was *Bacillus pseudotetanicus* (Krusse) Migula, a member of the group of spore-producing soil aerobes possessing considerable resistance to high temperatures. The parent culture was one secured from Dr. Ford, of Johns Hopkins. The bacteria were grown on 0.5 per cent dextrose agar slants, incubated at 30° C. for four days to insure adequate sporulation. The growth from a single culture was suspended in 10 cc. physiological salt solution. This suspension was centrifugated to remove clumps and passed through a sterile filter to secure a uniform suspension. In all cases the effect of temperature was studied by adding 1 cc. of this suspension to 9 cc. of 1 per cent peptone solution already heated to the desired temperature. A de Khotinsky portable water bath was used for maintaining a constant temperature, with corn oil substituted for water, as ex-

perience showed a much more constant temperature could be maintained at 80° C. and above by this means. The peptone solution was held at the temperature of the bath for the desired length of time, counts of the numbers of viable bacteria present being made at short intervals by plating. At higher temperatures the time intervals used were necessarily shorter than at lower temperatures. After the heating had been continued for the desired length of time, 1 cc. was transferred to a second tube of peptone containing 9 cc. of solution and at a temperature of about 1° C. maintained by the use of an ice bath. The length of exposure to the cold was arbitrarily fixed in each case at 5 min. A sample was then taken for a plate count, and the tube placed in the thermostat where it was heated together with the tube containing the "unshocked" bacteria.

Counting was carried out in general in conformity with standard methods. Salt solution was used for dilutions. The plating medium used was a 1 per cent dextrose, 2 per cent agar. This gave a relatively stiff medium and prevented the development of spreading colonies, a serious difficulty with softer media. The plates were incubated at 30° C. for 48 hrs., then counted.

It has been shown by several investigations that the deaths of microorganisms when subjected to any fixed unfavorable conditions will occur in conformity with the well-known equation of monomolecular reactions. This may be expressed:

$$k = \frac{1}{t} \log \frac{B}{b}$$

in which k = velocity coefficient of the rate of death of bacteria, a constant

t = interval of time between observations

B = number of bacteria at beginning of any time interval

b = number of bacteria at end of time t

Preliminary tests with the spores of *Bacillus pseudotetanicus* showed satisfactory agreement with the law; under a given set of conditions the value of k was found to be nearly constant, that is, the number of bacteria dying off in any unit of time is nearly proportional to the number present at the beginning of that time interval. It is evident that the effect of the cold shock upon bacterial spores may be determined by a comparison of the values of k found before and after "shocking" the bacteria, *i. e.*, if the value of k increases, the spores have lost their resistance to some degree and die off more quickly than do the "unshocked" bacteria.

It is apparent that considerable experimental error is inevitable. The results, however, are on the whole satisfactory.

Several methods may be used for calculating the value of k in any experiment. It is evident that the initial inoculum probably may contain some viable vegetative cells which will have a very different death rate from spores. The value of k may be approximated by (1) substituting for B the number of bacteria at beginning, for b the number of bacteria after

¹ Abstracts of *Bact.*, 2 (1918), 5.

² "The Influence of Cold Shock in the Sterilization of Canned Foods,"

the varying time intervals, and averaging, or (2) substituting for B the number of bacteria at beginning of each time interval, and for b the number at the end of each time interval, and averaging, or (3) substituting for B the number of bacteria at the end of the first time interval, and for b the number of bacteria after each of the following time intervals, and averaging. The values of k were determined by each method as illustrated by the following example:

TABLE I—ILLUSTRATING METHODS OF DETERMINING VELOCITY COEFFICIENT ON DEATH RATE AT 80° C.

Time after Inoculation Min.	Viable Bacteria per cc.	k Calculated by Method 1	k Calculated by Method 2	k Calculated by Method 3
0	890,000	0.0021	0.0021	
15	827,000	0.0024	0.0027	0.0027
30	752,000	0.0025	0.0028	0.0028
45	681,000	0.0029	0.0039	0.0031
60	594,000	0.0028	0.0026	0.0031
75	537,000	0.0027	0.0021	0.0028
90	504,000	0.0032	0.0062	0.0029
105	406,000			
	Ave. 0.0026	Ave. 0.0032	Ave. 0.0029	

It is apparent that in this instance there is little to choose in the method of determining k . It is thought, however, that either the third, or an average of the averages, should represent the facts fairly well. In general, the latter index has been used.

EXPERIMENTAL RESULTS

Three sets of experiments were run at 80°, one at 85°, two at 90°, and one at 100° C. The data and determined values for k are given in the following tables:

TABLE II—DETERMINATION OF VELOCITY COEFFICIENT OF DEATH RATE AT 80° C. FIRST TRIAL

Time after Inoculation Min.	Viable Bacteria per cc.		
	Unshocked Bacteria	Shocked after Heating 15 min.	Shocked after Heating 30 min.
0	890,000		
15	827,000	81,000	70,300
30	752,000	72,000	67,100
45	681,000	60,350	64,000
60	594,000	39,650	
75	537,000	57,700	55,200
90	504,000	54,200	48,100
105	406,000	53,200	43,300
Value of k	0.0029	0.0025	0.0021

It will be noted that the values for the velocity coefficients of the death rates of the shocked bacteria are not higher than those of the unshocked. The differences are probably not significant. The general tendency in this and other experiments is for the value for the shocked bacteria to be slightly lower. This may possibly be due to unavoidable experimental error in that the chilled tube does not instantly assume the desired temperature when replaced in the water bath.

TABLE III—DETERMINATION OF VELOCITY COEFFICIENT OF DEATH RATE AT 80° C.

Time after Inoculation Min.	Viable Bacteria per cc.		
	Unshocked Bacteria	Shocked after Heating 15 min.	Shocked after Heating 30 min.
0	130,000	20,000	6,800
15	110,000		
30	60,000	6,900	4,650
60	30,000	2,800	3,600
90	13,500	1,150	
Value of k	0.0115	0.0136	0.0059
Time after Inoculation Min.	Viable Bacteria per cc.		
	Unshocked Bacteria	Shocked after Heating 15 min.	Shocked after Heating 30 min.
0	189,000	10,000	6,200
15	125,000	7,500	
30	82,000	4,700	4,700
60	34,000	2,300	2,800
90	32,000	1,000	1,880
120	15,200		960
135			360
150	6,300	360	
165		320	
Value of k	0.0106	0.0104	0.0065

The results in Table III are not comparable strictly and directly with those of Table II as these tests were performed with different lots of material.

Here again the differences in rates of death are probably not significant. In each of the following experiments it should be noted that the studies were made with different lots of material. The values of k determined in the various tables cannot be used therefore for a determination of the temperature coefficient of the reaction. Conditions were uniform in each experiment, but suspensions of bacteria prepared at different times did not give comparable results.

TABLE IV—DETERMINATION OF VELOCITY COEFFICIENT OF DEATH RATE AT 85° C.

Unshocked Bacteria		Shocked after Heating 10 min.	
Time after Inoculation Min.	Viable Bacteria	Time after Inoculation Min.	Viable Bacteria
0	2,180,000	0	183,000
10	1,850,000	5	173,000
20	1,089,000	25	116,000
40	621,000	50	88,000
65	45,600	60	27,000
Value of k	0.0127		0.0107

TABLE V—DETERMINATION OF VELOCITY COEFFICIENT OF DEATH RATE AT 90° C.

Unshocked Bacteria		Shocked after Heating 10 min.	
Time after Inoculation Min.	Viable Bacteria	Time after Inoculation Min.	Viable Bacteria
0	481,000	0	22,600
10	296,000	15	10,700
20	67,000	30	5,000
35	26,000	45	570
50	2,900	65	340
65	2,200	75	135
Value of k	0.0184	90	85
			0.0285

Time after Inoculation Min.	Viable Bacteria per cc.		
	Unshocked Bacteria	Shocked after Heating 5 min.	Shocked after Heating 10 min.
0	990,000	89,000	
5	810,000	61,500	35,300
10	790,000	57,000	34,500
15	357,500	51,000	29,500
20	164,500	37,100	
25	137,500	29,600	24,500
30	101,000	25,600	23,400
55	94,000	22,350	12,500
Value of k	0.0292	0.0180	0.0108

TABLE VI—SINGLE DETERMINATION OF VELOCITY COEFFICIENT OF DEATH RATE AT 98° C.

Time after Inoculation Min.	Viable Bacteria per cc.		
	Unshocked Bacteria	Shocked after 2 min.	Shocked after 4 min.
0	125,000	6,600	5,600
2	51,000	5,900	5,200
4	30,000	5,400	4,800
6		4,700	4,600
8	26,000	3,000	3,100
10	14,700	2,200	1,500
12	5,500	920	
Value of k	0.1106	0.0504	0.0257

It is evident that the experimental error for results such as given in Table VI should be rather large because of the difficulties in rapid manipulation, slowness with which tubes acquire a new temperature, and inaccuracies in correct estimation of time.

TABLE VII—SUMMARY OF THE VALUES OF k OBTAINED FOR DIFFERENT TEMPERATURES

Temperature	Value of k for Unshocked Bacteria	Value of k for Shocked Bacteria	Value of k for Shocked Bacteria
90°	0.0029	0.0025	0.0021
80°	0.0115	0.0136	0.0059
85°	0.0106	0.0104	0.0065
80°	0.0127	0.0107	
90°	0.0184	0.0285	
90°	0.0290	0.0180	0.0108
100°	0.1106	0.0504	0.0257

A summary of the values of k is given in Table VII. It will be noted that in one case only does the velocity coefficient of the death rate of shocked bacteria rise higher than the unshocked. An examination of this

table apparently justifies the statement that the rate of death of bacteria at high temperatures is not increased by preliminary heating and "shocking" by cold. The bacteriological utility of the blanching in the cold pack process of canning probably should not be ascribed to shock.

Is there, then, any bacteriological justification for the process of blanching in food canning? A can of food is sterile and will certainly keep in consequence whenever the number of living bacteria present, or the number of those which can multiply in the canned food, has been reduced to fewer than one to the can. The fact that sporulating bacteria die off at high temperatures in substantial conformity to the law governing monomolecular reactions emphasizes the point that the larger the number of bacteria initially present in the can, the longer under the same conditions will it take to sterilize. Blanching may be of some value because the initial application of hot water followed by cold not only kills many bacteria but removes them from heavily contaminated products in very large numbers. It is probable that there is some bacteriological justification for the blanching process because of this initial cleansing.

It may be noted that Bushnell's experiments on blanching were not in all cases, strictly speaking, blanching in the sense used in the cold pack process. This author demonstrated that if a food is heated, chilled, and heated, the total time of heating required to sterilize is as great as though there had been no chilling. This does not prove, however, that if the material had been immersed in boiling water, then in cold water, that the cleansing action may not have increased the ease of sterilization. This could be determined by quantitative determinations of the spores removed by this process. It is not improbable in many cases that the time of sterilization required with and without blanching would be practically identical, indicating that the number of bacteria (spores) removed was not very great. This is indicated by other results of Bushnell's where true blanching was practiced. A comparative study should also be made of the composition of the liquid of canned foods, vegetables in particular, which have been blanched with that from unblanched. Very slight differences in the acidity (hydrogen ion concentration) of the liquid under the two conditions might influence markedly the time needed for sterilization.

CONCLUSIONS

1—Comparisons of the velocity coefficients of the death rates of bacterial spores may be made to determine the effect of various conditions, such as temperature.

2—Bacterial spores are apparently not made more sensitive to heat by preliminary heating followed by chilling.

3—Blanching as a preliminary to the cold pack process of canning does not have bacteriological justification on the basis of increased susceptibility of the bacteria to sterilization because of "cold shock."

4—There is probably some bacteriological justification for blanching because of the marked cleansing

action of this process, resulting in the introduction of smaller numbers of spores initially into the canned product. It is probable that the time required for sterilization varies with the initial contamination; it is desirable therefore to reduce this as much as possible.

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THE NATURE OF THE RECOMBINED POTASH IN CEMENT MILL DUST

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In a previous publication¹ an estimate was made of the quantity of potash annually recoverable as a by-product in the flue dust of the cement mills of the United States. Attention was also called to the fact that in cement dusts which have been recovered a portion of the potash in the dust has been found to be insoluble in acids; a second portion insoluble in water, as determined by the official methods of the Association of Official Agricultural Chemists, but readily soluble in acids, while the remainder of the potash is soluble in water. In the oil-fired plant of the Riverside Portland Cement Company, where cement dust was first collected for its potash content, the greater part of the potash in the dust is readily water-soluble. This dust also contains some acid-soluble and acid-insoluble potash, but the proportions of these present are too small to be of practical significance. However, when dust was later collected at plants where coal is used for fuel it was found that in such plants the acid-soluble potash may constitute the greater part of the total potash in the dust and thereby greatly depreciate the value of the dust for sale as a fertilizer. This observation was first made at the plant of the Security Cement and Lime Company by Mr. R. C. Haff, Chief Chemist, and Mr. R. D. Cheesman, at that time Assistant Chemist of the Company. In explanation of the result the view was advanced by R. J. Nestell and E. Andersen,² of the Western Precipitation Company, that the potash occurring in the acid-soluble form was due to a recombination within the kiln of the volatilized potash with the siliceous ash particles of the coal used for fuel.

In a recent article by N. S. Potter, Jr., and R. D. Cheesman³ the view is advanced, on the other hand, that there is no recombination of the volatilized potash with the siliceous ash particles, but that the water-insoluble potash in the dust is due to the potash in the ash of the coal used for fuel and in the raw mix carried over mechanically in the dust. After quoting passages from articles by Nestell and Anderson⁴ and by the authors,⁵ the statement is made that the potash content of the coal ash had hitherto been quite neglected in considering the sources of the potash occurring in cement dust.

¹ W. H. Ross, A. R. Merz, and C. R. Wagner, U. S. Dept. Agr., *Bulletin* 572.

² *This Journal*, 9 (1917) 646.

³ *Ibid.*, 10 (1918), 109.

⁴ *Ibid.*, 9 (1917), 646.

⁵ *Ibid.*, 9 (1917), 467, 1035.

TABLE I - POTASH IN CEMENT DUST SAMPLES FROM DIFFERENT SOURCES

PLANT	Fuel	Water-soluble K ₂ O in Percentage of		Acid-soluble, Water-insoluble K ₂ O in Percentage of		Acid-insoluble K ₂ O in Percentage of		Total K ₂ O	
		Dust	Total K ₂ O in Dust	Dust	Total K ₂ O in Dust	Dust	Total K ₂ O in Dust	In Percent- age of Dust	Per Tbl. of Cement
Atlas Portland Cement Co., Northampton, Pa.	Coal	1.69	19.65	5.47	63.60	1.44	16.74	8.60	1.74
Alpha Portland Cement Co., Cementon, N. Y.	Coal	2.92	41.59	3.41	48.59	0.69	9.83	7.02	2.73
Security Cement & Lime Co., Hagerstown, Md.	Coal	6.79	59.57	4.06	35.61	0.55	4.83	11.40	2.61
Riverside Portland Cement Co., Riverside, Cal.	Oil	9.76	91.62	0.73	6.85	0.16	1.51	10.65	2.13

In making our calculations from the analyses already referred to of the average potash volatilized from the different plants of the country in terms of the cement produced we made reference as follows to the matter of potash in coal:

"In making this calculation no account was taken of the potash in the coal which at most would not amount to more than a few tenths of a pound per barrel of cement. Any potash present, however, would tend to increase the value given for the amount of potash volatilized. Cf. R. K. Meade, "Portland Cement," 2nd ed., p. 179."

At the plant where R. K. Meade carried out his investigations, 110 lbs. of coal were consumed per barrel of cement produced. The potash in the coal amounted to 0.16 per cent and evidence was given that of the coal ash formed in the kiln only about one-half escaped with the dust.² On this basis, the quantity of potash in the dust that had coal as its source would amount to only 0.09 lb. per barrel of cement. This value is so small as to be practically within the limits of experimental error and when it is considered that the potash in coal is almost entirely in the water-insoluble form it was decided to omit in our calculations the yield of potash from this source.

In Table I are given analyses of four cement dust samples for acid-insoluble, acid-soluble, and water-soluble potash.

In the case of the first sample listed in Table I, the water-soluble potash amounts to 1.69 per cent of the dust and the water-insoluble potash to 6.91 per cent. These analyses were made on a sample of dust which was especially collected in such a way as to represent the entire dust as it escapes from the kiln rather than that which is collected by present commercial methods. In any dust the potash that is carried over mechanically cannot exceed the total percentage occurring in the raw mix multiplied by a certain factor which depends on the degree to which the dust has been calcined before escaping from the kiln. At the plant under consideration 600 lbs. of raw mix are required to yield 1 barrel (380 lbs.) of cement. If it be assumed that the dust undergoes a 50 per cent calcination³ then the factor referred to will amount to 600/490. The potash in the raw mix of this same plant amounts to 0.74 per cent. It follows, therefore, that in the dust of this plant the potash carried over mechanically will

amount to not more than 0.91 per cent¹ of the dust. This leaves a balance in the dust of 6.00 per cent of water-insoluble potash, amounting to 69.8 per cent of the total, which, according to Potter and Cheesman, comes from the ash of the coal used as fuel. Expressed in terms of the cement produced this would be equivalent to 1.22 lbs. per barrel.

In Table II are given the analyses for potash of several coal samples received from different cement plants where potash-bearing dust is now being collected. It will be noted that the average of the values found for the total potash in coal ash is less than half that reported by Potter and Cheesman.² The first sample listed in the table represents the coal used in the plant under discussion at the time the analysis was made of the potash in the raw mix and cement. If the assumption is correct that there is no recombination of potash and even if it be granted that all of the ash from the coal escapes from the kilns with the dust, then at least 530 lbs. of coal would have to be burned in this plant per barrel of cement in order to give the quantity of water-insoluble potash that is actually found. This quantity of coal is much in excess of what is actually used and the excess would be still more marked if proper allowance were made for the coal ash that does not escape from the kilns. Again, if the coal were responsible for the excess of water-insoluble potash found in the second dust listed in Table I, upwards of 500 lbs. of coal would have to be used per barrel of cement, or 1000 lbs. if only 50 per cent of the coal ash escapes from the kiln. Either value is greatly in excess of that used in any cement plant in the country. The conclusion must therefore be reached that in these plants, at least, the ash of the coal and the dust carried over mechanically are not the only sources of the water-insoluble potash of the dust. The only other possible source is the potash that has been volatilized in the process of burning and which has undergone a recombination during its passage from the kiln. More direct evidence in support of this is furnished when a dust from oil-fired kilns like those of the Riverside Portland Cement Company is ignited in the presence of a coal ash. This brings about, as will be shown later, a marked reduction in water-soluble potash and a corresponding increase in water-insoluble potash. A recombination of a portion of the soluble potash originally present in the dust to make a water-insoluble com-

¹ U. S. Dept. Agr., Bulletin 572, p. 8.

² "Portland Cement," 2nd ed., p. 179.

³ Paper (pp. 38, 39, 43) by W. A. Schmidt, presented at the Meeting of Amer. Inst. of Mining Engineers, Globe, Arizona, Sept. 21, 1916.

¹ The true value will actually be considerably less than this, owing to the fact that part of the potash silicate in the raw mix is decomposed in the process of burning and also to the dilution of the dust by the addition of the volatilized potash.

² Loc. cit.

TABLE II—POTASH IN COAL ASHES

PLANT	Ash in coal Per cent	Potash in Percentage of Ash				Total Potash in Coal Per cent
		Water- soluble	Acid- soluble	Acid- insoluble	Total	
Atlas Portland Cement Co.	12.6	0.07	0.50	1.23	1.83	0.23
Alpha Portland Cement Co.	14.4	0.09	0.42	1.14	1.65	0.24
Clinchfield Portland Cement Co.	12.8	0.09	0.67	2.28	3.04	0.39
Security Cement and Lime Co.	7.8	0.04	0.61	1.41	2.06	0.16
Tidewater Portland Cement Co.	15.6	0.07	0.46	1.39	1.12	0.30

bination must therefore have taken place. The fact of the recombination of potash having thus been established, the following experiments were undertaken to determine the nature of the compound formed.

POSSIBLE FORMS OF POTASH COMBINATION

In the case of coal-fired kilns the potash that is volatilized in the hottest part of the kiln will first come in contact with the ash of the coal and the principal constituent elements of any dust that could be collected at this point should consist of the alkalies, aluminum, silicon, sulfur, oxygen, and carbon. As this dust passes from the kiln it would be diluted with lime and the other constituents occurring in the raw mix. It has long been known that when a mixture of the elements first mentioned is ignited in the proportions of about 25 parts of clay to 25 of soda to 3 of carbon and 15 of sulfur there is formed a sodium aluminum sulfosilicate known as ultramarine or artificial lapis lazuli. The natural product is represented by the formula $\text{Na}_4(\text{NaS}_3\text{Al})\text{Al}_2(\text{SiO}_4)_2$. Other related minerals are Hauynite, $\text{Na}_2\text{Ca}(\text{NaSO}_4\text{Al})\text{Al}_2(\text{SiO}_4)_3$, and Nöselite, $\text{Na}(\text{NaSO}_4\text{Al})\text{Al}_2(\text{SiO}_4)_3$.

Ultramarine is insoluble in water but is readily decomposed by dilute acids and is able to withstand a red heat when heated out of contact with lime. These properties of ultramarine and the method of its formation suggested the possibility at first that the recombined potash in cement dust may be an artificial compound analogous to the artificial sodalites, but having soda replaced by potash.

It is well known, however, that if the constituents used in making ultramarine are taken in such proportions, or ignited under such conditions that ultramarine is not formed, there is then obtained instead an amorphous product or glass. Ordinary glass is considered as an alkali silicate with a silicate of one or more bases, the alkali being sodium or potassium and the base usually calcium or lead. These are commonly used in the form of such raw materials as silica, lime, and the carbonate or sulfate of sodium or potassium. When the sulfate is used some carbon is also added as a reducing agent, which facilitates the liberation of the sulfur during the process of fusion. It is thus seen that the same constituents are to be found in the dust of the hottest zone of a cement kiln as are used in the manufacture of window or bottle glass, though not necessarily present in the proportions used for making glass.

The properties of the glass produced from the constituents mentioned depend entirely on the proportions taken. Increasing the alkali content of a glass increases the solubility of the alkali in the product, while an increase in the silica content has an opposite effect. For equal contents of silica the glass which contains the most lime and the least alkali is the most

resistant. A high proportion of lime with respect to the silica, however, would make a product insoluble in water but very soluble in acids. By varying the proportion of the constituents it is thus possible to prepare glasses in which the alkali present is mostly soluble in water, mostly acid-soluble, mostly insoluble in acids, or the glass may be of such nature that considerable amounts of any two or three of the forms of potash may be obtained. It would thus seem that it might be possible to calculate the solubility of the alkali in a glass from the proportion of the constituents taken, or *vice versa*, but we have not been able to locate any formula by which this may be done.

These considerations with regard to glass formation suggested another possible explanation of the nature of the recombined potash in cement dust, in addition to that already mentioned in discussing the sulfo-silicates. Owing to the extreme fineness of the potash-bearing portion of the dust no evidence respecting any of its combinations could be secured from a microchemical examination of the dust. The fact that the recombined potash is slowly hydrolyzed also precluded the possibility of separating it from the rest of the dust for chemical analysis. It was therefore decided to make a study of the subject in an indirect way by igniting artificial mixtures so prepared as to approximate in composition that of cement dust as it is found in different parts of the kiln.

COMBINATION OF POTASH IN ARTIFICIAL MIXTURES

In the zone of the kiln where the greater part of the potash is volatilized the latter will necessarily first come in contact with the ash of the burning coal in an atmosphere of sulfur dioxide and carbon dioxide. In the first set of experiments, 3 g. of ash were accordingly ignited with 0.9 g. of K_2O as potassium sulfate, at temperatures of 600°, 1000° and 1300°. The ignitions were repeated, using the same amount of potash in the form of the carbonate. The ignitions were all made in an open platinum dish in an oxidizing atmosphere. In a second set of experiments, 1.5 g. of carbon (lampblack) were thoroughly mixed with the corresponding mixtures used in the first set of experiments and ignited at the same temperatures in closed wrought-iron vessels shaped like a J. Lawrence Smith crucible. In this way the ignitions were made under reducing atmospheric conditions. Under cement kiln conditions, the ash-potash mixture as it passes through the kiln would be diluted, as already pointed out, with a new constituent in the form of lime. In a third set of experiments, 3 g. of lime (CaO) were therefore mixed with each of the mixtures described in the first and second set of experiments and the ignitions again carried out under the same conditions as before. The results obtained are given in Table III.

TABLE III—EFFECT OF LIME AND OF CARBON ON THE COMBINATION OF POTASH WITH COAL ASH

MIXTURE	K ₂ O in Percentage of Total in Mixture														
	Unignited			Ignited at 600°			Ignited at 1000°			Ignited at 1300°					
	Water-soluble			Water-soluble			Water-soluble			Water-soluble			Water-soluble		
	Acid - soluble, water-insoluble	Acid - insoluble		Acid - soluble, water-insoluble	Acid - insoluble		In residue	Volatilized	Total	Acid - soluble, water-insoluble	Acid - insoluble		In residue	Volatilized	Total
Ash + K ₂ SO ₄	94	2	4	90	5	5	60	0	60	35	5		3	9	12
Ash + K ₂ SO ₄ + Carbon.....	94	4	4	90	2	1	28	0	28	54	18		16	26	44
Ash + K ₂ SO ₄ + CaO.....	94	4	4	93	1	0	86	12	98	2	0		2	66	87
Ash + K ₂ SO ₄ + CaO + Carbon.....	94	4	4	92	1	0	44	6	50	40	10		49	41	90
Ash + K ₂ CO ₃	94	4	4	74	26	0	17	0	17	71	12		3	2	5
Ash + K ₂ CO ₃ + Carbon.....	94	4	4	73	27	0	29	0	29	38	24		24	15	39
Ash + K ₂ CO ₃ + CaO.....	94	4	4	95	5	0	86	14	100	0	0		28	65	90
Ash + K ₂ CO ₃ + CaO + Carbon.....	94	4	4	86	14	0	54	14	68	24	8		13	43	56
															4

The proportion of potash taken for the experiments listed in Table III amounted to about 20 per cent of the unignited ash and potassium carbonate (or potassium sulfate) mixtures, or about 10 per cent when the mixture also contains lime. This would represent about the maximum ratio of potash to coal ash that would ordinarily be met with in any cement kiln. With a view to testing out the effect of using a smaller proportion of potash, a second series of experiments was run, using one-third as much potash as in the first series. The results are given in Table IV.

The analyses for water-soluble and total potash in the different mixtures as given in Tables III and IV were made by the official methods of the Association of Official Agricultural Chemists. The acid-soluble potash was determined by boiling for 1/2 hr. in a 5 per cent hydrochloric acid solution, using 75 cc. of acid per gram of ash taken. For the determination of water-soluble potash the old Official Method was used rather than the one adopted last year, as the former was more convenient for our purpose. Both of these methods, as well as that used for the acid-soluble potash, are entirely arbitrary and duplicate results are not likely to agree very closely unless the analyses are carried out each time in exactly the same way. When making the analyses care was therefore taken to follow the same procedure in each case as closely as possible.

The proportion of potash volatilized was determined by noting the difference between the total potash taken and the total remaining in the residue. In a similar way the acid-insoluble potash was found by taking the difference between the total in the residue and that which was acid-soluble. In cases where the values obtained by difference are small, any small change in either of the original values will produce a comparatively large difference in the result. The experimental error for acid-insoluble and volatilized potash was therefore rather large when the values represented by these determinations were low. For higher values and also for those values obtained by direct analysis closely agreeing results were obtained.

An examination of the values given in Tables III and IV will show that the results obtained with potassium sulfate did not differ in any very marked manner from those obtained with the carbonate, particularly when the ignitions were made at the higher temperatures. At 600° with the ash-potash mixture the carbonate is more reactive than the sulfate, but a noticeable combination takes place with both salts even at this temperature. At 1000° the extent of combination is

much more marked than at 600°, and at 1300° this is still greater than at 1000°. This tendency of the potash to combine with coal ash is so great that little or no loss of the former may occur even when ignited at 1300° for 40 min. It is to be noted also that in every case the extent of the combination was greater when the lower proportion of potash was used in the mixture.

The effect of adding carbon to the ash-potash mixture did not seem to have any pronounced effect on the results when considered as a whole. In this set of experiments, as in the first, the carbonate was more reactive than the sulfate at 600°, but both salts behaved in much the same way for the other temperatures. This would indicate that the potash combination is in the nature of a potash slag or impure glass rather than a sulfo-silicate. To test out the effect of using a siliceous material known to be entirely free from sulfur, a portion of the ash was ignited with carbon, treated with dilute hydrochloric acid, and the residue, which was then washed and dried, was ignited with potassium carbonate with and without carbon. Essentially the same results were obtained as before. These experiments thus furnish no evidence in favor of the view that the recombined potash in cement dust is in the nature of a sulfo-silicate.

The time of ignition of the experiments listed in Tables III and IV was 40 min. It was found, however, that the time of ignition could be shortened somewhat without much change in the results. Thus when the ash-potassium sulfate mixture given in Table IV was ignited for 10, 20, 30, and 40 min. the proportion of the added potash that underwent combination amounted to 82, 89, 91, and 93 per cent, respectively.

The addition of lime to the ash-potash mixture, as shown in Tables III and IV, brought about a decided change in the results as was to be expected. This basic constituent being less volatile than the alkalis, is able to replace the latter in their combinations with siliceous materials when ignitions of the mixtures are made at a sufficiently high temperature. It thus happened that the same results were obtained when coal ash and potassium sulfate (or carbonate) were first ignited at 1000° alone and then subsequently at the same temperature with lime as when but one ignition was made of all three compounds. In both cases the greater part of the potash remained or was obtained in a water-soluble form. In this set of experiments, however, as in the case of those made with ash and potash alone, the proportion of water-soluble potash in the

TABLE IV—EFFECT OF LIME AND OF CARBON ON THE COMBINATION OF POTASH WITH COAL ASH

MIXTURE	K ₂ O in Percentage of Total in Mixture															
	Unignited			Ignited at 600°			Ignited at 1000°			Ignited at 1300°						
	Water-soluble	Acid-soluble, water-insoluble	Acid-insoluble	Water-soluble	Acid-soluble, water-insoluble	Acid-insoluble	Water-soluble			Acid-soluble, water-insoluble	Acid-insoluble	Water-soluble			Acid-soluble, water-insoluble	Acid-insoluble
							In residue	Volatilized	Total			In residue	Volatilized	Total		
Ash + K ₂ SO ₄	84	4	12	59	16	25	12	37	51	2	10	12	52	36	8	
Ash + K ₂ SO ₄ + Carbon.....	84	4	12	66	12	22	11	0	11	31	58	2	19	21	71	
Ash + K ₂ SO ₄ + CaO.....	84	4	12	79	1	20	62	0	62	38	0	91	54	9	37	
Ash + CaO + K ₂ SO ₄ + Carbon.....	84	4	12	71	7	22	32	0	32	47	21	26	39	65	14	
Ash + K ₂ CO ₃	84	4	12	47	46	7	4	0	4	84	12	2	1	3	45	
Ash + K ₂ CO ₃ + Carbon.....	84	4	12	43	55	2	5	0	5	82	13	0	3	2	51	
Ash + K ₂ CO ₃ + CaO.....	84	4	12	68	24	8	34	0	34	66	0	29	54	82	17	
Ash + K ₂ CO ₃ + CaO + Carbon.....	84	4	12	66	22	12	44	0	44	39	17	39	34	72	25	

ignited residue was less with the lower than with the higher percentage of potash in the mixture.

When carbon was added to the ash-potash-lime mixtures, the proportion of water-soluble potash remaining after ignition was then found to be considerably below the corresponding values obtained without carbon. The effect of the carbon was thus to diminish the action of the lime in setting free or keeping in a water-soluble form the potash in the mixture. It was observed that ignition at 1300° for 40 min. reduced the ash-potash-lime mixture to a hard clinker, but when carbon was added and the mixture ignited as before in a closed vessel it remained as a powder and no clinkering whatever took place. It would seem therefore that the presence of the carbon serves as a protective coating between the lime and the other constituents, thus diminishing at the same time the sintering of the mass and the action of the lime on the alkali silicates.

Further evidence in support of this view was furnished by igniting both with and without carbon a mixture of feldspar and lime in the proper proportion to make cement. Both mixtures were ignited for 1/2 hr. at the same temperature (1300°) in similar wrought-iron containers, excepting that the one containing the carbon was loosely closed at the top while the other was left open. After ignition, the carbon-free residue was found to be clinkered to a hard mass, while that containing the carbon remained as a fine powder. An analysis of each residue for water-soluble, acid-soluble, and acid-insoluble potash showed, as indicated in Table V, that the feldspar was decomposed to a much greater extent in the carbon-free mixture than in that to which carbon was added.

TABLE V—DECOMPOSITION OF FELDSPAR BY IGNITION WITH LIME WITH AND WITHOUT CARBON

MIXTURE	K ₂ O in Percentage of Total in Mixture				
	In resi- due	Volatil- ized	Total	Acid-soluble, water-in- soluble	Acid-insol- ible
Feldspar + CaO.....	20.0	75.4	95.4	4.6	0.0
Feldspar + CaO + Carbon.....	23.5	18.2	41.7	43.4	14.9

This action of the carbon in decreasing the proportion of water-soluble potash furnishes an explanation of the results obtained by one of us when the Security and Cementon dusts were ignited first in open and then in closed vessels.¹ The latter dust differed from the former in containing a comparatively high percentage of free carbon amounting to 9.26 per cent of the dust. In the case of ignition in open vessels any carbon present would be burned off, limestone would be reduced to the oxide, and in the light of the results

obtained with the prepared mixtures it would be expected that a greater or smaller proportion of the recombined potash would therefore be set free, depending on the amount originally present. This was found to be true, for in the case of the Security dust, which contained 6.3 per cent of water-soluble and 11.4 per cent of total potash, the potash which was water-soluble was increased by ignition in an oxidizing atmosphere at 850° from 60 per cent to 95 per cent of the total present. The water-soluble potash in a sample of the Cementon dust on the other hand, which contained only 2.9 per cent of water-soluble and 7.0 per cent of total potash, was increased only from 41 to 73 per cent of the total by the same treatment.

The results obtained with the prepared mixtures also indicate that when a cement dust containing carbon is ignited in a closed vessel there would be less water-soluble potash in the residue than when ignited in an oxidizing atmosphere and that whether the treatment will actually bring about an increase or decrease in the water-soluble potash will depend on the relative proportion of water-soluble to recombined potash originally present in the dust. The experimental results in this case were likewise found to be in agreement with what was predicted. Thus when the Cementon dust, containing originally 9.6 per cent of free carbon, was ignited at 850° for 40 min., the water-soluble potash was actually decreased from 41 to 30 per cent of the total, while in the richer Security dust when the same amount of carbon was added and ignited in the same way the water-soluble potash was increased from 60 to 65.4 per cent.

In view of the foregoing observations it would seem probable that the proportion of recombined potash in those dusts which contain free carbon might be reduced to some extent if more of an oxidizing atmosphere were maintained in the kilns during the burning of the cement.

From the experiments described it might also be predicted that the addition to the raw mix of a salt of sodium, as sodium chloride, would bring about a reduction of the recombined potash as has actually been observed at the plant of the Security Cement and Lime Company. It is known that when sodium chloride is ignited with feldspar a replacement of the potash in the feldspar by the soda takes place,¹ showing that the sodium aluminum silicate formed is more stable when ignited with potash than is the corresponding potash salt in the presence of soda. When sodium chloride

¹ A. R. Merz, THIS JOURNAL, 10 (1918), 106.¹ H. P. Bassett, U. S. Patent No. 1,072,686.

occurs in the dust of a cement kiln there is, therefore, likely to be a replacement of the recombined potash in a way analogous to that brought about by lime.

RECOMBINATION OF VOLATILIZED POTASH WITH THE SILICEOUS PARTICLES OF THE RAW MIX

As already pointed out in Tables III and IV, very little combination of potash with coal ash takes place in the carbon-free mixtures when lime is present and the proportion combined is less in the higher than in the lower potash mixtures. It would be expected, therefore, that since lime is intimately mixed with the silicates of the raw mix in cement manufacture there would be only a limited recombination, in an oxidizing atmosphere, of the volatilized potash with the siliceous particles of the raw mix. In the presence of carbon the extent of recombination might be expected to be somewhat greater. To gain further experimental evidence on this point portions of a sample of raw mix from the Security Cement and Lime Company were ignited at 1000° to drive off carbon dioxide and then with different proportions of potassium sulfate with and without carbon. The results, as shown in Table VI, are in keeping with what was expected from the preceding experiments.

TABLE VI—COMBINATION OF POTASH ON IGNITION WITH CEMENT RAW MIX

MIXTURE	K ₂ O in Percentage of Total in Mixture—					
	Before Ignition—			After Ignition—		
	Water-soluble	Acid-insoluble	Acid-soluble	Water-soluble	Acid-insoluble	Acid-soluble
Raw Mix + K ₂ SO ₄	96.4	2.0	1.6	93.3	7.3	0.3
Raw Mix + Carbon.....	96.4	2.0	1.6	83.0	15.5	1.5
Raw Mix + K ₂ SO ₄	90.1	5.6	4.3	76.8	21.4	1.8
Raw Mix + Carbon.....	90.1	5.6	4.3	30.3	64.3	5.4

Further evidence with regard to the recombination of volatilized potash with the raw mix was shown in experiments with dust from the Riverside Portland Cement Company, where oil is used for fuel. The total potash in the sample amounted to 10.65 per cent of the dust and the water-soluble potash to 91.61 per cent of the total. On igniting the dust alone at 1000° for 40 min. there was an actual increase in water-soluble potash which now amounted to 94.8 per cent of the total. When ignited with carbon, however, the water-soluble potash decreased to 70.4 per cent of the

TABLE VII—RECOMBINATION OF POTASH IN RIVERSIDE DUST WITH AND WITHOUT ADDED COAL ASH

MIXTURE	K ₂ O in Percentage of Total in Mixture—							
	Unignited—			Ignited at 1000°—				
	Water-soluble	Acid-soluble	Acid-insoluble	Water-soluble				
				In residue	Volatilized	Total	Acid-soluble	Acid-insoluble
Riverside dust + Carbon.....	91.6	6.9	1.5	94.8	3.3	98.1	1.9	0.0
Riverside dust + Carbon.....	91.6	6.9	1.5	70.4	6.9	77.3	10.2	12.5
Riverside dust + Ash.....	78.3	9.4	12.3	62.9	1.2	64.1	27.1	8.8
Riverside dust + Ash + Carbon.....	78.3	9.4	12.3	9.6	5.2	14.3	79.7	5.3
Riverside dust + 1/2 Ash.....	86.7	7.8	5.5	86.8	3.5	90.3	9.7	0.0
Riverside dust + 1/2 Ash + Carbon.....	86.7	7.8	5.5	70.0	7.0	77.0	20.4	2.6

total, showing that a combination took place to some extent between the soluble potash naturally occurring in the dust with the siliceous material which originally came from the raw mix. When the acidity of the dust was increased by the addition of coal ash and the mixture ignited as before, the extent of the recombination of the potash in the dust was much more marked, as was anticipated, than in the corresponding experiments

without ash. This is shown by the values given in Table VII which represent the results obtained when one part of dust was ignited with an equal weight of dust alone and than with 1/2 part of carbon.

ACID-SOLUBLE POTASH FROM PARTIALLY DECOMPOSED SILICATES IN THE DUST

In the dust from a cement plant there may be found different particles that have been subjected to all the variations of temperature that prevail in the different parts of the kiln. It thus happens that of those potash silicates which ultimately are carried over into the dust a certain fraction has been ignited sufficiently to be completely decomposed, while a further portion has undergone no decomposition at all. Between these extremes are to be found silicates which have been subjected to intermediate temperatures of burning and in consequence must have undergone a more or less partial decomposition. It therefore occurred to us that while the potash in such partially decomposed silicates might not be readily water-soluble, it might, however, be slowly water-soluble or readily soluble in acids and thus behave in a way similar to the recombined potash of cement dust. To test this point, uniform mixtures of feldspar and lime in the right proportion to make cement were ignited in a platinum dish for different lengths of time at 1000°, and again at 1300°.

TABLE VIII—SOLUBILITY OF POTASH IN FELDSPAR PARTIALLY DECOMPOSED BY IGNITION WITH LIME

Time of Ignition Min	K ₂ O in Percentage of Total in Mixture—							
	Ignited at 1000°—				Ignited at 1300°—			
	Water-soluble	Acid-soluble	Acid-insoluble	In residue	Water-soluble	Acid-soluble	Acid-insoluble	In residue
15.....	10.5	33.2	56.3	34.0	8.6	52.6	55.1	2.3
30.....	9.4	43.0	47.6	32.8	57.8	90.6	7.4	2.0
45.....	7.8	50.8	41.4	8.2	89.1	97.3	2.7	0.0

It was found, as shown by the results given in Table VIII, that the residue obtained in each experiment contained both water- and acid-soluble potash. When the ignition was made at 1300° for 45 min. the greater part of the potash was volatilized and no acid-insoluble potash remained in the residue. When ignited at 1000° the residue contained some acid-insoluble potash, but the greater part was in a form soluble in dilute acid but insoluble in water. It may be concluded, therefore, that the greater part of the acid-soluble potash in the dust from oil- or gas-fired kilns is due to a partial decomposition of the potash silicates originally occurring in the raw mix. In the dust from coal-fired kilns a corresponding percentage of the potash will be acid-soluble for the same reason; but because the quantity of this potash is limited by the total in the raw mix and also because of the recombined potash that may be present, this acid-soluble potash, due to the partially decomposed silicate, may amount to only a comparatively small percentage of the total acid-soluble potash present in the dust.

SUMMARY

1—The water-soluble potash in cement dust owes its source (a) to the volatilization of potash in the burning of the cement, (b) to the decomposition of pot-

ash silicates of the raw mix carried over mechanically in the dust, and (c), in the case of coal-fired kilns, to the ash of the coal which may yield up a portion of its potash through the action of the lime in the dust. The first-mentioned source is ordinarily much the most important.

2—The water-insoluble but acid-soluble potash of cement dust is due (a) to a recombination of a portion of the volatilized potash with the ash of the coal used for fuel, (b) to a recombination to a much smaller extent, and only under certain conditions, with the siliceous material originally occurring in the raw mix, and (c), to a partial decomposition of the silicates of the raw mix and also of any coal ash which is carried over mechanically in the dust.

3—The acid-insoluble potash in cement dust is due to undecomposed silicates and coal ash carried over mechanically in the dust and to a recombination of the volatilized potash with the ash of the coal when the amount volatilized is low.

4—The portion of the potash in the dust which has undergone recombination is of the nature of a potash slag or impure glass. When the amount of potash volatilized is low, and particularly in the presence of carbon, some recombination may take place with the siliceous material of the raw mix as well as that of the ash.

5—It is probable that the extent of the recombination would be reduced if the burning of the cement were done under oxidizing rather than reducing atmospheric conditions.

6—The extent of recombination would also probably be reduced by any procedure that would introduce lime or sodium chloride into the dust at the hot-test part of the kiln.

7—The greater the amount of potash volatilized, the lower will be the proportion that will undergo recombination in the dust.

BUREAU OF SOILS
U. S. DEPT. OF AGRICULTURE
WASHINGTON, D. C.

LABORATORY AND PLANT

RESULTS OF FURTHER COOPERATIVE WORK ON THE DETERMINATION OF SULFUR IN PYRITE CHECK SAMPLE NO. 4¹

By H. C. MOORE

The July 1915 and December 1916 numbers of THIS JOURNAL contain reports of the cooperative analyses of pyrite for sulfur. This report may be regarded as covering a continuation of the work described in the former reports.

The first two reports pointed out anew several sources of error in this determination, especially in connection with the Lunge method and its various modifications. They also proved the Allen and Bishop Method to be practically free from these errors, and the results by

this latter method to be much nearer the truth, and while the discrepancy between the maximum and minimum results was rather wide, by excepting a few results, evidently extreme, the agreement was uniformly better.

The purpose of the investigation covered by this report was to continue the work, using only one sample, to invite a larger number of laboratories to participate, to search for the weaknesses, if any, in the Allen and Bishop Method, and to acquaint a larger number of analysts with this method. There was a very generous response to the invitation, and results were received from thirty-nine (39) laboratories, including the work of fifty-one (51) analysts, as follows:¹

C. Clifton Howes
J. M. Coleman
W. E. Dickinson
Gascoyne and Company
Paul Rudnick (analysts W. J. Imig, R. A. Greene)
J. O. Holbrook
Wiley and Company
F. F. Chapman
L. C. Drefahl (results from eight (8) branch laboratories)
P. R. Sabin
W. R. Austin and F. K. Wanner
W. S. Allen (results of four analysts)
C. A. Butt
E. Fitzpatrick (results of two analysts)
W. J. Rattle and Son
A. Stanley Fox
C. C. Nitche
V. A. Moore
Harry Johnson
J. A. Root
Crowell and Murray
W. D. Richardson (result of four analysts)
C. B. McComas
F. J. Bartholomew
McCandless Laboratory
M. H. Coblenz
E. W. Magruder and J. H. Parkins
C. N. Hoadley
Hargree Chambliss
H. M. George
N. F. Burg
H. C. Moore
R. D. Caldwell
H. M. Hutson
J. D. Clark, Jr.
S. Brown

Davison Chemical Company
Planters Fert. and Chem. Company
International Agl. Corporation
Gay Street
Armour and Company
Southern Fert. and Chem. Company
Gay Street
E. L. du Pont de Nemours and Company
Grasselli Chemical Company

American Zinc Company of Illinois
Tennessee Chemical Company
General Chemical Company
International Agl. Corporation
Nichols Copper Company
501 Commercial Bank Building
Aetna Explosives Company
Mineral Point Zinc Company
Armour Fertilizer Works
Standard Oil Company
Anaconda Copper Mining Company
406-11 Perry-Payne Building
Swift and Company
Armour Fertilizer Works
N. J. Zinc Company of Illinois
Rhodes Building
F. S. Royster Guano Company
F. S. Royster Guano Company
Mountain Copper Company
Commercial Acid Company
Empire Zinc Company
Butterworth-Judson Company
Armour Fertilizer Works
Armour Fertilizer Works
Armour Fertilizer Works
Armour Fertilizer Works
Armour Fertilizer Works

Baltimore, Md.
New Orleans, La.
Columbia, Tenn.
Baltimore, Md.
Chicago, Ill.
Savannah, Ga.
Baltimore, Md.
Wilmington, Del.
Cleveland, Ohio
E. St. Louis, Ill.
Nashville, Tenn.
Laurel Hill, N. Y.
Atlanta, Ga.
Laurel Hill, N. Y.
Cleveland, Ohio
New York, N. Y.
Depue, Ill.
Chrome, N. J.
Bayonne, N. J.
Anaconda, Mont.
Cleveland, Ohio
Chicago, Ill.
Baltimore, Md.
Palmerton, Pa.
Atlanta, Ga.
Macon, Ga.
Norfolk, Va.
Martinez, Cal.
E. St. Louis, Ill.
Canon City, Col.
New York, N. Y.
Atlanta, Ga.
Atlanta, Ga.
Atlanta, Ga.
Atlanta, Ga.
Atlanta, Ga.

¹ Presented before the Fertilizer Division at the 56th Meeting of the American Chemical Society, Cleveland, September 10 to 13, 1918.

¹ Not listed in the same order as given in the subsequent tabulation of results.

The sample used for this work, designated as Check Sample No. 4, is a Canadian pyrite. A large sample was ground to pass an 80-mesh screen and very carefully mixed for a considerable length of time so as to insure uniformity. The sample was then spread out in a thin layer and individual bottles filled by taking small portions from several places. The bottles were tightly stoppered and sealed. It is confidently believed that the samples sent out were uniform and that discrepancies in results are not due to non-uniformity of samples. This opinion is confirmed in part by the results obtained by five analysts in this laboratory on five separate sealed portions, which results appear in Table II. This opinion is further confirmed by the fact that the agreement between most of the laboratories familiar with the modified Allen and Bishop method is very close.

The instructions accompanying the sample were as follows:

**INSTRUCTIONS FOR COLLABORATORS IN COÖPERATIVE
WORK ON THE DETERMINATION OF SULFUR IN PYRITE**

SAMPLE

The sample for this work is marked No. 4, is a sample of Canadian ore, and has been ground to pass an 80-mesh screen and requires no further preparation.

MOISTURE

Dry 5 g. in an oven at 100° C. for one hour.

SULFUR

METHOD 1. MODIFIED ALLEN AND BISHOP METHOD—Transfer 0.5495 g. to a tall form beaker, 300 to 400 cc. capacity, and add 6 to 8 cc. of a mixture of 2 parts by volume of liquid bromine and 3 parts carbon tetrachloride. Cover beaker, and after allowing to stand for 15 min. at room temperature, with occasional shaking, add 10 cc. concentrated nitric acid and let stand at room temperature with occasional shaking for 15 min. longer. Heat below 100° (placing beaker on a piece of asbestos on top of the steam bath is convenient), until all action has ceased and most of the bromine has been expelled. Now place the beaker in the rings of the steam bath and evaporate to dryness. (Evaporation is greatly hastened by raising the cover glass with one or more bent glass rods.) Cover residue with 10 cc. concentrated hydrochloric acid and again evaporate to dryness, keeping beaker covered as before.

DEHYDRATE THE SILICA by leaving the beaker on the steam bath, or in an air bath at 100° C. for from 1/2 to 1 hr.

EFFECT SOLUTION by moistening the residue with 1 cc. concentrated hydrochloric acid followed by 50 cc. hot water and rinse down cover, riders, and sides of beaker. Remove riders, replace cover glass, and warm until solution is complete. Then allow to cool for about 3 min.

REDUCE IRON by adding 0.1 g. of powdered aluminum and shaking beaker (covered) to thoroughly mix with the liquid. (Sufficient aluminum powder must be added for complete reduction of the iron but any considerable excess is to be avoided. Subsequent filtration is facilitated by having the excess aluminum small.) When reduction to ferrous iron is complete, as indicated by the color of the solution, and the latter has cooled sufficiently so that no "misting" is noted in the beaker, rinse down cover glass and sides of beaker.

FILTER to remove insoluble matter, or excess aluminum powder, through an 11 cm. or 12 1/2 cm. paper (B and A, grade A, S and S 590, or Munkelt No. 0) into an 800 cc. beaker and wash the residue thoroughly with hot water.

DILUTE the filtrate to a volume of 650 cc. with cold water,

add 2 1/2 cc. concentrated hydrochloric acid, and stir to mix thoroughly.

PRECIPITATE sulfate by adding 50 cc. of cold 5 per cent barium chloride solution, without stirring, and in single drops at the rate of about 5 cc. per min. A precipitating cup, designed by Allen and Bishop, or a capillary tube connected to a burette or suitable container is convenient for this purpose. When the barium chloride has been added, mix the solution by stirring, and let settle for 2 hrs. or, preferably, over night.

FILTER through a No. 4 porcelain Gooch crucible (35 cc. capacity) having a fixed bottom and packed with a thick layer of asbestos. After the clear liquid has run through the filter, rinse the precipitate into the crucible by means of a stream of cold water, thoroughly police the inside of the beaker and after transferring all of the precipitate wash 6 times in the crucible with cold water.

DRY THE PRECIPITATE in the drying oven for about 1 1/2 hr. A longer period of drying is a protection against breaking the crucible during the subsequent ignition, also against spattering of the precipitate.

IGNITE THE PRECIPITATE by heating the crucible in a moderate flame for a minute or two, then igniting to constant weight over the full flame of a Fletcher, Meeker, or similar burner, or in an electric furnace at 1600° F.

THE PER CENT OF SULFUR is found by dividing the weight in grams of barium sulfate by 4 and multiplying by 100.

NOTE—An electric hot plate, having suitable temperature control, is a convenient substitute for a steam bath, but the surface temperature of the plate should not much exceed 100° C. else some of the free sulfuric acid is lost by volatilization.

METHOD II—Follow your usual methods and describe briefly the details used.

NOTES

1—Run a blank test to determine and correct for any sulfur present in the reagents used. The bromine and carbon tetrachloride should be tested before using, as some lots of these reagents marked C. P. have been found to contain considerable amounts of sulfur compounds. Baker and Adamson's make of these reagents, marked pure, and specified to be free from sulfur compounds, have been found satisfactory.

2—For packing Gooch crucibles, long fibered Italian asbestos (if obtainable) which has been prepared by scraping up into lint and digesting with strong hydrochloric acid to remove impurities, is especially recommended.

3—The method of Allen and Bishop as originally presented by the authors may be found among the original communications, *Eighth International Congress of Applied Chemistry*, Vol. 1, pp. 33 to 51.

4—When igniting the barium sulfate it is advisable to observe the precaution proposed by Folin.¹ To avoid mechanical loss the crucible should be provided with a cover and bottom. If a porcelain Gooch crucible is used the cover for a platinum crucible may serve as a bottom, the crucible resting on the platinum lid which is supported by a triangle. The flame is applied to the platinum lid. Folin states that unless this precaution is observed, mechanical loss of barium sulfate follows.

REMARKS

1—Please supplement your report with any comments you care to make.

2—When reporting results please give individual results as well as averages and in order that there may be no misunderstanding report moisture, sulfur (wet basis), and sulfur (dry basis).

3—Please state whether or not you have had previous experience with the Allen and Bishop method, either as originally proposed or as slightly modified under Method I above. Also state if you have found any difficulties or objectionable features

¹ *J. Biol. Chem.*, 1 (1906), 149.

TABLE I—PYRITE CHECK SAMPLE No. 4 PER CENT SULFUR ON DRY BASIS

ANALYST No.	H ₂ O Per cent	Mod. A. and B.	Orig. Mod. A. and B.	Misc. A. and B.	Mod. Misc.	ANALYST No.	H ₂ O Per cent	Mod. A. and B.	Orig. Mod. A. and B.	Mod. Lungue	Misc. A. and B.	Mod. Misc.
1.....	0.02	41.28	41.31	...	...	34.....	0.21	41.92	...	...	...	...
2.....	0.14	41.42	41.09	...	...	35.....	0.24	41.92	...	42.14	...	...
3.....	0.23	41.44	...	...	41.27(a)	36.....	0.16	41.96	...	41.30	...	41.78(k)
4.....	0.24	41.49	...	41.39(b)	...	37.....	0.25	41.96	...	41.54	...	...
5.....	0.22	41.51	...	...	...	38.....	0.12	41.98	41.90	...	...	...
6.....	...	41.53	41.60	...	41.35(c)	39.....	0.12	41.99	...	41.49	...	...
7.....	0.20	41.53	...	...	...	40.....	0.19	41.99	...	41.17	...	...
8.....	0.21	41.54	41.56	...	...	41.....	0.13	42.03	...	40.06(m)(s)	41.02(n)	42.34(j)
9.....	...	41.55	...	...	41.62(d)	42.....	0.07	42.09	42.15	...	...	...
10.....	0.17	41.60	41.63	...	41.66(e)	43.....	0.18	42.31	42.18	...	...	...
11.....	0.21	41.66	...	...	41.94(f)	44.....	0.08	42.36	41.95	...	...	...
12.....	0.16	41.68	...	40.90(g)(s)	41.40(h)	45.....	0.25	...	...	...	...	...
13.....	0.18	41.68	...	...	...	46.....	0.11	42.50	...	40.96(p)	...	42.34(o)
14.....	0.18	41.68	41.78	...	...	47.....	0.17	...	...	...	...	41.90(q)
15.....	0.21	41.69	...	...	...	48.....	0.03	...	41.51	...	...	...
16.....	0.27	41.70	41.65	...	...	49.....	0.23	...	...	41.51	41.25(r)	...
17.....	0.17	41.71	...	...	...	50.....	0.12	...	...	...	...	...
18.....	0.21	41.71	...	...	...	51.....	0.10	...	41.71	...	...	...
19.....	0.13	41.71	41.84	...	...	AVERAGE.	0.16	...	...	...	...	...
20.....	0.23	41.72	...	...	...	SUMMARY OF RESULTS OBTAINED BY 51 ANALYSTS IN 39 LABORATORIES						
21.....	0.16	41.73	41.51	...	...	Method of Analysis						
22.....	0.21	41.73	...	...	41.89(c)	Allen and Bishop						
23.....	0.17	41.74	...	...	41.99(j)	Mod. Orig. Mod. A. and B. Lungue						
24.....	0.17	41.76	...	...	...	No. analysts.....						
25.....	0.22	41.77	...	...	...	No. laboratories.....						
26.....	0.12	41.79	41.74	...	...	Maximum.....						
27.....	0.02	41.81	41.74	...	...	Minimum.....						
28.....	0.13	41.81	41.78	...	...	Average.....						
29.....	0.10	41.83	41.69	...	...	It is interesting to note that of the 46 results reported by the modified Allen and Bishop method:						
30.....	0.12	41.86	...	...	...	36 are between 41.50 and 42.00 incl. and average 41.82						
31.....	0.16	41.86	...	41.79(j)	...	22 are between 41.60 and 41.90 incl. and average 41.74						
32.....	0.10	41.92	41.73	...	...	19 are between 41.65 and 41.85 incl. and average 41.73						
33.....	0.12	41.92	41.59	...	...	(a) 0.5 g. in 250 cc. copper assay flask with 10 cc. H ₂ O, 10 cc. CCl ₄ , 15 cc. each HCl and HNO ₃ saturated with bromine and all at 40° and let stand at room temperature for 15 min. Heat very gradually and evaporate to 5 cc. Add 5 cc. HCl and 5 g. NH ₄ Cl and heat until bubbling ceases. Add 5 cc. HCl, 25 cc. H ₂ O, boil, filter, dilute to 200 cc., and to this solution heated to boiling, add slowly 25 cc. of a boiling solution of 10 per cent barium chloride and 150 cc. H ₂ O. Boil 5 min., settle 45 min in warm place, filter, etc., Wt. = percent S.						

(c) Practically same as modified A. and B. except CCl₄ omitted and precipitation done in smaller volume.

(d) Nitro-hydrochloric acid together with bromine and CCl₄ used to effect solution and then analysis completed by Lungue method.

(e) No details of method given.

(f) 0.5 g. dissolved in 30 cc. HNO₃, 10 cc. HCl, and 0.2 to 0.3 g. KClO₄ in 325 cc. Kjeldahl flask. Room temperature at first, finally increasing heat until residue is paste, add 10 cc. HCl and evaporate as before, repeat twice. Add 2 cc. HCl and 50 cc. water, reduce with aluminum powder, and finish as by modified A. and B.

(g) Same as (e) except using NaBrO₃ instead of KClO₄.

(h) Solution by Lungue method using HNO₃ and HCl.

(i) Solution by A. and B. method, completing analysis by Lungue method.

(j) Average of results by (a) modifications of combined A. and B. and regular method.

(k) 0.5 g. in No. 3 beaker, add few drops H₂O and 1 g. KClO₄ and mix. Add 20 cc. HNO₃, cover cold 20 min., then add 20 cc. nitric chloride mixture and place on steam plate and heat until solution is complete. Rinse down cover and sides of beaker and evaporate to dryness. Evaporate twice more with HCl. Add 25 cc. 1:3 HCl and heat for 40

min. Filter and make ammoniacal while hot but do not heat. Have volume 300 cc. and add excess BaCl₂ solution. Add HCl to dissolve iron precipitate and stir thoroughly, but do not boil. Let stand overnight, filter, etc.

(l) 0.2727 g. dissolved in 250 cc. beaker about same as in (j) and after evaporation take up in 12 cc. HCl and heat until foaming ceases. Then dilute until beaker is about 7/8 full, heat and precipitate with 25 cc. hot 10% BaCl₂ solution. Boil few minutes and filter after 1/2 hr.

(m) 0.625 g. in 250 cc. flask, 1/2 to 1 cc. bromine added, 15 cc. HNO₃ and 5 cc. HCl. Let stand at room temperature for about 15 min., and heat 2-3 hrs. on water bath. Add 25 cc. HCl, heat until solution is complete, make to volume and take 100 cc. aliquot, dilute to about 250 cc., nearly neutralize with NH₄OH, boil, add NH₄OH to slight excess, boil off excess of NH₃, add BaCl₂ slowly with stirring, and boil a few minutes. Add slowly excess HCl, boil few minutes, and let stand 3 to 5 hrs. or overnight, filter, etc.

(n) Modified Lungue method solution in HNO₃ and HCl.

(o) Same as (n) except bromine added with HNO₃ and HCl.

(p) Same as (o) except used 0.5 g. sample.

(q) Same as (m) except made solution in HNO₃, HCl, and KClO₄.

(r) No description given of method used.

(s) Sample dissolved in 1/2 g. KClO₄ and 10 g. HNO₃ saturated with KClO₄, cover beaker, and quickly bring to boil. Evaporate finally at low heat. Evaporate again with 10 cc. HCl. Take up with 2 cc. HCl and 60 to 75 cc. H₂O, and reduce iron with granular aluminum. Filter and dilute to 300 cc., add 5 cc. HCl, boil and precipitate hot with 10 per cent BaCl₂ solution, add slowly and with stirring. Let settle 1 1/2 hrs., filter, etc.

(t) Omitted from average.

in this method and how you regard it as compared to other methods.

4—Considerable time and work are required to properly arrange and classify a large number of results for easy reference and you are urgently requested to make your report by August 1 or as soon thereafter as possible.

ATLANTA, GA., June 1917

The results received from the thirty-nine (39) laboratories appear in Table I.

It is somewhat disappointing that the discrepancy between the maximum and minimum results by the modified Allen and Bishop method is so great, but as noted in the Summary of Table I, by omitting the extreme results, the agreement becomes very good indeed, and the average remains practically the same. It may be further stated that the results of those analysts who are thoroughly familiar with the original or the modified Allen and Bishop method are in very close agreement. The variation from the average by the modified Allen and Bishop method was, with but very few exceptions, not to exceed, plus or minus, 0.25 per cent sulfur. While the maximum discrepancy by the Lungue method is not so great as by the modified

Allen and Bishop method, yet the agreement by the latter method, with few exceptions, is much closer. It seems to be true in this case, as in most others which the writer has observed, that in the analysis of check samples, when the same method or apparently the same details of analysis are employed, elimination of a few of the extreme results does not affect the average.

The reasons for the discrepancies by the original or modified Allen and Bishop method have not been apparent. Except in a few cases, the observance of the following recommendations will probably eliminate most of these:

1—In the oxidation and solution of the sample the initial reaction should not be allowed to proceed too rapidly and sufficient time should be allowed to elapse after adding the bromine and carbon tetrachloride mixture. Several have recommended that the time of standing be increased from 15 to 30 min. It has also been shown that evaporation at too high temperature and allowing the beaker to remain on the hot plate at this high temperature causes loss of free sulfuric acid.

2—Carbon tetrachloride and some lots of bromine often contain some sulfur compounds, causing high blanks which are undesirable. Several have recom-

mended that glacial acetic acid be substituted for carbon tetrachloride as a carrier for the bromine, as this can be obtained absolutely free from sulfur more generally than carbon tetrachloride.

3—Care should be taken in the ignition of the barium sulfate in Gooch crucibles. One laboratory reported a long series of results showing the effect of different periods of heating, indicating clearly that barium sulfate underwent decomposition. This is probably true only in rare cases. Some laboratories observe the precaution, after the ignition of the barium sulfate, of adding a drop or two of strong sulfuric acid and again igniting. One laboratory reported a long series of results, showing a continued loss in weight following several periods of ignition. Folin¹ refers to this and recommends that when Gooch crucibles are used, they be protected from direct action of the flame by setting the crucible on a platinum lid or some similar arrangement. Ignition in this manner and over a direct flame have yielded the same results in our laboratory. It seems likely that the error in personal manipulation is the cause of some of the discrepancies in the extreme results, though just how, or at what stage in the analytical procedure, is not known. In this laboratory uniform results have always been obtained both by the original and modified Allen and Bishop methods, the latter being preferred. The figures in Table II illustrate this uniformity.

TABLE II—RESULTS OBTAINED ON PYRITE SAMPLE No. 4 IN LABORATORY OF ARMOUR FERTILIZER WORKS, ATLANTA, BY THE MODIFIED ALLEN AND BISHOP METHOD

By whom analyzed, etc. ¹	H ₂ O Per cent	Sulfur (DB) Per cent
Analyst "A".....	0.21	41.69
Thoroughly familiar with method.....		41.68
		41.65
		41.68
		41.68
		41.74
		41.72
Analyst "B".....	0.18	41.71
Man who makes most of the sulfur determinations.....		41.67
		41.67
		41.63
Analyst "C".....	0.21	41.68
Had made previously a few determinations by this method.....		41.69
		41.75
Analyst "D".....	0.17	41.68
A new man who had never seen or used the method before but who had used the Lunge method.....		41.81
		41.81
Analyst "E".....	0.17	41.67
A colored helper who has only once before made a determination by this method. He is a careful worker and able to follow instructions intelligently.....		41.78
		41.81
		41.68

¹ Each man selected a separate sealed bottle of sample, worked at different times and entirely independently, and followed strictly the details given. The individual results reported above include all that were obtained. No single result was omitted. The maximum difference between 22 results on 5 separate samples by 5 analyses is 0.18 per cent and the maximum difference between results on 3 samples by 3 men who had had previous experience with the method is 0.12 per cent.

It would be interesting to know at which step or steps in the analytical procedure errors are most likely to creep into the work, so that the necessary precautions could be pointed out generally and applied. The writer's rather extensive experience with the method has failed to disclose sources other than those included in the three mentioned above. In order to discover, if possible, other causes and at just what stage or stages these errors occur, the following plan was proposed in a report sent out several months ago to all collaborators:

¹ J. Biol. Chem., 1 (1906), 273.

That a sample of sulfuric acid, approximately half normal, or of such strength that 50 cc. would equal 2 g. of barium sulfate, be sent out and that the following tests on this solution be made:

A—Titrate 50 cc. against pure sodium carbonate, and against any other standard solutions you may have.

B—Precipitate 50 cc. after dilution directly with barium chloride solution, cold, as by the Allen and Bishop method.

C—Add to 50 cc. of the solution ferric chloride about equal to the iron equivalent of pyrite, evaporate to dryness, and finish as by the modified Allen and Bishop method.

D—Add to 50 cc. of the solution ferric chloride as above, reduce directly with aluminum powder, and finish as by the modified Allen and Bishop method.

Results by the above procedure would check up the method in all of the important stages and should serve to help to point out at what stage in the analytical operation most of the errors creep in. There are some objections to this scheme, for example, the errors in measuring exact portions, but with a carefully calibrated pipette the errors for measuring would be so small as compared to the errors in results on pyrite samples that this objection would not be so important. The accuracy of the measured portions could be confirmed by weighing.

The response to this proposal was not very general, owing to present conditions and pressure of regular work. Such a plan of cooperative work would check up the analytical scheme in its various stages and should, it seems, show each analyst the main cause of his discrepancies. If the interest seems sufficient to warrant the effort, this plan may be proposed again at a later date.

TABLE III—SUMMARY OF RESULTS FROM 15 OF THE 17 COLLABORATORS—1915

	A and B Method Sample No. 15095	Sample No. 15096	Miscellaneous Modifications Sample No. 15095	Lunge Method Sample No. 15096
Number of analyses	6	6	18	17
Max. per cent sulfur.....	39.59	47.87	40.00	47.88
Min. per cent sulfur.....	39.15	47.31	38.60	46.60
Average per cent sulfur....	39.47	47.49	39.18	47.28

¹ All results for sulfur are on dry basis.

TABLE IV—SUMMARY OF RESULTS REPORTED BY LABORATORIES HITHERTO THOROUGHLY FAMILIAR WITH THE ALLEN AND BISHOP METHOD, EITHER IN ITS ORIGINAL OR MODIFIED FORM—1916

	SAMPLE No. 1 Method Original A and B	SAMPLE No. 2 Same as No. 15095 in Table III Method Original A and B	SAMPLE No. 3 Same as No. 15096 in Table III Method Original A and B
Number of analyses	13	12	10
Maximum.....	53.27	53.14	53.34
Minimum.....	52.60	52.71	52.89
Average.....	52.98	52.96	53.11

(a) Method 1 is same as the modified Allen and Bishop method described previously in this paper.

TABLE V—METHOD 1, INCLUDING ONLY LABORATORIES FAMILIAR WITH ALLEN AND BISHOP METHOD AND OMITTING THE MAXIMUM AND MINIMUM RESULTS IN CASE OF EACH SAMPLE—1916

	Sample No. 1	Sample No. 2	Sample No. 3
Number of analyses	11	10	8
Maximum.....	53.14	53.66	53.32
Minimum.....	52.74	52.42	52.18
Average.....	52.99	53.53	52.74

The writer feels that the main purpose in this cooperative work on the determination of sulfur in pyrite has been largely accomplished, namely, that it has been shown that the Lunge method in its various modifications gives results between quite wide limits, and in the hands of most analysts, at least, is not to be com-

pared in accuracy and reliability to the original or modified Allen and Bishop method. Further, that the latter method is an excellent one, easy and simple of manipulation. Many laboratories hitherto unfamiliar with this method have now adopted it, either in its original or modified form, with the result that in future better agreement among laboratories on this determination may be expected.

Tables III, IV, and V give a brief summary of the work for the two previous years.

It will be noted in Table V, comparing results of Samples 2 and 3 with results on the same samples for the previous year, that the results on Sample 2 for both years are in close agreement, but in case of Sample 3, results are considerably lower than those in 1915. The reason for this is that Sample 3 is a sample of Spanish ore, which oxidizes quite rapidly when finely ground, and when samples for 1916 were bottled up after remixing the large portion, a distinct odor of SO_2 was observed.

CONCLUSIONS

The conclusions arrived at for the work of previous years seem to apply equally to that of the present year and are as follows:

1—The disagreement by the Lunge method is about in line with past experience.

2—The agreement by the Allen and Bishop method, either the original or the modified, is much better and in the hands of analysts experienced with the method yields results in close agreement, closer, in fact, than is the case with most analytical determinations.

3—The Allen and Bishop method is recommended to all chemists as an accurate method for determination of sulfur in pyrite.

The writer wishes to thank again all those who have so generously participated in this undertaking for their work and valuable suggestions. It is hoped that all who have taken part feel amply repaid for their efforts and it is believed that in future a better agreement between laboratories for the determination of sulfur will be observed.

ARMOUR FERTILIZER WORKS
ATLANTA, GEORGIA

A PAPER TEARING-RESISTANCE TESTER

By H. N. CASE
Received August 9, 1918

To anyone making a review of the literature on strength tests for paper, the subject would appear simple and quite well defined.

After making tests on the Mullen "pop tester" and the Schopper tensile machine, the writer was therefore surprised to find that the results often bore no relation to the usefulness of the paper. For example, two papers were to be compared for use in making "tension envelopes." The one was a rope Manila and the other a short fibered offset paper. These results were obtained:

	Rope Stock Lbs.	Offset Stock Lbs.
Weight per ream, 500—24 × 36 inches	79	79
Mullen test	54	58
Tensile strength on Schopper tester	Kc	Kc.
With grain	12.6	14.0
Across grain	6.5	7.0

From these tests the offset sample would appear a good match in strength to the rope stock. But envelopes made from the offset stock proved worthless.

An off-hand examination of these two papers with the fingers showed a great difference in the tearing quality as is to be expected when the difference between their compositions is considered. A Schopper folding tester would, no doubt, have shown a great difference between these papers, but none was at hand.

A means was then sought for measuring the tearing quality of paper. The method finally adopted gave the following results on the two samples mentioned:

TEARING RESISTANCE	Rope Stock Grams	Offset Stock Grams
With grain	240	95
Across grain	250	125

The test as now used has many disadvantages, but gives reliable information, particularly when used along with the Mullen tester. A low Mullen test and a high tearing resistance is sometimes a highly desirable condition. The Mullen tester shows the hardness and rigidity, while the tearing resistance shows the fiber strength and the extent of peeling. A wrapping paper that peels when tearing is certainly superior to one that does not.

The effect of humidity variation upon the results obtained with the tearing-resistance tester has not yet been worked out. The indications are that these tests are not affected to the same extent as those made on the Schopper folding tester.

The details of making the test are as follows:

Twelve strips, 1 in. by 2½ in., are cut from samples representative of the lot to be tested. Six of them are cut with the long dimension parallel to the grain of the paper, and six are cut across the grain. These are cut with the scissors, as shown in Fig. 1. It is easier to slit the test piece to about ¼ in. from the end of the strip and then to cut off the end AA', so that the slit stops ¼ in. from the end. A knife slit is not to be recommended; neither should the tip of the scissors be used at the end of the slit.

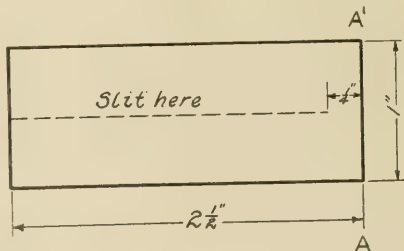


FIG. 1

The apparatus (Fig. 2) is provided with a set of three buckets of different sizes, so that when filled with water a range of weight from 15 to 600 g. can be obtained. One of these buckets is selected according to the strength of the paper.

The test piece is clamped, as shown, and the water allowed to run slowly into the bucket until the two parts of the piece completely separate. The cock is

instantly* shut off and the bucket with the water and lower clamp weighed. The weight in grams is taken as the tearing-resistance number. It will be noticed in making these tests, that there often is an initial tear when only a small amount of the load is applied. This tearing stops before the final maximum load is reached.

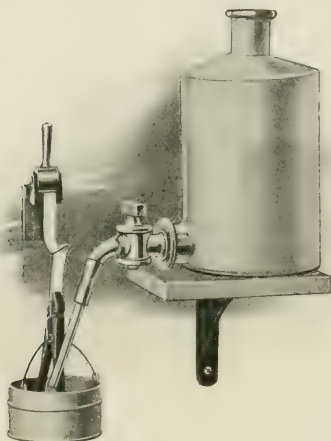


Fig. 2

If a tearing distance of more than $\frac{1}{4}$ in. is used, the peeling effect will have more influence upon the results. Several attempts have been made to measure the tearing resistance of paper when it is torn for a considerable distance, but the great irregularity in formation and the peeling tendency discourage these methods. Also, no very satisfactory results can be obtained by clamping the slit test piece described above in a Schopper tensile machine and then measuring the load required to separate the two pieces.

The exact width and length of the strip is of little importance, except in the case of very stiff cards, such as postcard stock.

The water should not be permitted to splash into the bucket. Its exact rate of flow is not important, except that the amount of water allowed to run into the bucket after shutting off the cock must not introduce an error large enough to be of any significance. Of course, the delivery tube must not drain after the cock is shut off. The bucket need fall but an inch so that there is no danger of any of the water splashing out.

Weight per Ream 500—24 × 36"	Mullen Test	Tearing Resistance		Schopper Tensile Strength	
		With Grain	Across Grain	With Grain	Across Grain
43	17.7	47	43	5.1	3.5
50	18.8	41	49	6.5	3.2
50	23.1	39	46	7.3	5.5
60	28.4	68	73	8.7	5.8
60	23.0	39	50	7.7	5.0
70	18.9	49	47	6.7	5.3
70	61.0	88	111	15.5	5.3
80	54.0	240	250	12.6	6.5
80	54.9	92	118	15.4	5.7
80	22.0	93	69	7.4	4.5
86	67.4	96	133	20.6	6.5
86	74.1	96	148	21.2	5.9
124	29.2	95	74	9.4	6.6
125	97.0	196	217	..	..
125	87.0	214	236	Over 29	12.8
126	32.0	112	122	11.6	8.5
200	96.0	444	418	..	Over 29 ..

TABLE II—KRAFTS FROM DIFFERENT LOTS OF PAPER MADE BY SEVERAL MILLS

Weight per Ream 500—24 × 36"	Lbs.	Mullen Test	Tearing Resistance	
			With Grain	Across Grain
13	13	13	34	44
19	18	18	43	50
21	10	10	29	40
22	21	21	63	113
23	14	14	25	48
24	23	23	45	76
25	21	21	28	30
26	24	24	56	73
27	16.5	16.5	26	36
27.5	21	21	34	41
28	23	23	50	52
29	24	24	39	40
30	19	19	31	44
30	16	16	32	33
31	20	20	45	56
32	24	24	43	57
32	21.5	21.5	49	67
33	21.5	21.5	57	69
33	19	19	35	32
34	21	21	49	66
34	23	23	45	86
34	25	25	55	66
35	33	33	65	126
35	19	19	49	59
36	20	20	45	81
36	25	25	48	71
36	24	24	45	73
37	21	21	52	58
37	24	24	42	80
40	21	21	62	61
40	24	24	53	62
42	32	32	63	96
48	34	34	73	93
50	43	43	130	209
50	46	46	59	71
50	48	48	101	126
51	43	43	95	180
52	35	35	77	92
54	37	37	80	94
55	60	60	111	128
58	54	54	115	130
60	38	38	50	78
60	44	44	102	124
62	39	39	84	86
66	68	68	128	152
68	44	44	102	124

TABLE III—WRAPPERS

Weight 500—24 × 36"	Lbs.	Mullen Test	Tearing Resistance	
			With Grain	Across Grain
53	42	42	53	27
65	46	46	62	12
73	53	53	59	20
73	63	63	56	32
72	65	65	65	32
72	69	69	103	42

TABLE IV—ENAMELS

Weight per ream, lbs.	Low-Grade			High-Grade
	Low-Grade	Low-Grade	Low-Grade	
500—25 × 38 in.....	66	67	63	65
Rag content, per cent.....	None	3	3	20
Mullen test, lbs.....	21	20	25	30
Schopper test, kilos.....	4.7	5.9	5.3	5.3
With grain.....	4.7	5.9	5.3	5.3
Across grain.....	3.3	3.0	3.0	3.0
Tearing resistance, grams.....	19	19	27	27
With grain.....	19	19	27	27
Across grain.....	23	25	31	31

TABLE V—MISCELLANEOUS

SAMPLE	Weight Found	Tearing Resistance		Mullen Test	SERVICE
		With Grain	Across Grain		
1—Enamel.....	25 × 38—60	18	25	17	Fair
1—Draw sheet.....	0.010 in.	10	18	17	Too brittle
1—Draw sheet.....	0.010 in.	104	139	68	Not satisfactory
2—Draw sheet.....	0.010 in.	146	151	70	Satisfactory
3—Draw sheet.....	0.010 in.	180	190	82	Very satisfactory
1—Cover stock.....	25 × 38—143	93	100	39	Not satisfactory
2—Cover stock.....	25 × 38—145	140	175	60	Satisfactory
3—Cover stock.....	25 × 38—145	200	175	72	Very satisfactory
1—Tag stock.....	25 × 38—60	590	670	150	Not satisfactory
2—Tag stock.....	25 × 38—60	820	800	150	Satisfactory
3—Tag stock.....	25 × 38—60	1110	800	155	Satisfactory
1—Envelope.....	24 × 36—60	41	52	14	Good
2—Envelope.....	24 × 36—60	33	83	12	Fair
3—Envelope.....	24 × 36—58	36	36	18	Fair

The tables above will show the relation of the tearing-resistance number to other tests. The data is representative of a large amount of routine testing done during the past three years. No attempt was made to pick out abnormal samples.

Discrepancies between the Mullen and tearing-resistance numbers are more often found in testing

Manilas than krafts. The old "point per pound" standard is a fairly reliable one in the case of krafts; still there are several instances shown in Table II where soft kraft samples have a greater tearing resistance than the Mullen test would indicate.

ADVANTAGES OF TEARING-RESISTANCE TEST

- 1—The comparative length of the fiber and the peeling qualities of the stock are shown in the result.
- 2—Sizing does not increase the tearing resistance to such an extent as it does other tests.
- 3—The apparatus is simple and depends upon no springs or gauges. It is applicable to both light and heavy papers.
- 4—The amount of grain in the paper is shown.
- 5—The load is applied with an unchanging rate of increase.

DISADVANTAGES OF TEARING-RESISTANCE TEST

- 1—The testing is tedious.
- 2—There is an apparent disadvantage due to the sensitiveness of the test in that the individual tests on the same sample vary so greatly that even the average of these tests appears unreliable until it is observed that the tearing-resistance numbers of different grades of paper show much greater distinction between the grades than the corresponding Mullen, Ashcroft, or Schopper tests. In a series of tests on Manilas, the Mullen tests ranged from 10 to 97, while the tearing-resistance figures ran from 15 to 450. In sensitiveness, the tearing-resistance tester resembles the Schopper folding machine.

The above method of testing the strength of paper is not submitted with the idea that it is the final word in paper testing, but only to awaken interest in developing more satisfactory methods of specifying paper quality.

PRINTING PLANT LABORATORY
SEARS, ROEBUCK AND COMPANY
CHICAGO, ILLINOIS

ABSORPTION PIPETTES

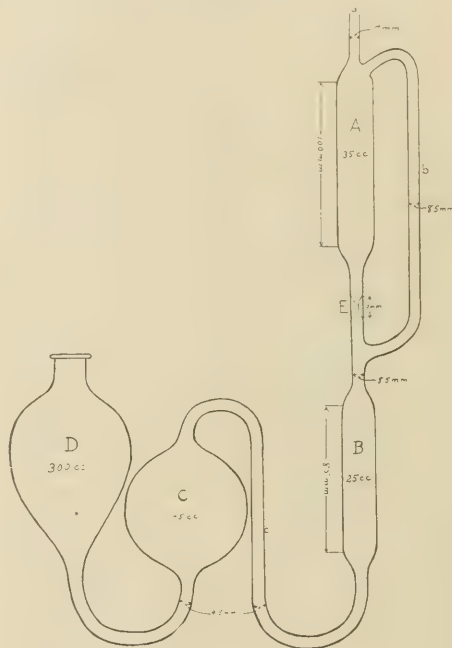
By E. VAN ALSTINE

Received July 13, 1918

While using the Parr carbon apparatus for determining both carbonate and total carbon in soils, it seemed desirable to have an absorption bulb which would be effective and rapid, and yet which would not contain glass beads or glass rods. In order that the absorption may be complete and rapid it is necessary that the gases come in close contact with the absorption liquid and if beads or rods are to be dispensed with the next best means is to bubble the gas through the liquid. The accompanying diagram is of an apparatus designed by the writer to accomplish this.

The size here shown is best for absorption of a volume of carbon dioxide up to 100 cc. from a volume of 100 to 200 cc. of air. Bulb A has an outside diameter of about 22 mm. and a capacity of 35 cc.; bulb B, an outside diameter of about 20 mm. and a capacity of 25 cc. Bulbs B and C together should hold as much as the volume of the unabsorbed gas, and bulb D

should hold somewhat more than this volume so that there may always be an excess of strong absorption liquid. A piece of capillary tubing, 1.3 mm. inside diameter and 10 mm. long, is inserted at E. The outside diameter of the tubing used is 7, 8.5, and 9.5 mm. as indicated. If absorption from a smaller volume of air is made, a pipette with smaller bulbs A and B and a smaller capillary at E should be used. If absorption from a larger volume of air is to be made, then bulbs C and D should be larger and bulb A should have a capacity of 40 or 45 cc., but the volume of bulb B should not be changed.



When gas enters at *a*, it quickly forces the liquid from tube *b* and bulb B through tube *c* into bulb C. Such gas as still remains to be forced into the pipette must pass through bulb B, the sides of which are being continually wet by the liquid dripping slowly through the capillary tube E. It must then bubble through this liquid, which collects in the lower bend of tube *c*. By the time bulb A is about half emptied, all of the gases have been forced out of the carbon apparatus and in a few more seconds A will become emptied, about half filling bulb B. While this is taking place the gas which filled B is forced through tube *b* into bulb A, thus being kept in motion. When bulb A is emptied the largest part of the gas has been trapped in bulb C by the liquid in bulb B, and when drawn back into the Parr apparatus it must bubble through this liquid.

It is not necessary to shake the apparatus to insure rapid action as must be done when bulbs without

beads or rods are used, yet absorption is as rapid as with either.

These pipettes may be made by any good glass blower, or they may be obtained for about \$5.00 each from Mr. Paul Anders, Urbana, Illinois.

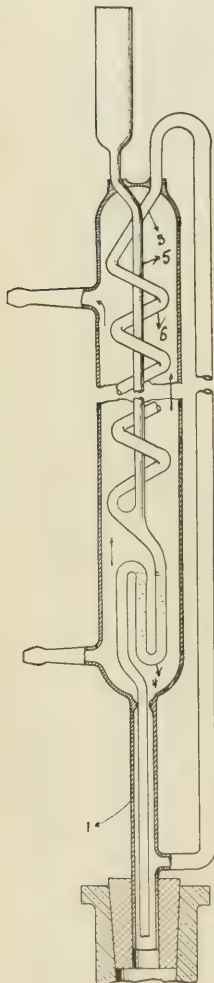
COLLEGE OF AGRICULTURE
UNIVERSITY OF ILLINOIS
URBANA, ILLINOIS

NEW REFLUX CONDENSER

By JAMES J. BAJDA

Received July 10, 1918

A modified type of reflux condenser, applicable to



most kinds of laboratory work, has been found very satisfactory, especially in those cases in which the refluxing liquid has a comparatively high boiling point.

In the usual type of reflux condenser, hot vapors enter the relatively cold portion of the cooling chamber and allow the condensed liquid to collect in the inner tube, until overbalancing pressures therein cause the liquid to spurt back into the receiver. This spurring back is often not very desirable, especially as the receivers are usually made of glass.

The improvement here is obvious from the accompanying drawing and consists of a vapor conduit, 2, forming a part of the adapter of the condenser 1, through which the vapors pass and are led therefrom into the upper part of the condensing coil 3. The condensate flows into the trap 4, by means of which is provided regular and undisturbed flow into the receiver. Any tendency to disturb the balanced relation of the condensed liquid in the trap will find outlet through one arm of the Y-tube which leads upwardly and axially, 5, through the cooling coil 6.

The flow of cooling water in a direction opposite to that of the condensates diminishes the strain on the glass.

FLUSHING, L. I.
NEW YORK

MELTING POINT OF ROSIN

By T. LINSLEY CROSSLEY

Received August 2, 1918

Certain large buyers of rosin have recently specified a melting point limit for this material. Samples have been submitted for this test, but without specifying how the test was to be carried out.

Properly speaking, rosin, like asphalt, has no definite melting point, therefore, any specification aiming to grade it by reference to its behavior on heating should state the method for obtaining results.

Schwalbe and Kuderling¹ not only state melting points but record results to fractions of one degree and claim to differentiate between certain rosins by their melting points.

Several methods have been used to determine the quality of rosin as indicated by its action on heating. The closed capillary tube, of such general application, is used largely but, unless conditions of heating and observation are closely controlled, results are not uniform with different operators.

The following results were obtained on the same four samples by methods indicated:

Rosin	1/4 in. Column ° F.	1/8 in. Column ° F.	Film ° F.	Capillary ° F.
1.....	174-184 172-183	169-172 169-172 165-173	150 146 ...	146 145 154(a)
2.....	176-187 174-185	174-182 167-176	147 155 156	154 147 153
3.....	169-167 161-157	149-151 145-146	120(b) 134 126	128 130 ...
4.....	153-155 147-155 149-153	145-147 144-145 ...	135 133 ...	138 136 ...

(a) Heated until clear.

(b) Probably mechanical weakness of film.

The first three methods were carried out as follows: Glass tubes of about 3/16 in. inside diameter and 2 in. long were prepared. These were dipped in melted rosin so that on cooling there was left inside the tube a column of rosin of the required depth. In the case of the method marked "Film" the foot of the glass tube was heated slightly and applied carefully to the surface of the molten rosin so that upon cooling a thin film only of the rosin was formed. The tubes were attached to the thermometer in such a way that the bottom of the tube with the rosin was located about the center of the mercury bulb. The thermometer with tube attached was immersed in cold water in a 400 cc. beaker with the bottom of the rosin column 1 in. below the surface. The temperature was raised about 3° per minute.

In the cases of 1/4 in. and 1/8 in. columns, it will be noted that two temperatures are given. The lower temperature indicates the point at which the rosin is soft enough for the water to enter the tube, the other being the point at which the water breaks through. The result is of course merely the point at which the viscosity is so reduced that it is overcome by the pressure of 1 in. of water. It is necessary that the heating should be well regulated. If heat is applied too rapidly it will naturally result in a higher final temperature and a wider spread between the two points.

¹ "Rosin Studies," *J. Soc. Chem. Ind.*, **30**, 1397.

The capillary tube method was carried out as follows: Tubes about 1 mm. in diameter were prepared and sealed at one end. The rosin was pulverized between two pieces of paper. About 2 cm. of the tube were filled with the powder, and it was attached to the thermometer as in the other cases, being also immersed in cold water and heated as before.

A reading glass was used to observe the result and the point at which the particles coalesced was noted as the melting point. It was not found advisable to carry the heating until the whole of the rosin in the tube became clear as this increased the range of personal error. There was found to be a more definite

indication and closer agreement when the point of coalescence was noted.

The results obtained by the "Film" method are for practical purposes the same as those obtained by the "Capillary" method, but the tests are prepared more rapidly and with much less trouble, especially in the hands of unskilled assistants. The end-point is definitely established by the penetration of the water.

In all of these tests recently boiled water should be used, otherwise the rising bubbles of dissolved gases interfere in several ways.

43 SCOTT STREET
TORONTO, ONTARIO

ADDRESSES

THE FUTURE OF THE AMERICAN DYE INDUSTRY¹

By W. H. NICHOLS, President, American Chemical Society

When war was forced upon the world in 1914, the chemical industry of England, France, Russia, and Italy was quite unprepared for the tremendous demands made upon it, some of the most insistent being for materials hitherto unmade in any of those countries, due to the shrewd policy pursued by the Germans for many years in anticipation of the event. The chemical industry of the United States was in far better state of preparation and, as is well known, was able to fill the gaps. On our own entry into the war, it appeared to those in authority at Washington that large additions should be made to the chemical output. To accomplish this result, our Government thought best to construct largely, and to assist certain individuals and corporations in doing likewise. As the chemical industry was thoroughly prepared to take care of the requirements of our own country before the war, it is fair to assume that it is in position to do so when we return to lines of peace. It is therefore manifest that a number of works in which the Government is interested will not be needed, and it is hoped that the manufacturers who so bravely and liberally contributed to the increase in output, will not now find themselves in competition with governmental plants. While I am informed the Government will take careful account of this, and will do what it can to protect industry already organized when the war began, I believe the potential injury should be alluded to in order that the large gathering of manufacturers here might be in position to express itself should it so desire.

The fortunes of the chemical industry are naturally bound up with the fortunes of industry at large, and the same rules which apply to any other industry would apply in almost every case to the chemical. If the country returns to its pre-war state of manufacturing capacity, the chemical industry will be able to take care of itself and any demands that are made upon it. Therefore, its future will be identical with the future of all the great undertakings with which we are involved. I have not thought it best to take up your time with discussing general details, knowing that these will be considered in the ordinary course of events.

I have thought that with the limited time accorded me, I might be of some service in calling specific attention to an industry which is practically new in this country, which is vital, and which absolutely needs encouragement; in fact, all the encouragement which can be forthcoming from every source. I refer to the manufacture of coal-tar dyes and medicinal preparations which up to 1914 were produced almost exclusively either in whole or in part by the great German concerns. Owing

to the fact that for nearly forty years these concerns had earned and obtained a practical monopoly of the whole world, they were able to charge prices which made it possible to write off all or the greater part of their plants, so that to-day they are in the position of having plants, doubtless largely increased by war orders, which stand on the books at comparatively small sums. In addition to this, they have the further advantage of having works which are perfected to date, whereas other countries have had to invest in plant, and will still have to do so, with the certainty that much of its construction may be scrapped as knowledge advances. With a full appreciation of these difficulties, manufacturers of England, France, and Japan have received the strongest kind of encouragement from government cooperation, financial and otherwise, and Switzerland permits by its laws the combination of the chief color works, three in number, in such way that processes and patents may be pooled for the common good. In Germany, as is well known, a union of all the great color works has been effected, binding for fifty years, and while the various units composing the same do not lose their identity, or control over their works, etc., still their activities will be controlled by their ability to produce stated products at minimum costs. Profits will be pooled and divided as already agreed; losses likewise. These various facts leave the United States as practically the only great country this side of China frankly open to the German assault, which is sure to come and which should be nipped in the bud. Our present protective tariff is entirely inadequate. I understand that plans have been completed to ship goods already prepared in immense quantities from Sweden, Holland, Switzerland, etc., so that their German origin will be carefully camouflaged.

Of the several branches of chemical industry, at the outbreak of the war, none bulked so large in the eye of the public as the coal-tar dyes and none so gripped public attention. The reason is now not difficult to determine. While the coal-tar dye and its directly related industries do not occupy a leading rank in the world's activities when measured by the customary and usual standards, such as those of labor employed, capital engaged, value of output, tonnage of output, power consumption, and the like, yet their products did perform almost, if not wholly, indispensable functions in very varied industrial operations of exceeding magnitude, importance, and ramification. It is this functional value, rather than any intrinsic direct money value, that now determines the importance in which the public holds these products. Out of this new viewpoint as applied to coal-tar dyes has grown an entirely new public conception of utility which the public has embodied in the now widely-current expression of "key" or "pivotal" industries by which emphasis is very decidedly placed upon functional importance, and other considerations are deliberately relegated far to the background.

¹ Address to the Chamber of Commerce of the United States Atlantic City, December 6, 1918.

The public has decided to have all "key" industries firmly established at home.

Just before the war the world's total coal-tar dye production was under, rather than over, \$100,000,000 in value and approximately 250,000 short tons in weight, probably not in excess of 50,000 persons of all ages and positions engaged in their production from primary coal-tar products; in the United States just over 3,300 tons, valued at \$2,470,096, were produced, employing not over 530 persons but using almost entirely foreign-made "intermediates;" but these 530 persons produced other articles valued at \$1,126,699, tonnage not stated. Similarly, the above 50,000 persons produced other things such as medicinals, photographic developments, and the like of unknown value and tonnage, the world's average pound-value of dyes thus being 20 cents, and of the United States production 37.5 cents.

On account of the unavoidably mixed and therefore uncertain nature of all general statistical information on this subject, both in this country and abroad, it is hazardous to attempt great detail; the following is a very rough attempt to sketch the outline and a few of the details of this very complicated business.

With the above reservations in mind, it may be stated for the purpose of rough comparison only that in making dyes from primary coal-tar products, the world's pre-war labor per capita production in terms of dyes was not less than 5 tons per annum; in the United States just over 6 tons of dye for labor per capita were produced, but using foreign-made intermediates.

From a recent publication of the United States Tariff Commission, it appears that we had in this country in 1917, 81 establishments producing dyes, or dyes and intermediates, and 119 establishments making intermediates only; that 19,643 persons were so engaged, producing 23,000 tons of dyes or just over one ton of dye per person engaged per annum. If this be the proper interpretation of that publication, then it discloses an efficiency in tonnage production of about one-fifth of the pre-war efficiency in terms of persons engaged. Of the approximately 300 intermediates needed for our normal dye requirement, 134 were made here in 1917 as against but a very small number, perhaps five, made here in 1914. In 1917 we made no fewer than 180 chemically different dyes and all from intermediates of domestic manufacture. Of the variously estimated 500 or 600 chemically different dyes imported in the fiscal year 1913-14, 154 were made here in 1917 from domestic intermediates, in addition to 18 not then imported and 8 of not now known composition; our imports in that year totaled 23,000 tons; our 1917 production tonnage was a trifle higher; the tonnage imported in 1913-14 of the above 154 dyes amounted to 13,500 tons or 60 per cent of the total 1913-14 importation. Hence, our domestic dye industry in 1917 was directing its efforts very intelligently towards the production of those individual dyes of major importance to the industries requiring this class of products, and in producing substitutes for other dyes since much of its needed material had to be diverted to other uses for one or the other of the belligerent countries including, of course, our own country.

This whole business is made up of a host of different finished products calling for a multitude of semi-finished products representing an individual consumption of the widest conceivable range both as to tonnage or poundage as the case may be, and in values as are now set forth in sketchy outline.

For 383 presumably chemically different dyes imported in 1913-14 and for which values and poundages are known totaling 18,000 tons, the annual importation is 47 tons; of these 383 dyes only 67 are equal to or above this average tonnage, and 316 dyes are below it; the largest individual shipment amounts to 4,253 tons and the smallest to $\frac{1}{17}$ of a ton; 30 dyes are less than $\frac{1}{2}$ ton; the total value of these 18,000 tons was \$6,496,882, or an individual value of \$26,479; the individual annual values

range from \$1,090,773 to \$43. Some dyes (value not given) were imported in amounts even as small as 9 lbs. for the year.

In considering the future of our domestic dye industry it must not be lost sight of that with proper combination of physical plant and proper elimination of duplicated effort the German dye industry could reduce the total number of persons engaged; maintain, if not even increase, the output tonnage, and increase the annual tonnage output for labor per capita. It seems not unreasonable to expect that this might ultimately be one and one-half times the pre-war figure or say approximately eight tons per person engaged per annum.

In any event, the foregoing annual production of one ton of dye per person engaged in our domestic industry for 1917 must be considerably improved if our industry is to be permanently on a sound competitive footing. This apparently poor showing of efficiency must not be construed unfavorably to American effort; it is an unavoidable and wholly to be expected result of the conditions under which our chemists have been compelled to work by circumstances wholly out of their control, or the control of the public.

Our pressing and paramount problem has been to get these goods; matters of cost, labor-efficiency, and the like were wholly secondary; the goods had to be made. In the synthetic organic chemical industry, of which the coal-tar dye business is the largest factor, many ways of making one and the same thing are generally open and it calls for much experience, which can be gained only through time-consuming manufacturing effort, to decide which is the most efficient and the cheapest way. Our chemists did not have time or opportunity to enter into these refinements, they had to begin at the very beginning, and having found one way that would give them commercially usable products they bent their energies towards making that way, no matter how defective it might be, produce the greatest weight of goods in the shortest possible time, regardless of refinements as to efficiency and wastes. That was not a mistaken policy under the circumstances. Time and the goods were the essence of the problem; everything else was supremely secondary; the large domestic industries and needs dependent thereon had to be helped out of an emergency and they were effectively helped. This is not an apology: our chemists are in no sense under any obligation whatever to apologize; it is merely an explanation.

Having made this most important contribution toward winning the war, toward keeping our domestic industries going even though knowing all the time that from the point of view of efficiency his then manufacturing methods were woefully defective and wholly inconsistent with professional standards, should not the American chemist now be given an opportunity to improve the efficiency of the methods heretofore employed, or to devise new and better ways so that we can have this key industry firmly established at home? He must have these opportunities if he is successfully to weather the stress of foreign competition. It is not a question of raw or basic chemicals; we have all of these, except Chilean nitrate, in domestic abundance, and to spare, and at prices as low as anywhere. There is no magic in attaining the highest efficiency but it requires slow, painstaking, and voluminous investigation and testing to arrive at this maximum. Our chemists have the necessary training, skill, ingenuity, and resourcefulness to accomplish this. What they need is proper opportunity, and to be relieved from this production pressure, in order that they may improve their methods. Such a procedure is very costly. Who will foot the bills and how? These are not matters that can be successfully solved in a laboratory; they require try-out on manufacturing dimensions and under manufacturing conditions and hence are inseparable from actual manufacturing plants operating for commercial ends. For that reason our governmental research agencies cannot effectively aid in the solution of the problems

confronting our dye manufacturers. This work, therefore, devolves wholly upon the manufacturers themselves. Since the normal pre-war competitive manufacturer's value of our total annual dye consumption is not over \$10,000,000 for several hundred, possibly one thousand, widely different products, including intermediates and dyes, most of them of small individual value and tonnage, it is clear from our past experience that our manufacturers cannot themselves finance this expensive undertaking of refining and improving all needful manufacturing processes so as to have this key industry in its substantial entirety firmly established here. Our Federal legislators must find effective ways and means of lifting this financial burden and production-pressure from our dye makers while they are perfecting their processes and increasing the variety of their output.

We, of course, have a protective tariff. In my opinion this alone will not accomplish the purpose, nor do I think that it will do so even in connection with the anti-dumping law now in force. As stated before, in England, Japan, France, and Italy, the respective governments have taken more direct action ranging from direct government financial participation to guarantee of dividends. Yet these measures seem in the opinion of some not to promise success. Additional help in the way of complete prohibition of imports of all dyes or that device modified by permitted importations of limited amounts of specified dyes not then made at home, under government license, all for a limited number of years, have been seriously proposed abroad. This problem is rendered the more difficult by the very practical and important consideration that dyes enter commerce not only as such and in packages like kegs, casks, and barrels, but also on finished commodities such as textiles, leathers and leather goods, printed and painted articles, and an uncounted host of other things. It might even be necessary to prohibit the importation not only of dyes and the like as such, but also all articles, like textiles, which are dyes or colored with such dyes except where we have domestic sources of all the dyes involved in any shipment.

From this it is clear that this problem is not only complex, but exceedingly difficult; that the best minds in foreign friendly countries are not agreed as to the needful helps; that the more this phase of the subject is studied, both here and abroad, the more drastic the proposed measures become. It is also clear that half-way measures cannot promise success. Since we are really determined to have this particular key industry firmly established at home, we must be prepared to pay the full price and we ought to be prepared to pay rather more than "just enough" in order to make ultimate success not only certain but speedy of accomplishment.

If public measures are taken for the purpose of establishing this key-industry at home, it is perfectly clear that those who enter into or remain in it are in duty bound to make the country not merely seemingly but actually and intrinsically independent of all foreign competitors by producing not only the staples and the specialties in quality, quantity, and cost equal to anything offered from abroad, but also to lead or at least to keep abreast of the highest foreign developments by assiduous, intelligent and resourceful research, both scientific and technical, of the whole field and all its ramifications.

Just how this shall all be brought about, no man can with any confidence say to-day, but surely our dye-makers, our users of dyes, and our importers of dyes and materials into which dyes enter, can find by patriotic and clear-headed conference and cooperation ways and means that will commend themselves to our legislative and other government officials as being best designed to accomplish the will and desire of the American public which has been repeatedly and determinedly expressed and in a way that cannot be ignored.

Given a fair chance, with confidence that there will be no

outside interference for a certain period, it is my conviction that the American dye industry will not only stand alone, but that it will lead the world.

THE PROBLEMS OF THE DYESTUFF INDUSTRY¹

By F. W. TAUSSIG, Chairman, United States Tariff Commission

It is not necessary for me to rehearse the events of the last three years or the facts of the present situation. You are familiar with the history of the industry and with its problems. You know well the extraordinary story—the unique dominance of the German industry before the war, the passive acquiescence of most countries in that dominance, the virtual cessation of imports during the war, the rapid growth of the dyestuff manufactures in this country and in others. You know too that there is impending an equally sudden transition to new conditions. It is these new conditions that now demand our attention. I shall not weary you either with congratulations on the achievements of the past, or warnings about the possibilities of the future. Nor shall I undertake any discussion of general questions of industrial policy or general problems of reconstruction. I shall confine myself to the problem which is before the dyestuffs industry now and here.

Before considering, however, the possible lines of legislative action for the immediate future, I shall ask your attention to one general proposition, simple and unquestionable in itself, but of special relevancy at this time.

Stability is of the first importance for any industry and at all times. Business can accommodate itself to almost any conditions, provided they be steadily maintained. This is true as regards prices and wages, banking and monetary systems, income taxes and taxes on business, and, not least, as regards tariff duties. It is quite as important, probably more important, that duties should be settled as that they should be high or low, well- or ill-adjusted. It is imperative to know on what basis business calculations may be made.

Not only is this the case with regard to an individual business or a particular industry; it is true also as regards the prosperity of the country at large. Vacillation and uncertainty in tariff policy are probably more harmful than any extreme of high duties or of low duties. The good results which are obtainable through a protective system endure only if such a system is maintained consistently for a considerable period—if time is given for the development of domestic industries, for growth under assured conditions, for the introduction of improved methods through long-continued experiment. And similarly, the good results which are obtainable under a policy of free trade are dependent upon its maintenance over a long period. They can come only through steady competition among foreign producers and domestic distributors, and the adjustment of export trade as well as of import trade to larger volume. A consistent policy followed for a considerable stretch of time is in either case essential for the attainment of the desired results.

Let us now look at the situation which is to be expected in the immediate future in this country, and look at it frankly and openly. Let us not disguise the facts by vague generalities, by pleasant words, by rose-colored optimism. The truth, plainly stated, is that the outlook for stability is poor. Indeed, the prospects are of the slightest for anything in the nature of a settlement of the tariff. Consider the obvious facts of the political situation. We are at the beginning of the short session which closes the 65th Congress. In the 66th Congress, which will be in session from March 4, 1919, to March 4, 1921, there will be no unification of control and hence there can be no

¹ Address before American Dyestuffs Manufacturers Association, New York City, December 6, 1918.

unification of policy. One party will have a majority in the House of Representatives; the Administration itself is of another party; the Senate will be very evenly divided. Not only is this the case, but the traditional division of opinion and policy on the tariff will not only be maintained, but is likely to be accentuated. The controversy on the protective policy will go on, and will be conducted on party lines. That controversy, it need hardly be said, is not between protection and free trade. The practical issue is one of degree—whether there shall be high and strong protection all around, or limited and moderate protection. But the cleavage is clear. I shall not undertake to say whether a permanent settlement will ever be reached in this country; but it would seem certain that not even such a provisional settlement as comes by the enactment of a general tariff law is within the bounds of probability for the next two or three years.

Further, we must expect a certain amount of political maneuvering. Legislation will be proposed and debated, not so much with an expectation that it will be enacted, as with a design to make plain what is the policy proclaimed to the country, and therefore promised as likely of adoption if a more conclusive political settlement is reached. The drafted bills will be very much in the nature of a political platform. And if, by chance, any legislation is adopted by the present Congress, or by the next, it will be tentative and provisional, presumably to be revised in the Congress to follow.

In other words, nothing in the nature of a settlement of the tariff question, even for a period of four or eight years, is to be expected before the Presidential election of 1920 and the establishment of a new administration for the period beginning with March 1921. Until that date the country will not know where it is, or whether it is moving, as regards this important factor in its industrial prosperity. Whatever is done in the way of legislation during the session of Congress which begins in 1919 can hardly be more than provisional.

In forecasting the immediate future in this way, let me not be understood to impute blame to any individual or any party. No arraignment is made, no criticism implied. The situation is the simple consequence of our constitution. It is an inevitable concomitant of the system of checks and balances. Our Government was not designed to be under unified control, nor is it adapted for the prosecution of a single-minded policy. The election of a new Congress in the middle of a presidential term was expressly intended to give a check on the uncontrolled maintenance in power of any party or any administration. It is idle for us to speculate in connection with such problems as we are here discussing, whether the system of checks and balances in this respect operates well. The mid-term elections have always brought perplexing consequences, and they will continue to do so. It is not a new thing in our history that legislation has become hesitating, uncertain, affected by political maneuvers and sometimes by political pretenses, because of the patent fact that power was divided and that a settlement one way or the other was for the time being impossible. This was the situation in 1911-12, the era of the well-known pop-gun tariff bills. It is precisely the present situation. The uncertainty is most regrettable, but is clearly there. We should be like the ostrich who buries his head in the sand if we refused to view it openly or if we failed to observe the consequences to which it leads. We must face things as they are.

It may be asked, however, whether some particular phases of the tariff question cannot be rescued from the general predicament and dealt with irrespective of party differences. Is it not possible that the dyestuffs industry can be treated by itself? Can it not be rescued from political strife? Is there not some chance that it will be considered upon its merits, without regard to political complications, and disposed of as an urgent matter needing immediate attention? Cannot this brand be rescued from the burning?

There are grounds for hoping that special attention will be given to this industry, and that its case will be regarded as unique. Some promise of an attitude of this sort can be inferred from the enactment, two years ago, of the revised duties upon dyestuffs which are now in force. As you need not be reminded, a special title was contained in the revenue act of 1916, imposing revised and increased duties upon intermediates and upon dyestuffs. The legislation then put into effect was admittedly not satisfactory in every respect, yet it was an earnest of the recognition of a peculiar situation. Moreover, the present administration, irrespective of any general attitude to which it is committed on tariff questions, has viewed with concern the dependence of this country upon foreign dyestuffs and has cooperated in the endeavors to bring about, not only by legislation, but by departmental encouragement and support, the development of an American supply of dyestuffs.

Further, the industrial conditions are obviously different from those in many other industries. This is an entirely new industry. It is largely in the experimental stage. It has had a short and disturbed period in which to develop. It has not yet found itself in normal conditions. It is confronted by foreign competition from an industry which is not only long established and well equipped, but is organized in such way as to threaten ultimate danger to consumers as well as immediate danger to producers. And not least, it is closely connected with the military problems, because of the interrelations between explosives and dye products. These are matters familiar to all of you. Indeed, so far as a gathering like yours is concerned, there is no need of explaining wherein your industry stands in a class by itself.

Not only this, but it would be admitted on all hands that there are matters connected with tariff legislation which could readily be disposed of without raising any controversial questions. Not every measure relating to import duties is necessarily contentious. Take, for example, the matter of customs administration. This has long been in a confused and unsatisfactory state. Admittedly there is urgent need of an amendment and of clarification of the customs administrative laws. The Tariff Commission has prepared with great care a draft for such amendment, and has brought it to the attention of Congress in the hope that it may be disposed of without arousing political debate. Again, there are matters of classification and definition in the tariff laws, unexpected and undesired anomalies, which also can be disposed of on simple grounds of consistency and common sense. Problems of precisely this type arise in the dyestuffs act of 1916, and in the chemical schedule of the act of 1913. Our immediate question is whether the duties on dyestuffs can be brought to the attention of Congress in such a way as to obviate strife, or at least to minimize it, and to secure early and unbiased attention to the special difficulties of the case.

The answer depends upon the way in which the situation is approached and handled. It seems clear that any proposal of an extreme character would arouse opposition and would stir controversy. A radically new policy of any sort has little chance of being carried into effect. It seems equally clear that any great division of opinion among those who are interested in the industry and who have given special attention to its progress would have the same effect. If the manufacturers, consumers, importers, chemists, editors of chemical journals, the Tariff Commission itself—if all these come before Congress with different and discordant proposals, nothing is likely to be accomplished. Only if all concerned unite upon some moderate plan will it be possible to secure that unbiased and undisturbed attention which will result in legislation. If indeed there be a consensus of opinion in all quarters, then there is a possibility that the problem will be dealt with in a noncontentious spirit.

As you know, various plans and proposals have been suggested. Some of them must be characterized as extreme. It has been suggested that there be for a period of years an entire prohibition of importation. It has also been proposed, as an alternative, that there be something in the nature of discretionary prohibition. The alternative suggests that there be established a system of import license and import regulation, under which an administrative body shall have authority to permit foreign dyes to be imported in cases where domestic supply is non-existent or quite inadequate, the American market, however, being reserved completely for the domestic producers as regards commodities which they are able to supply, perhaps at high prices, but at all events, in adequate volume and of satisfactory quality. Of a different sort is a proposal for entirely remodelling the present plan of classification in the act of 1916, by the virtual abolition of the class of intermediates and by the application of the same rate of duty to all products which are beyond the stage of crudes. There is something to be said for each of them, and there are objections to each. My present point is that, whether they are good or bad, they seem to be now not feasible of early execution. They are radical beyond the limits to which measures must be confined which have a chance for enactment. Simplicity, moderation, no violent departure from existing methods and existing legislation—these seem to be the requisites of a feasible plan.

The Tariff Commission has given prolonged and careful attention to the dyestuffs problem. It has secured a thoroughly competent expert staff of its own. It has conferred in the most painstaking way with the officials of the Administration, with the representatives of the customs division of the Treasury, with consumers, and with manufacturers. It has proposed and elaborated a bill that conforms to the conditions which I have just indicated. That bill endeavors to make effective the policy adopted in 1916, and also to show the way to some moderate extension of that policy in new directions. The legislation of 1916 was in many respects a great improvement on what preceded. But defects have already appeared, and there is beyond question occasion for amendment. Evasion of some of the salient provisions of the present law is possible, especially through the importation of intermediates which are nearly advanced to the stage of finished dyestuffs. The bill prepared by the Commission goes over the list of commodities with care, rearranges the enumeration of intermediates and finished dyes in such a manner as to prevent evasion, and removes some anomalies which clearly need attention. It raises frankly the question whether the specific duty of 5 cents which was not applied by the act of 1916 to indigo and to all indigoids, whether or not obtained from indigo, to natural and synthetic alizarin, and to dyes obtained from alizarin, anthracene, and carbazol, should be made applicable to these now exempted commodities. This opens a question of policy, but one which, we may perhaps hope, will be dealt with irrespective of general party differences.

The measure which is proposed by the Tariff Commission may not be perfect, but we are confident that it represents a great improvement on what is now on the statute books. It is a measure of the sort which may be laid before Congress with propriety under any circumstances and at any time. It is the sort of measure upon which all concerned may unite, and which

may receive the sober and cool-minded attention of congressional committees and of Congress itself. This report is now in the hands of the printer and will be available for distribution at an early date.

If anything at all is to be done, it would seem that this is the practicable plan, and this the practicable procedure for bringing it to fruition.

In conclusion let me say a word about the Tariff Commission itself, its functions and its duties, as illustrated by this particular case. During the debates which preceded the establishment of the Tariff Commission, much was said about the need of a scientific settlement of the tariff question, and of the removal of that question from the domain of politics. This is Utopian. It is quite impracticable, and indeed undesirable, that the settlement of a great question of principle should be put into the hands of any administrative body. The commercial and industrial policy of the country must be settled by the people and by Congress, and cannot by any possibility be taken out of their hands. Certainly the Tariff Commission has no such high-flying ambition. It is soberly conscious of the limitations upon its possibilities, and of the character of the work to which it must confine itself. Its business is to prepare the way for the intelligent and well-considered application of whatever policy the people determine by their votes and Congress carries into execution by its legislation. Our business is to gather information and to take preparatory steps such as will enable Congress to act with light and to avoid ill-planned or misdirected efforts. This is an important and much needed kind of work. We have endeavored to do it in the particular case of the dyestuffs industry.

The Commission would not go so far as to say that all information which it is possible to get is at our command, still less suggest that all the information has been secured which it is desirable to have. As you know better than any one, the whole industry is in a stage of flux and transition the world over. In Great Britain, in France, in Switzerland, as well as in the United States, there are new developments. What will be the conditions of international competition in the future, what the prospects of the various branches of the growing industry in the United States, no one can now say. Nor can any one say, as I have explicitly pointed out, what industrial policy will finally be adopted by the United States. That policy cannot but be affected by the character and terms of the general international settlement. We cannot peer far into the future. For the moment we can follow only provisional lines of action.

The war is over, and with it the excitement and the shouting, the absorption in the task of the moment. Before us now are the problems of peace. We can no longer plan for what could be done and should be done under the conditions of war. And it is no longer profitable to utter words of encouragement and confidence, and perhaps of glorification, which were natural during the stress of conflict, but which now would simply obscure the troublesome facts of the new situation. These facts I have tried to face squarely, without concealment or equivocation or flattery. I trust that in so doing I have spoken in accord with your wishes, and perhaps have aided you in reaching a conclusion concerning the course of action which the representatives of your industry should follow.

FOREIGN INDUSTRIAL NEWS

By A. McMILLAN, 24 Westend Park St., Glasgow, Scotland

NEW VEGETABLE OIL

A sample of "piassava" oil from Sierra Leone, presumably a product of the palm from which the piassava fiber of commerce is derived or some related species, has been examined at the Imperial Institute, London. The oil was found to resemble palm

oil in odor, but was rather darker in color and more liquid. The results obtained in its chemical examination were similar to those recorded for palm oil and if it can be shipped to Great Britain in commercial quantities it should be saleable at prices similar to those realized for palm oil.

GERMAN AIRCRAFT

Reports recently prepared by the Technical Department, Ministry of Munitions, London, describe some types of German fighting biplanes. The following, taken from the *Times Engineering Supplement*, is a description of the two-seater Halberstadt machine, which bears the date April 14, 1918, and may be taken as the high-water mark of German two-seater aeroplane construction. It is well and strongly made, the principal points in its design being the single bay arrangements of wings, the conspicuous set-back of the main planes, freedom of the empennage from wires, tapering of the fuselage to a horizontal line at the rear, and the construction of the pilot's and observer's cockpit in one. Its general behavior in the air is good according to modern fighting standards, but it cannot be considered stable as there is a tendency to stall when the engine is on and to dive when it is off. Directionally owing to propeller swirl, the machine swings to the left, but with the engine off it is neutral. Pilots report that it is light and comfortable to fly. Its maneuverability is good, and this feature, in conjunction with the exceptionally fine view enjoyed by the pilot and observer and the field of fire of the latter, makes it a machine to be reckoned with as a two-seater fighter, although the climb and speed performances are poor, judged by contemporary British standards. In tests the climb to 10,000 ft. took 24½ min. and to 14,000 ft. just under 52 min. The greatest height reached was 14,800 ft. in 64 min. 40 sec., the rate of climb at this height being 50 ft. per min. At 10,000 ft. the speed was 97 miles an hour with the 180 h. p. standard high-compression Mercedes engine making 1,385 r. p. m.

BRITISH OPTICAL GLASS INDUSTRY

An account of the steps taken by the British Government to develop the manufacture of optical glass is given in the *Board of Trade Journal*. When war broke out, Britain was dependent on Germany for 60 per cent of its supplies; 30 per cent came from France and the balance of 10 per cent was made by Chance & Co., Birmingham, England. In January 1916, Messrs. Chance undertook to complete an extension of their works which would greatly increase their output and the Government undertook on their part that British optical glass would be used as far as possible for optical instruments required for naval and military purposes. Scientific research, the report states, into the chemical constituents and optical properties of the various kinds of glass has moved hand in hand with commercial production. In 1913 there were 11 types of optical glass made in England and the total home output was not great enough for home requirements. Now, however, 75 types of glass are made in this country. During the first quarter of 1918, English makers produced more than 90 times as much optical glass as was made during the first quarter of 1913. They are thus making glass at a rate nine times as great as the total consumption of the United Kingdom in the year before the war.

ITALIAN CHEMICAL INDUSTRY

The *Z. angew. Chemie* says that many new factories have been erected in Italy for the production of artificial manures and colors. The government seems to have taken much interest in the chemical industry. The "Anonima" concern was formed for the production of aniline colors with a capital of \$1,200,000. For the production of soda and chlorates, a company was formed in Genoa with a capital of \$500,000. The soap industry and glycerin production have grown up with the manufacture of soda, and carboic acid crystals are prepared in the explosives factories of Piedmont. In Milan, the German specialties, antipyrin, aspirin, phenacetin, and lecithin, are produced. New works are established at Legno for the production of ammonium nitrate, while in Turin a rubber factory has been set up with a capital of \$800,000.

ALCOHOL FROM SEAWEED

Attention is being called by Sir Edward Thorpe to the possibilities of obtaining alcohol for motor fuel from seaweed. After commenting on previous attempts that have been made to obtain alcohol from non-alimentary materials, Sir Edward holds that certain seaweeds, all of which are abundant, may be made to yield considerable quantities of alcohol by suitable treatment. Thus it has been stated that 100 lbs. of red wrack is capable of yielding about 6 liters of alcohol and it is alleged that, under industrial conditions, this amount may be increased. If these statements can be verified we have in seaweed a ready and cheap source of alcohol and the possibility of employment to people whose livelihood was greatly impoverished by the loss to them of the kelp industry. A correspondent of the *Times*, London, remarking on the above statement, suggests that the use of peat would afford a cheaper method as it would be easier to handle. He also adds that it should not be forgotten that motor spirit can be obtained from various oils, and calls attention to certain oil-transformation processes on which Sir Oliver Lodge reported very favorably in October 1913.

SWITCHGEAR

A catalog issued by the General Electric Company who have now taken over works at Erith, England, deals with high-tension switchgear and sundry other appliances. Descriptions and illustrations are given of various types of three-phase, oil-break switches which are suitable for voltages up to 6,600, and can be arranged with automatic features, to open an overload, on reverse power, or when the voltage fails. Details are also furnished with dimension drawings in most cases, of truck-type switchgear, tension limiters and lightning arresters of various patterns, choking coils, isolating links, high-tension plug fittings, relays, time limit fuses, and static leakage detectors. An underground switch-box for disconnecting high-tension cables is formed of cast-iron with a clamped-on lid. The three-phase switch inside is operated by an external hand wheel, the cables being brought in by a trifurcating box, and the case is filled with oil. Light loads up to 50 amperes at 6,600 volts can be broken satisfactorily.

ALLOYS OF LEAD AND MAGNESIUM

It is known, says *Engineer*, that the addition of small quantities of sodium or potassium or magnesium to lead hardens the metal considerably. If tin is added to either of these alloys its brittleness is somewhat diminished and its resistance to chemical action increased. According to *Metal and Era*, an alloy of soft lead and magnesium which in moist air is slightly attacked on the surface is proof against such action when tin is added. The tin is equally effective in an alloy of lead and sodium. The hardness of these alloys may be increased by an addition of copper. The proportion of tin as of copper must not exceed 5 per cent. The proportion of sodium or magnesium should not be greater than 4 per cent.

BRITISH BOARD OF TRADE

During the month of October the British Board of Trade received inquiries from firms at home and abroad regarding sources of supply for the following articles. Firms which may be able to supply information regarding these things are requested to communicate with the Director of the Commercial Intelligence Branch, 73 Basinghall St., London, E. C.

Button moulds
Corks with attachment for applying liquid renovator, evenly, to leather goods
Corrugated steel fasteners for boxes
Machinery for making sand-paper

Machinery for boot-cleaning
Machinery for coating carbon paper
Metal tubes for shaving soap and brushes
Pattingers (small metal collar or cuff fasteners)

AN INSTITUTE FOR COÖPERATIVE RESEARCH AS AN AID TO THE AMERICAN DRUG INDUSTRY

In order to gain as many views as possible concerning the proposed institute for coöperative research as an aid to the American drug industry, a symposium on which was printed in the last issue of *THIS JOURNAL*, reprints of that symposium were forwarded to many who would naturally be interested in the subject and their views thereon requested. These are printed below without any effort at editing as it is desired to have as unrestricted a discussion as possible of this important subject before the matter should take any definite line of organization. A number of other contributions on this subject have been promised and will be printed in our next issue.—[EDITOR.]

AMERICAN DRUG MANUFACTURERS' ASSOCIATION

Your proposal that a national institute for drug research should be established is, I believe, timely. Such an institute organized along broad lines will meet a very real present-day need of American drug and chemical manufacturers. It should, of course, be organized and financed in such a way as to leave it entirely independent of all outside influences so that without let or hindrance the search for truth could go forward and its findings be accepted everywhere at a 100 per cent valuation.

Not least among its practical benefits would be its possibilities as a training school from which our manufacturers could recruit their various scientific workers. Under present conditions when scientific workers are wanted, manufacturers do not know where to turn to get them.

Your proposal is so full of interesting possibilities that I know the members of the American Drug Manufacturers Association, representing as they do the principal American manufacturers of pharmaceuticals, biologicals, medicinal chemicals, surgical dressings, and essential oils, will want to hear directly from you on this subject, and I am, therefore, asking Secretary Woodruff to extend to you an invitation to address us at one of the sessions of our annual meeting to be held at the Waldorf Astoria, New York, in March next. You will receive a formal invitation in due time.

In the meantime a very general discussion of the subject by those competent to consider it may so crystallize the proposal as to enable you to present something very definite to our members at our meeting in March.—CHAS. J. LYNN, President, American Drug Manufacturers Association.

MANUFACTURERS

It is with great pleasure that I respond to your request to add my mite of information and suggestion to your proposed symposium upon the coöperation of science and industry, for in the last analysis this is what the proposed institute represents and embodies.

Ever since I returned from a two years' course of study in foreign universities in 1891, I have been preaching and advocating from platform and in print the coöperation of science and industry. I was first forcibly impressed with this idea when I applied to Prof. A. W. von Hofmann, of the University of Berlin, for an "Arbeit" and he took me into a room adjoining his private laboratory, and said, pointing to several tables filled with bottles, boxes, and bundles, "Select one from this assortment." Each parcel was a scientific problem seeking solution by some industry in the country and submitted to this University because these industries had been unable to solve it. These industries covered perfumes, flavors, cement, leather, medicines, coal, steel, dyestuffs, glass, textiles, etc., etc.

The industry reserved the right to own and control the result of any successful solution of the problem in whole or in part, and the chemist solving it received the credit and right to publish his result and perhaps benefited to some extent in the profits that resulted.

There were the university and the manufacturing plant coöperating for the mutual welfare of the common fatherland. The result has been the unprecedented growth of all industries, notably the chemical industry, in Germany. In our country this coöperation has been conspicuous by its absence and it required a great war to stimulate this industry. What is yet needed is the coöperation between science and industry and the present time is most auspicious for it, as many plants built to produce war materials must be converted into plants to produce peace materials. For this reason your present symposium is timely and its constructive and practical value reflect credit upon your judgment and energy. As to how the coöperation shall be accomplished, I beg leave to submit in concrete form some suggestions based upon years of thought and experience in the matter and after having read the several interesting papers and plans submitted by other members of the AMERICAN CHEMICAL SOCIETY and practically all friends of mine.

First, there should be organized under the sole auspices and direction of the AMERICAN CHEMICAL SOCIETY with the coöperation when requested of the American Medical Association, the American Pharmaceutical Association, the Hygienic Laboratory of the Marine Hospital Service, the Bureau of Chemistry of the Department of Agriculture, the American Drug Manufacturers Associations' Committee on Standards and Deteriorations, and such other associations as its board of trustees may determine, a biochemical institute.

Second, this institute should be built and established by money contributed for that purpose by individuals, associations, corporations, or anyone interested in the study of medicinal preparations and their effect upon the human or animal body. This should be contributed to the AMERICAN CHEMICAL SOCIETY for this specific purpose and be controlled and expended by that Society acting through a board of trustees of said institute, appointed by the AMERICAN CHEMICAL SOCIETY.

Third, on this board of trustees should be representatives of the several units coöperating and contributing to the fund and work, and the board should not be larger than twelve, and if possible, smaller.

Fourth, the institute should have a scientific director and staff of chemists, pharmacologists, bacteriologists, pathologists, etc., and should consider work upon, and solve, all such problems as are presented to it by any of its members or contributors.

Fifth, there should be an annual membership fee independent of and in addition to any contributions, which membership fee should be nominal and with fees for work actually done, also charged at reasonable rates, should constitute the income of the institute with which it should meet its expenses, salaries, etc.

Sixth, the institute should if possible be endowed so that the contributions made to build it should provide also for an endowment fund securely invested so as to provide an annual income to pay most of the fixed charges.

Seventh, the work of the institute should be divided into several departments:

A—Pharmacological, where substances are tested as to their therapeutic action upon animals.

B—Hospital dispensary, where patients are received and treated, either ambulatory or in wards, and upon which clinics are to be held to demonstrate the efficiency and effect of medicines.

C—Chemical, where synthetic and analytic work is done upon chemicals, drugs, animal products, etc., looking to develop some new therapeutic agent for the cure or alleviation of disease and suffering.

Eighth, the hospital dispensary department is an essential feature of this institute, for animal experiments alone are insufficient to prove the value of a medicine. This could be a separate or an existing hospital that would coöperate. It would, however, be preferable to have the hospital as in case of the Rockefeller Institute under the management and control as well as the roof of the institute.

Ninth, there should be established fellowships, endowed or provided by members or contributors, to serve the double purpose of providing a worker to undertake a specific piece of work for the founder of the fellowship and of developing and training a prospective employee for this kind of work.

It seems important that there shall be upon the board of trustees as well as upon the committee coöperating with the director of the institute in determining the nature of the problems to be undertaken by the institute itself, outside of the problems sent to it for solution, some business men, with scientific training if possible, so as to develop at least some practical useful products alongside of those of theoretical interest.

It is important that no one association other than the AMERICAN CHEMICAL SOCIETY should be permitted to dominate the management or policy of this institute. They should all be asked to coöperate as extensively and actively as they may desire, but the AMERICAN CHEMICAL SOCIETY should always retain the control of the institute.

In the same spirit no one industry or individual should be permitted to contribute sums that would justify and properly entitle him to dominate the institute because that would at once largely destroy much of its usefulness and influence. A democratically organized and representatively managed institution seems the proper plan to make a success in the twentieth century.

Best wishes for the ultimate establishment of your desirable, badly needed, and extremely humanitarian project.—A. R. L. DOHME, Sharp & Dohme, Baltimore, Md.

It is with much pleasure that I respond to your kind note under date of November 27 requesting my views concerning the establishment of an institution to be devoted to the study of the properties and actions of drugs. The wonder is that someone had not thought of this enterprise a long time ago. Its value and need goes without saying and I trust that it may in due course become an established fact.

While there are many pitfalls to be avoided in planning such a work, it is a clear-cut proposition after all and the gentlemen who have it in charge are certainly capable of steering it to a splendid result.

The proposed basis of a strong organization for the investigation of the fundamentals and general guidance, with another force to specialize on the various problems, is certainly a rational one and should meet with prompt response and support from those who are interested in the scientific aspect as well as the commercial possibilities.

As I see it, commercial houses are really the media through which valuable discoveries are made available, and it is pleasing to see that as time passes the prejudice against commercial exploitation of good things in a proper manner is passing away. You may depend upon the concern with which I am connected coöperating to the fullest.

We would consider it a great honor to be permitted to establish one of the first scholarships.—J. K. LILLY, President, Eli Lilly & Company, Indianapolis, Ind.

An experience covering thirty years, which period includes the rise and decline of the use of synthetic drugs, has made me wonder whether the advertising of these products has not done more harm than good and whether any drug is worthy of recognition and use by the medical profession if the demand for it would decline if the advertising were discontinued.

Soon after the introduction of antipyrine, antifebrine, and phenacetine there was such a swarm of synthetic products put on the market that the lists of new remedies increased to the size of volumes, and, as only a small fraction of these survived, the question naturally arises: Did the patients to whom they were administered have any better fate?

Unless a drug is good enough to make practitioners want to use it again, after they have once tried it, it ought not to be used at all. The vital question in this discussion is how to find out whether a synthetic has merit and, if this has been proved, then how to inform the world of its qualities and insure an ample supply of it without having the introduction of it made by those who are interested in its sale and who, therefore, will not be able to make impartial statements regarding its properties.

The instinct which leads the medical profession to protest against the patenting of remedies is a true one, because, if the thing is really potent to prevent suffering, it should not become a monopoly. Under present conditions it seems to be essential, in order to produce and market the product, that the producer should be assured of the monopoly of it for a given time, but this might be obviated if some such plan as follows were adopted:

An international commission, provided with an ample fund to compensate inventors and to conduct an international research laboratory, to ascertain the value of the drug and, if it is of value, authorize its manufacture and sale and at the same time make the official world-wide announcement as to its properties and effects, any manufacturer to be at liberty to produce and sell it, on the sole condition that he report to the international commission the entire quantity that he sells; the compensation of the inventor to be paid from the international fund and the amount of his royalty to depend upon the quantity of the drug sold; the international commission to determine the percentage of his royalty, which should be generous and could perhaps be better figured on the number of doses than on the number of pounds sold. Such a plan would do away with the evils of medical advertising and would avoid the inflated demand which we have so often experienced for drugs with very moderate merits and often very dangerous properties, a demand created by skillful propaganda and advertising on a huge scale. It would make the synthetic drugs available at moderate prices everywhere and it would stimulate the research chemist, because he would know that if his synthetic product should possess virtues making it worthy of use, he would receive his reward without going through the anxious ordeal of endeavoring to interest capitalists to manufacture and exploit it. Moreover, the prediction can be made with confidence that if such a plan were adopted the number of new synthetic remedies would diminish to such an extent that the medical profession could have a clear view of the situation and not be groping in a fog that necessarily causes distrust of all new remedies. It might well be that only one synthetic worthy of use would appear in a decade, and who shall say that humanity would not be the gainer?

Some manufacturers would continue the effort to develop and introduce their own synthetics, but this policy would be inadvisable and the practice would be reduced to a minimum if penalties were imposed on any one making misleading statements concerning a medicinal preparation, and the international

commission should have it as one of its duties to test the products on the market and confirm or disprove the claims made for them.

The international commission should receive recognition and should receive compensation adequate to secure scientists of the first rank and of the highest personal character. The suggested policy may seem paternal but is it really democratic when contrasted with the corrupt methods of the huge German color factories, with their staffs of experts concealing their processes from each other and teaching only one step to one group of workmen and trying to filch their secrets one from another and bribing the foremen in the dyeing establishments to pay high prices for old colors under new names, presenting an example of commercialized science, which should make every lover of truth and of liberty fight to exalt science to a position where she would be safe from such contamination.—WM. JAY SCHIEFFELIN, Schieffelin & Co., New York City.

In the December issue of the *Journal of Industrial and Engineering Chemistry* writers have quite fully discussed the desirability of an institute for drug research as originally outlined by Dr. Herty. A number of them have outlined plans for the formation and conduct of such an institute.

It seems to me that it is a mistake to limit the plan to the producing of new remedies or, indeed, to the study of synthetic medicines. Undoubtedly, however, a central medicinal research laboratory, such as has been outlined by the various workers, would be found to be of great usefulness and would undoubtedly invite the cooperation of the various societies and associations who have been and are now doing some work in this line, and would be a great boon to many manufacturers who often reach the limit in their own laboratories and who would be glad to pass on to an institute given over to pure research those problems which they feel they cannot pursue and which indeed they should not be called upon to pursue because of the wide-spread bearing upon the science of medicine.

It seems to me that the work of an institute put together as has been outlined would be much more far-reaching than that of any particular association or even of that fostered by departments of the general government.

During the great war a number of efforts were made to cultivate certain medicinal plants, although the number of varieties actually cultivated was very small but in most instances sufficient to avoid what might have been a famine. Unless we are to allow things to drift back to the pre-war status there is much yet to be done. For the most part the work has been done either by interested manufacturers or by the agricultural departments of the various states. The agriculturalists look upon the problem strictly from their own point of view, *vis.*, the growing of a crop that will pay. There yet remain many questions to be answered, such as the production of a better strain, the acclimatizing of certain plants of foreign origin, the improvement of methods of handling, preparation, and preservation. Here chemistry and pharmacology are both involved.

Again, we have a number of native products which would probably form efficient substitutes for those heretofore imported. For this latter there is need of thorough investigation.

Finally, it has been well stated that there is not a crying need for new drugs either natural or synthetic, but we do need to know more about some of the drugs which we already have at hand. I might put the thing in this way: look in the *Pharmacopoeia* and select a dozen of the most common vegetable drugs named therein, look up the literature as embraced in the *Dispensatory* and kindred works, and it will be seen that for the most part that which is written has come down from the ages and much of it is tradition. It has not been checked up or gone into since the original inception. What is known is for the most part historical, in respect to many of them there

is a statement as to what is believed to be the active principle, a routine statement as to the physical and therapeutic action, and that is all. When we come to check up the Galenical preparations made therefrom we find that these preparations have been put together sometimes empirically, that is to say, a certain menstruum of a certain strength is employed probably because it has always been employed and not always with regard to exhibiting the drug in its most potent form to fulfill its therapeutic action.

In brief, a long study could undoubtedly be made of a dozen or more of the most common drugs which we possess which would involve pharmacology, chemistry, and therapy. There remains much to be learned in the study of drugs and thus I believe that an institute of the character which has been outlined would be of great value to the healing art and would be welcomed by manufacturers and individual workers.—FRED. B. KILMER, Johnson & Johnson Laboratories, New Brunswick, N. J.

The first thing that strikes me after reading your editorial for September 1918 and the addresses in your December issue on "An Institute for Coöperative Research as an Aid to the American Drug Industry," is the utter candor of the discussions. The confession that we have no institute as yet in this country where therapeutic advances can be tried out in an unbiased fashion was a brave one to make. I knew this to be a fact. The impression that most Americans had was that medical colleges and the great hospitals of this country were open to this sort of research. As a matter of fact, neither of these have either the facilities nor the inclination required.

In the first place, I heartily agree that there should be such an institute as outlined in the various addresses. It should be free of governmental and commercial control. Pure research should be indulged in.

There are several points, however, at which I disagree with the thoughts expressed. I fully realize that the addresses made were more or less impromptu and simply to give a sense of direction and outline to the work proposed.

The chief objection is that too much stress is laid upon producing synthetic drugs. This is simply harking back to the German idea that man can improve on nature's handiwork. Why we should have synthetic salicylic acid and synthetic camphor as medicines, is beyond my comprehension. I feel sure that if the medical profession had not been misled by the clever German propaganda, they would never have accepted so freely the synthetic products made from the phenol group and the marsh gas group. To simply imitate what the Germans had made would be rather poor work for such an institute as is proposed, for we may rest assured that the Germans have continued their researches even during the war period, and if they intend to continue their before-the-war chemical activities, they will have made improvements on what was formerly introduced into this country from Germany.

In the next place, chemotherapy has assumed too prominent a place in the healing arts and has been stressed too much in the past. It is undoubtedly true that many new compounds of minerals and metals may be devised that would be more acceptable than have been the cruder products employed in the past. But if the institute is to be limited to this sort of work, it will fall short of its possibilities.

As I see the subject, such an institute should take up the entire field of organic chemistry, no matter from which field the raw materials are obtained—mineral, plant, or animal.

The whole question of plant substances as curative agents is really only in embryo. As a matter of fact, no general study has been made of plant substances during the last three or four decades, either in the United States or in any other country, with the possible exception, in a measure, of France. In this country, there has been a tendency on the part of pharma-

cologists to discredit plants upon rather flimsy ground. There has, in the later years, crept into the work of American pharmacologists the dangerous concept that to be effective a drug necessarily must be toxic. Such is far from the fact, as demonstrated by clinical experience.

Even such study as has been made in the past on plant substances, has been of rather crude character. Chemically they have been studied for starches, pectins, and other so-called inert matter, on the one hand, and on the other for alkaloids, glucosides, resins and resinoids, and so-called active principles.

Pharmacologically they have simply been studied from a mechanistic point of view, namely as excitants or depressants of the various organs, such as the heart, lung, kidneys, uterus, etc.

The problems of colloidal chemistry in relation to plane substances and the presence of ferments, open still another very large field for original research. If it be the intent of the organizers of the institute to so broaden the scope of their work, as to include all of these substances in their research, it will have the hearty support not only of manufacturers, but of all physicians generally.

It is important that the work of such an institute shall be investigative and advisory. It should never be clothed either directly or indirectly with dictatorial powers. The moment such dictatorial powers are assumed, the usefulness of the institute is in large measure negated. It must be borne in mind that science is ever progressive and that any facts that are proven are to be looked upon as signposts, indicating the road never to be looked upon as the end of endeavor.

Please do not misconstrue my statements above as in any way opposed to the institute. I simply wish to point out its possibilities and urge that there be no limitations to the study of substances to be employed in therapeutics. I assure you of my hearty support in every way possible, in the establishment and maintenance of such an institution.—CHAS. G. MERRELL, President, The Wm. S. Merrell Chemical Co., Cincinnati, Ohio.

PHARMACEUTICAL CHEMISTS

I am much interested in your editorial in the September issue, entitled "War Chemistry in the Alleviation of Suffering." It may be that a short review of my experiences in attempting to have tested several crystalline substances isolated from certain animal products of a glandular character may be interesting.

These crystalline bodies were the result of several years of tedious research. When the chemical work had been completed. I sought the services of a pharmacologist to make the necessary physiological tests, the results, concisely stated, being as follows: In accordance with my experience, there are in America a very limited number of pharmacologists, and only a few of these are well trained. A few of the better trained ones are in the employ of less than half a dozen large pharmaceutical manufacturing concerns, and their services are not generally available. The remainder and, generally speaking, the best, are associated with the universities, with the exception of those employed in work in endowed institutions, of which the Rockefeller Institute is the chief exponent. The pharmacologists of the universities have, as a rule, limited facilities, limited means, and are overworked. Much of their time, even that of the chief of laboratories, is given to teaching. In my experience, all of these university men are pleased to give advice and make suggestions, but can give no service for two reasons: first, because, as previously indicated, they have more work than they can do; second, and more particularly, because it is generally considered non-ethical to do work for industrial concerns. I would call your attention to Article 2, Section 3 of the Constitution of the American Society of Pharmacology and Experimental Therapeutics, which reads as follows: "No one shall

be admitted to membership who is in the permanent employ of any drug firm."

I have been able to locate several trained pharmacologists—part-time workers in universities—who would have been quite willing to have devoted part time to pharmacological work for the industrial concerns of which I am a member, had it not been for the section of the constitution just mentioned. Pharmacologists of experience and reputation will not, as a rule, devote either part time or entire time to industrial work, because there is a prejudice in professional circles against so doing.

At the present time we still have on hand the crystalline bodies before mentioned, and our investigation is held up until we can have these and other less pure preparations tested. Your suggestion for the establishment of an institute analogous to the Mellon Institute, in which adequate provision for laboratory tests of all kinds will be made, and to which, through the establishment of fellowships, the manufacturing organizations could send well-trained young men for working out specific problems, if carried out, would in my opinion result in a great service to all the people of this country and of the world.

There are one or two questions which I should like to ask in this connection. Are not well-trained young men for pharmacology extremely rare? Would it be practicable to have a corps of trained workers to whom products, preparations, and simple substances might be submitted for testing, and a charge made commensurate with the service given? I am sure that many industrial concerns will be interested in your proposition and will be willing to cooperate, but the only practical way to establish the institution, in my judgment, is to interest some philanthropist in furnishing funds for an endowment.—H. A. B. DUNNING, Hynson, Westcott & Dunning, Baltimore, Md.

To-day there is an insistent demand upon every organized profession, craft, or trade for public service designed to promote the general well-being of all. The public bestows its goodwill and support upon those organizations only that work continuously, forcefully, and creatively for public welfare. Neither chemistry as a science nor the AMERICAN CHEMICAL SOCIETY as an organization will ever outgrow the need for support and encouragement from other professions and from the multitudes untrained in science.

Chemistry has to-day come perilously near being regarded by many persons as useful only in the development of agents of destruction but the need of the science in preventing and curing disease should be and will be made known if the organized profession acting through the AMERICAN CHEMICAL SOCIETY found or control an institute devoted to chemical research on problems associated with the relief of pain and the preservation of health. For its own good name and repute and as evidence of its willingness to promote the public good, if for no other reasons, the Society should work actively for the founding of such an institute.

All of us earnestly desire that science and industry in America shall contain within America all essentials for development and be built upon such broad and strong foundations that any growth of whatever magnitude will be well supported. An institute of chemotherapeutical research will greatly help to place the drug industry of America upon such a solid basis. If approached, the industry will declare itself ready for this institute, will grant it large responsibilities, and will give it many opportunities to prove its worth.

Ample financial resources, coordination of many lines of study, enthusiastic workers, an impartial, exacting, and able board of control will answer the question, "What and who?" But there is another question that will be frequently asked, "Will their report be accepted by the people we wish to influence?" Upon the answer to this question depends largely the position of the institute in its relation to the drug, and associated biological and chemical industries.

Reputable houses in such lines want to know that articles of their production, or which they may plan to produce, are desirable therapeutic agents, but this knowledge has little or no value if kept to themselves. It must be told to others under conditions and for purposes that are legally and economically right. Furthermore, it must be told to a great number because each person may have few opportunities to use this knowledge though at each opportunity it becomes of great importance. These persons must be approached along many and diverse avenues and very many of them will be influenced to finally accept or reject this proffered knowledge by phenomena falling within their own fields of observation. Thorough consideration should be given at the outset to securing the acceptance of the institute's findings either in pure science or on problems arising from cooperation with industry.

Who shall be asked directly to accept these findings? Not the man in the street, let us decide at once

Through what channels shall these findings be presented and how controlled?

Ignoring these questions will not prevent the asking; they bear directly upon the steps to be taken in effecting the organization of the proposed institute.

In deciding the merits of an article used for the cure of disease, the balance and other instruments of precise measurements upon which chemistry relies are not the only witnesses to be heard. Those who desire to reach truthful and widely-accepted conclusions in therapeutics, must tread cautiously and travel far.

To establish a testing laboratory for drugs, a research institute for the study of chemical therapeutic agents or of synthetic organic chemicals, or to demonstrate that chemistry should be more extensively applied in the study of suffering are each and all projects worthy of the best efforts of any ambitious society or group of men. Their accomplishment is more probable now than it has ever been before. The Advisory Committee to whom the New York Section resolutions were referred may well find that the organization or control of the proposed institute very properly falls within the Society's activities and that it is a feasible and practical solution of difficulties which frequently confront members of the Society.—A. D. THORBURN, Pitman-Moore Company, Indianapolis, Ind.

RESEARCH INSTITUTES

I have nothing to add to the statement made by my colleague Dr. P. A. Levene. The ideas which he expresses and the mode of procedure he proposes meet my full approval.—JACQUES LOBB, The Rockefeller Institute for Medical Research, New York City.

The reports of the symposium on the subject of a research institute for the development of chemistry as applied to medicine must be vitally interesting to all who are concerned with the development of a rational independence for our country, especially to any who are either from choice or necessity concerned with the narrower operations of any of the many particular sciences or businesses involved. That we may be able to re-direct a potent fraction of the enormous energy, which as a people we have recently so happily exerted for our own protection and the success of our friends, into an activity of this nature, is profoundly desirable.

Objections and difficulties obtrude themselves when the problem is viewed in detail and in the light of experiences which one can too easily recall from his memory. To me the chief of these was rendered negligible by the spirit displayed by those participants in the discussion of November 8 who most directly represented the industry. That Mr. Eldred should see so clearly that much of the outstanding activity of the past has been simply exploitation; and that Mr. Jayne should insist that the

future of the industry must depend upon the merit of the products rather than upon advertising, and also that the organization under discussion should tend to assure this by being strong enough in both ability and integrity to dominate the situation,—these are expressions of opinion which certainly can be considered a sufficient answer to the fancy that much of the energy of such an institution need be worn out in putting useless products or ideas in the scrap.

In general, then, I agree with the earlier participants to the discussion in believing that there is a distinct need for such an organization or institute. I think that the AMERICAN CHEMICAL SOCIETY is the only body at present organized which could hope so to combine the interests involved as to give the project a chance of success, and that it is highly desirable (from the point of view of one who is not a member) that the Society should take the necessary initial steps with promptness and vigor.

As to the scope of the work of such an institution, it is evident that each person will be biased by his particular experience, and it is possible that for the present it will be most helpful that each should express such views as those experiences have given rise to. My own belief is that the institute should concern itself primarily with research in the field of organic chemistry, especially synthetic, and that in its applied aspects particular attention should be paid to the field of pharmacology and therapeutics. Physiological chemistry, as it has been understood by most, and the analysis and processing of natural products as they have concerned the industry of the past will receive consideration secondarily as fields from which valuable indications for work may be drawn.

In carrying out the purpose effectively there will naturally be gathered together a certain number of research men of the highest possible standing. The problems of the institute as such will, as a matter of fact and regardless of the most careful planning in advance, be those in which these men become interested after they are collected together. Limitations on the freedom of choice of these men in their personal researches cannot, of course, be made. Over and above their individual interests it may, however, be expected that the staff of the institute individually and as an organization will assume certain broader duties. Thus they will endeavor to advance the interests represented by the institution by cooperative aid extended to others working in the field but not supported by the institution.

Concretely, active work is called for in an educational way among both chemical manufacturers and teachers of organic chemistry. Manufacturers need to be taught that there are near at hand large advantages to be derived from an exchange of ideas and products and that these advantages can for the most part be had without endangering in any way their proper possession of trade secrets. This is most certainly true if emphasis is laid on products and their properties rather than on processes. Teachers of chemistry need to be shown that while they are teaching their students processes and reactions in practical courses they may be of the greatest service by actually producing a wide variety of compounds which, if cared for, could be put to good use either by themselves or others. An important item in this educational work would be the maintenance of a working museum of chemicals, to which manufacturers and teachers and research workers should alike contribute, and from which properly qualified persons might withdraw samples and be furnished with reliable information as to where further supply might be obtained.

A working laboratory might by cooperation with manufacturers also be established where the latest models in apparatus should be installed and where qualified individuals, not on the institute staff, would be welcomed to put through particular processes and reactions required by their own researches but not otherwise available to them.

The services to be rendered by such an institute to manufacturers have been well developed by other parties to this discussion.

The control of the institution and its policies might well be divided in such a way as to separate in considerable measure the responsibility of the scientific work and the finances. The financial advisers might well be selected from among those who have shown a capacity to make money by reason of their knowledge of chemical processes, and who may have a "dollar a year" interest in promoting chemical and medical research.

The scientific control should be entrusted to a board of trustees or advisers which should be made up of a well-balanced combination of men who have succeeded in the field of, first, chemical research; second, medical research; third, the management of research activities in either chemistry or medicine; and fourth, industrial research in chemistry.

Such an institute at present would be faced at once with a fundamental question of policy, *i. e.*, the necessity of reaching a clear-cut decision as to its attitude toward patents on medicinal preparations. It is highly desirable that the institute, if it is established, should never have to consider this matter, but this can be avoided only by having an agreement reached between chemists and medical men on the patent question before the institute is put into operation.

The attitude of the medical profession on the patent question has seemed in the past to be clearly defined, but it has become apparent that the letter of the medical law does not fit modern conditions. It would, on the other hand, be a national calamity if the spirit of those articles in the code of ethics which absolutely prohibit a physician becoming party for profit to the exploitation of manufactured products in their application to medicine should be in any manner lost sight of. Would it not be well for properly appointed committees of the AMERICAN CHEMICAL SOCIETY and the American Medical Association working together to formulate a policy to which both professions could unhesitatingly subscribe as being in the public interest.—PAUL A. LEWIS, The Henry Phipps Institute of the University of Pennsylvania, Philadelphia, Pa.

In the December issue of the *Journal of Industrial and Engineering Chemistry* appear various addresses delivered at a meeting of the New York Section of the AMERICAN CHEMICAL SOCIETY, on a proposed institute for cooperative research by manufacturers, chemists, and investigators in the medical sciences. The objects of such an institute are outlined as (1) an aid for the development of the American drug industry by scientifically testing and establishing the values of their products and improving already existing products, and (2) a great central station for extensive chemotherapeutic investigations for the alleviation of human suffering, by finding new remedies and drugs as yet unknown. The two objects are, of course, intimately connected, and success in the attainment of the second would cause vast strides in the first.

The speakers at the symposium have already fully covered the field as to the fundamental principles which should govern the formation of such an institute. Certain ideas which have been advanced should be further emphasized to assure the success of such an institute on a large scale. Such a project naturally divides itself into two parts: (1) Cooperative research and pharmacological and therapeutic testing for the manufacturers and outside chemists, and (2) pure research for new remedies, which will involve a great deal of theoretical investigation on the relation of chemical constitution to pharmacological action by pharmacologists and organic chemists, aided by biochemists, bacteriologists, physical chemists, and other specialists as needed. Too much emphasis cannot be placed upon the second part of the institution, the pure scientific research. The institute, as I understand the plans, is a Peace institution as opposed to a War one, that is, one which is not

necessarily limited by time for the solution of its problems, but one which is building for all time, for the relief of suffering and the happiness of the human race. The testing division of the institute can deal with the immediate needs for improvements by the manufacturers, while the other part will concern itself with more prolonged problems which may take years for solution, but which, if solved successfully, will yield immense rewards in the advancement of knowledge, the relief of suffering, a tremendous stimulus of the drug industry, and great financial return. As an illustration, the problem of chemotherapy for any one of the better-known and widespread bacterial diseases is by no means a hopeless one, but one, however, which is to be solved only by such facilities and cooperation as outlined for this institute. The attempts which have already been made in the chemotherapeutic study of bacterial disease, although not eminently successful, would warrant a group of cooperative investigators giving their lives to the problem. If successful, the results would be more far-reaching than Ehrlich's salvarsan. As regards the personnel of such an institute, there is no question that eminent men and specialists of the highest order should be selected for the important posts. The investigators should be given the utmost freedom of action and the most perfect support possible. Every searcher after truth has found that the important end-result of many an investigation is far removed from the initial impetus that started it. One feature of the personnel which would seem desirable is that the institute should have some arrangement whereby it could secure temporary service from investigators in the universities and industries, because so frequently when a problem touches a field in which some investigator is an eminent master, it can be solved more accurately and quickly by this man than by any other.—E. K. MARSHALL, JR., American University Experiment Station, Washington, D. C.

UNIVERSITIES

Replying to your letter of November 27 requesting an expression of opinion on the subject of an institute for the study of drugs I will say that this is a subject which has long interested me.¹

The subject was so well covered at the recent symposium that I can add little. There is one point, however, which I think should be especially emphasized, the need of absolute freedom in research on the part of those in charge of such an institute; they should be free at any time to discontinue work on one class of compounds and take up the study of another class. Similarly they should be free to abandon research on one disease and take up that on another. The importance of this entire freedom may be illustrated by Ehrlich's discovery of salvarsan. This discovery is the most notable achievement in this field and since its very beginning has not been described. As I am probably the only person familiar with it, it may be of interest to record it; it illustrates the accidental way in which an important research may begin. Nocard visited Ehrlich's laboratory in 1902 and told of his work on certain pathogenic trypanosomes and Ehrlich requested him to send the institute an infected rat. A few days after Nocard's visit I, who was working in the Institute, received from Ehrlich a note (which I happened to keep), suggesting that I try the effects upon the trypanosomes of certain substances in which I was interested. Among the drugs suggested were certain dyes and some quinine derivatives (the study of one of which later led to the work on ethylhydrocuprein, a compound which seems to just miss being of value in an entirely different disease, *vis.*, pneumonia) and also atoxyl. (The mention of atoxyl in this note, which bears the date of Dec. 12, 1902, is of interest in view of the contention recently made that Ehrlich got the idea of trying the arsenic compounds, which ultimately led to salvarsan, from the work

¹ See, for example, *J. Am. Med. Assoc.*, 49 (1907), 1690.

of some English investigators some years later.) My own work was soon interrupted but it was continued by others. At first the relation of dyes to trypanosomes was studied, then the effects of certain arsenic compounds upon these organisms, and finally the effects of the arsenic compounds upon spirochetes. This led, after 7 years of intensive work, to the discovery of salvarsan. The point I wish to make is that had Ehrlich been limited to a study of the pharmacology of dyes (which might easily have been the case had his work at that time been financed by a dye manufacturer) he would not have discovered salvarsan. Similarly, had an unwise government restricted Ehrlich's researches to trypanosomes (in which the Berlin officials were deeply interested from their desire to find a means of checking the ravages of sleeping sickness in the German African colonies) the remedy for syphilis probably would not have been discovered. There has been a tendency in this country to restrict researches to definite subjects; this is shown by the large appropriation of the Government for the study of pellagra, for example, and of private endowments for cancer research.

In an institute of the kind proposed the chief investigators should have absolute freedom of research. But this would not preclude the inclusion of organizations within the institute to study the action of certain groups of chemicals (dyes and their precursors, for example) on the one hand, or remedies for certain diseases on the other. The inclusion of such organizations would be most desirable from every standpoint; it would give chemical manufacturers an opportunity to have their products tested for useful and also for possibly harmful properties, and it might encourage the manufacturers to contribute in various ways to the support of the institute. But the latter should be so well endowed as not to be wholly or even largely dependent upon support contributed for studies on specific subjects.

An institution along somewhat similar lines has recently been established at the Harvard Medical School. A group of public-spirited manufacturers (chiefly of New England) have provided funds for work in industrial hygiene, the problems to be undertaken to be determined by the faculty. In addition, certain manufacturers have provided funds for the investigation of special problems in which they are particularly interested. One of the functions of this organization will be the investigation of chemical compounds used in the industries in the hope that in the future such widespread injury to employees as has resulted in the past in certain chemical factories may be avoided.

As to the need of an independent, well-endowed institute of the character suggested at the symposium there can be no doubt. Such an institute should not only provide ample facilities for its own workers but an equally important function would be, as has already been suggested, to assist workers at university and other laboratories. In your editorial on "War Chemistry in the Alleviation of Suffering" you report a conversation with an organic chemist who was perplexed as to how he could get his products tested. A similar conversation is very likely to occur whenever two or three American pharmacologists are gathered together. "But where can I get such a compound?" is a very familiar question and the usual answer is, "You can not get it at all in America." And the compounds in question are often such as can be easily and cheaply made but the pharmacologist can not suspend his own special work to make them, even if he has the facilities and training to do so. Hence, an important function of such a proposed institute would be the providing, at cost, or at a moderate profit, of chemical compounds, drug plants, etc., to independent workers; the same effort should be made to supply outside investigators with such material as would be made to supply its own members.

It would surely seem that an institute of the kind suggested, which not only would have its own independent investigators but which would offer facilities for special workers and be of so much assistance to university and other investigators, should

appeal to broad-minded philanthropists; the studies in such an institute would surely contribute as much to the welfare of man as do the magnetic surveys, geophysical, embryological, anatomical, nutrition, and other institutes which have been founded in this country.

But the foundation of such an institute should not be interpreted by government and university officials as relieving them of a responsibility to foster work of this kind. The universities need pharmacological laboratories not only for research but for purposes of instruction, and the experience of the last few years should have convinced lawmakers that scientific investigation is too vital to the welfare of the country to be left to chance or charity. It has been estimated that the profits obtained from the people of the United States by German drug manufacturers in recent years would have enabled Congress to appropriate for such studies \$100,000 a year for a century or more.

It may not be generally known that when the late Surgeon General Wyman in 1902 secured the enlargement of the U. S. Public Health Service and of the Hygienic Laboratory he included a division of pharmacology; this was the first recognition of this subject on the part of the Government and was at a time when but two or three of the universities had independent chairs in pharmacology. It was General Wyman's idea that such a division should primarily endeavor to discover new drugs and that it should work in cooperation with the other divisions (chemistry, bacteriology, pathology, and zoology, including parasitology) of the laboratory and the score or more Public Health Service hospitals. But various circumstances have prevented this laboratory from fulfilling the high purposes which both General Wyman and Congress had in mind. This would seem to be an opportune time to urge Congress to increase the resources of this laboratory and to make the positions in it more attractive to investigators.

Finally, a few words may be added as to the functions of the universities in the development of work of this character. The contributions which university pharmacological laboratories (chiefly German) have made for the alleviation of suffering are often overlooked. Thus many of the most important drugs—drugs which have stood the test of time—discovered in the last 50 years, *i. e.*, since the development of scientific pharmacology, owe their origin to the investigations in university pharmacological or closely allied laboratories. The discovery of the action of chloral hydrate (the basis of most of the subsequent work on the halogen-containing hypnotics), paraldehyde, antipyrin, sulfonal, the urethane group of hypnotics, strophanthin, physostigmin, cocaine, the nitrites, theobromine and other purine diuretics, and the suprarenal extract, need only be mentioned. Yet pharmacology in the universities of the United States is in a primitive condition; in some institutions, owing to lack of funds, or in other cases to a failure to appreciate the full meaning of pharmacology, this subject is still combined with some other subject, always to the detriment of pharmacology.

While, however, the study of pharmacology by the Government and by the universities should receive every encouragement, an institute such as that proposed would fill a place not occupied at present and would be of more immediate interest to the members of the Chemical Society, and the institute would, in turn, profit more by their interest.

It is one of the tragedies of history that the means of relieving suffering for which the whole human race has most passionately yearned have at times been in the hands of man years or even centuries before their value was ascertained. Ether, for example, was well known for three centuries before its anesthetic properties were discovered; the crudest of pharmacological experiments would have shown that this drug had the pain-preventing properties dreamed of since the time of Adam. Carbolic acid, the use of which by Lister paved the way for

modern surgery with all that this means, had been known to chemists for years when Lister first used it. Chloroform, chloral hydrate, the bromides, cocaine, and many other valuable drugs had the same history. There can be no doubt that the present generation is overlooking equally or even more valuable drugs simply because few of the new compounds being discovered are tested from this point of view.—REID HUNT, Department of Pharmacology, Harvard University Medical School, Boston, Mass., and President, American Society for Pharmacology and Experimental Therapeutics.

The proposal for a national pharmacological institute as outlined in the addresses before the New York Section of the AMERICAN CHEMICAL SOCIETY on November 8, 1918, is most interesting. Dr. Herty's invitation to contribute something to the further discussion of this plan moves me to call attention to two points requiring further emphasis—the question as to whether the fundamental viewpoint is to be medical or chemical, and the problem of the relation of our universities to the proposed institute.

In the first place, what is to be the institute's chief object? As I understand it, the alleviation of human suffering by every possible means upon which the science of chemistry has a bearing. The alleviation of suffering being desired, whence must come the initiative? Obviously from the one who is in contact with the sufferer.

Indispensable as it is to pharmacological achievement, the chemical viewpoint cannot serve as the sole guide; medical sciences must be the starting point.

A concrete example may clarify this contention. A man wishes to discover the ideal antipyretic drug. He must first acquaint himself with the physiology (physical and chemical) of heat regulation. He must then gain a conception of the pathology of fever in general and determine the individual peculiarities of those forms of fever which require antipyretic treatment. He should proceed further to test upon animals and man at least one member of each of the best classes of antipyretics already known. He must determine their effects, if any, upon the normal regulation of bodily heat. This will require not merely accurate measurements of body temperature but studies of the total metabolism and of the separate mechanisms by which bodily heat is dissipated. A *sine qua non* is, of course, the exclusion of toxic side effects. Attention may then be turned to like tests upon febrile individuals. To clear up satisfactorily every point thus far involved would require more than a lifetime. Yet it is obvious that such preliminary investigations must precede consultation with his colleague in organic chemistry relative to the structural modification of the most promising drug. It is surely better that the pharmacologist spend his life in such a biologically directed search than in the promiscuous testing of those substances which the synthetic chemist happens to find easy of preparation or the industrial chemist discards as superfluous by-products.

Emphasizing again that we cannot dispense with the chemical viewpoint, let the guiding motive of an institute for the alleviation of human suffering be medical.

In the second place, what part should universities take in the work of the national pharmacological institute? I am inclined to the belief that it should be at least the major part. A multiplication of institutes devoted solely to research may, in time, defeat its own end by drawing away from the medical schools men who are not only efficient in research but in inspiring and training subsequent generations along lines of investigation. The supply of thoroughly trained pharmacologists is dangerously small at the present time. To furnish, however, a more adequate number in the future the medical investigator's profession must be made more attractive financially. This is the opportunity of the university.

The correlation of chemistry and therapeutics can, I believe, be far more extensively developed within the confines of the leading universities than it is at present. Broad pharmacologic vision is needed. By all means have a central national institute of the highest grade, provided it does not detract from the development of pharmacology in medical schools. In addition to the minor functions of the institute, such as the provision of a central chemical collection, library, etc., as well as a "censorship" for pharmacological suggestions which would be welcomed from all sources, *e. g.*, chemists, pharmacists, and medical practitioners, there might be attempted some sort of coordination of the work being done in the separate schools. Steps would, of course, be taken against violation of the independence of the individual investigators. In a given university, however, all departments concerned should, if adequately financed for the purpose, be willing to devote a generous amount of attention to the particular field of work which might be assigned to or selected by that particular school.

The division of topics should be along physiological lines. For example, chemists, pharmacologists, pathologists, and clinicians might concentrate in one university upon local anesthetics, in another upon cardiac and vascular remedies. Some schools might be best adapted to the investigation of the chemotherapy of certain diseases, for example, pneumonia, tuberculosis, or syphilis.

Upon the pharmacologist in each university would perhaps devolve the duty of representing the central institute and of coordinating the work.

Each department concerned should control one or more fellowships founded for the purpose of cooperation upon pharmacological problems. The organic chemist would, of course, supervise the synthetic work. The department of medicine would be equipped to provide the cases and make the clinical tests in a ward set apart for the purpose. The pathologist, bacteriologist, and serologist would be provided with everything necessary for developing their sides.

The pharmacologist, in addition to the work of coordination, would supervise the tests for toxicity, the necessary tests upon various organs in animals, and as far as possible in man; but he should do more. He should develop the relationship between the problem in hand and the much neglected field of general pharmacology.

General pharmacology must be made attractive to graduate students. Benefactors of the institute should be led to appreciate its fundamental importance. The relation of chemical constitution to physiological action is but one of its phases. We are, for example, practically in darkness as regards those questions which relate to the precise mode of action of chemical substances upon living cells. The mechanisms also of absorption, distribution, fixation, and excretion of drugs in the animal organism are but superficially understood.

The above outlined suggestion as to the part universities should play in forwarding the aims of the national pharmacologic institute offers one very distinct advantage, it provides for more extensive utilization in this type of work of facilities now available. They can be widely developed for cooperative investigation in chemistry and medicine if the authorities can be made to appreciate the extent of the opportunity.

Is our condition still so pitiful that Elihu Root is justified in saying of research and the problem of its organization, "It cannot be successful if parcelled out among a lot of universities and colleges to be done by teachers, however eminent, and students, however zealous, in their leisure hours?"¹

Pharmacology may be as much in need of national organization as are other sciences, but conditions must be made favorable for keeping it where it belongs,—in the university medical school.

¹ *Science*, 48 (1918), 533.

This is, I realize, but a one-sided presentation of the institute question. Numerous phases have been left untouched. It is, however, of the greatest importance that medical men should take the lead in such a movement and that medical schools should thereby be developed and not depleted.—HENRY GRAY BARBOUR, Yale University School of Medicine, New Haven, Conn.

The papers read at the meeting of the New York Section on November 8, 1918, and your editorial in the September issue of the *Journal of Industrial and Engineering Chemistry* on the subject of an institute for research on the pharmacology and the chemistry of medicinal substances have interested me greatly, not merely as a member of the AMERICAN CHEMICAL SOCIETY, but chiefly as an officer of the American Pharmaceutical Association.

This Association, founded in 1852, has been aptly called "the clearing house of American Pharmacy" and it has been the fond dream of some of its members¹ for twenty years that an undertaking similar to that now suggested by you might come into being.

During the past few years two steps in that direction have been taken by the Association. The first is the idea of federation of the national associations of American pharmacy—manufacturing, jobbing, retail, and educational—and a committee, of which I have the honor of being chairman, has been studying the question during the past year. The second movement in this direction has been the creation, by the Association, of a Committee on Research, of which I had the honor last year of being chairman, to which has been entrusted the dual duty of encouraging pharmaceutical research and of administering, under the care of the council of the Association, the American Pharmaceutical Association Research Fund.

This fund represents the net profits accruing from the publication and sale of the National Formulary, one of the standards under which the national food and drug law is administered. This book, originally a purely private enterprise of the Association, having thus become an official book of legal standards, the Association wisely decided that its profits should be used for the common weal rather than for the advantage of its members, hence the establishment of this research fund in 1916.

Half of the interest on this fund is available until the fund reaches \$100,000 and thereafter the entire interest may be devoted to research problems.

On January 1, 1918, the fund amounted to \$7,043.41, an amount that is constantly increasing as the sales of the National Formulary continue, and it is hoped to have the fund further augmented by gifts from other sources.

You may be interested in noting that quite a number of the members of the American Pharmaceutical Association research committee (consisting of H. V. Army, of New York, G. M. Beringer, of Philadelphia, J. A. Koch, of Pittsburgh, Henry Kraemer, of Ann Arbor, Mich., E. Kremers, of Madison, Wis., C. H. LaWall, of Philadelphia, F. B. Power, of Washington, W. L. Scoville, of Detroit, A. B. Stevens, of Ann Arbor, Mich., and H. M. Whelpley, of St. Louis) are members of the AMERICAN CHEMICAL SOCIETY.

With the information in hand you will note that the American Pharmaceutical Association has among its aims work along the same lines you advocate. As was well pointed out at the meeting of the New York Section by the representatives of the Bureau of Chemistry, of the Rockefeller Institute, and of the Mellon Institute, the work contemplated is so vast that the

several available agencies can attack the different phases of the same problem without friction and without unfriendly rivalry. But on the other hand, cooperation means unified and conserved energy, whereas competition means energy wasted by working at cross purposes. It therefore seems to me that from the beginning an attempt should be made to correlate our efforts along the lines of research.

It would be the height of bad taste for me to attempt to speak at this juncture for either the American Pharmaceutical Association or for its Committee on Research, but I am certain that my associates will agree with me when I say that "team work" will bring far better results than will the independent efforts of several organizations.—H. V. ARMY, College of Pharmacy, Columbia University, New York City.

The wisdom of the establishment of a national institute for drug research is so obvious, that one wonders why the subject needs discussion. Such discussion is not necessary for those engaged in any branch of medical research. It is well known that our most valuable drugs have untoward actions that the combined efforts of the chemist and pharmacologist could unquestionably improve, and the value of their combined efforts in all branches of therapeutics cannot be overestimated. A few specific instances may be cited. In cancer of the gastro-intestinal tract, or in any other region for that matter, life is made bearable or relatively comfortable by the use of opium alkaloids. However, the pain-relieving effects of morphine are offset by the serious drawback of its constipating action. Atropine is a valuable drug in menstrual troubles, but its action in drying the secretions of the mouth and in dilating the pupil almost precludes its use in these cases. Quinine, the specific for malaria, has many serious untoward actions collectively termed chinchonism. Cascara sagrada, our most valuable remedy for chronic constipation, because of the griping it frequently produces seriously handicaps its use. The salicylates in rheumatism, salvarsan or the iodides in syphilis, thymol in hookworm disease, etc., etc., are all valuable remedies, yet all produce untoward symptoms, and all have, because of these actions, been the cause of death. All of these drugs might be improved by modification, and substitutes might be found vastly superior to the original drug, substitutes that are not merely palliative, but curative.

Marked improvement in many preparations has been made by the substitution of an amide group here, or a nitro or ethyl radical there. These cases are so numerous that examples need hardly be given. The introduction of ethyl for the hydroxyl hydrogen in alcohol has given us our best anesthetic. The introduction of nitro groups for the corresponding hydrogen in glycerin has given us nitroglycerin, one of our best remedies for angina pectoris. The introduction of ethyl groups into acetone has given us some of our most valuable sedatives. The search for an artificial quinine has led to the discovery of our most valuable antipyretics. In fact, haphazard, almost blind, groping has unearthed so many valuable remedies that a scientific basis for prediction is almost established. The possible results of the combined efforts of the pharmacologist and the chemist in this way are almost unlimited. The one knows what might be expected from such substitutions and introductions, but cannot make these; or if he is able to do this, can accomplish but a small fraction of a great volume of obvious work. The chemist knows how to introduce and substitute any atom or radicle almost at will, yet, so far as physiological action is concerned, he must work rather blindly. The combined attack of two men trained in these different fields would be decidedly synergistic, and the possibilities are unlimited.

Besides a direct attack on the many scourges of mankind the work indicated will do much to clarify the mechanism of life itself, and so open the way to the counteraction of all bodily ills. The great problem of the action of optical isomers in itself

¹ See Eliel, *Proc. Am. Pharm. Assoc.*, 46 (1898), 225; Lyons, *Am. J. Pharm.*, 73 (1901), 137; Simon, *Ibid.*, 73 (1901), 138; Kremers, *Ibid.*, 73 (1901), 139; Scoville, *Ibid.*, 73 (1901), 86; Real, *J. Am. Pharm. Assoc.*, 1 (1912), 1189; Wulling, *Ibid.*, 6 (1917), 780; Army, *Am. J. Pharm.*, 73 (1901), 92; *J. Am. Pharm. Assoc.*, 2 (1913), 510; *Am. J. Pharm.*, 89 (1917), 175 and 448.

may open a fruitful field. The facts that certain moulds can ferment dextrotartaric acid and not levo; that yeast will ferment such sugars as *d*-mannose, *d*-glucose, or *d*-fructose, but will not ferment *l*-fructose, *l*-glucose, *l*-mannose, or *l*-galactose; and that dextrohyoscyamine, dextro-epinephrine, etc., are so much more potent than the levo forms, are full of suggestions for work that can be successfully attacked only by combined effort. Countless examples of promising fields of research might be cited, which few, if any, laboratories have either equipment or support to attack. For example, the recent work of Kendall in isolating the hormone of the thyroid gland, now used in the treatment of goiter, required tons of material; cancer of old age is thought by some to be due to deficiency of thymus hormone, but just at present no laboratory, because of the expense and the amount of thymus needed, can begin work on such a suggestion. All such problems could be hopefully engaged by an adequately equipped national institution for drug investigation, or a national institute of pharmacology or chemotherapy. The expense of such an institute must be considerable, but in comparison with its importance and its possibilities for human welfare and the relief of suffering, any expense is relatively small.—HUGH MCGUIGAN, College of Medicine, University of Illinois, Chicago, Ill.

The several titles of papers presented in the symposium give indications of almost fundamental differences in conceptions of the objects sought in founding an institute of research such as has been proposed.

The editor speaks of "An Institute for Coöperative Research as an Aid to the American Drug Industry," clearly suggesting a purely utilitarian direction, while others who participated in the discussion appear to entertain ideas of research in pure science as a part, at least, of the functions of such an institute.

I am in hearty sympathy with the effort to develop American synthetic drugs, and take it that one may discuss the problem either from an idealistic, or a practical, point of view. The idealistic is of value as suggesting the general direction toward which the practical should develop so far as is possible within its limitations, and these limitations will depend upon the breadth of view of those whose interest in the problem can be aroused.

Without attempting to outline the scope of an ideal research institute completely, one may suggest a starting point, and the ideal research institute should have no limitations of development. Certainly it is highly desirable that it should include as much of the following organization as possible, but, on the other hand, there is no reason why a beginning should not be made long before it is possible to secure all that is desired. A university in its simplest form has been defined as consisting of a student and his preceptor seated on a log, but no one has ever successfully outlined an absolutely ideal university, or attempted to place any limitation on its scope. An institute of the character proposed would be almost, if not quite, equal to a university in scope.

In its simplest form it might begin with a laboratory accommodating a competent chemist and a capable pharmacologist. The need would soon be felt for capable assistants in both fields, and this in turn would lead to the demand either for a special hospital equipped for clinical study of synthetic drugs which the pharmacologists had found deserving of such study, or for affiliation with an established hospital where such studies could be made, the first being ideal, the second an approach to it.

The clinical study of drugs is far more difficult than the chemical and pharmacological as a rule. The problems of clinical study embrace all of those of the pharmacologist and many peculiar to therapeutics, hence, the hospital should have well-equipped laboratories of bacteriology and clinical pathology, and in time, others in addition.

More important by far than the mere number and variety of the several departments in such an institute, and even of the

capabilities of those who occupy the chief positions, is the question of its organization, especially with reference to the attitude of those who investigate the pharmacologic and therapeutic uses of newly discovered agents.

There is discernible in the discussion a note of enthusiasm regarding the probable financial returns resulting from such an institute of research. It is only human to look for financial rewards, and there is no reason why the chemist who discovers a valuable product should not profit from his discovery, but abundant experience teaches that it would be dangerous to permit those who decide upon the pharmacologic and therapeutic virtues of a product to profit by their opinions. It is obviously just as meritorious for the pharmacologist and the clinician to discover the disadvantages of a drug as it is to point out their partial advantages, and it is equally obvious that it would be wrong in principle to permit an arrangement whereby it would be to the interest of the pharmacologist or the clinician to render a favorable report.

Furthermore, it seldom happens that a single pharmacologic or therapeutic investigation results in conclusions that do not undergo important revision in the light of subsequent experience, but there is a strong tendency to attempt to justify a previous favorable opinion concerning a remedial agent, when subsequent experience shows that it is less valuable than the investigator had been led to suppose, and this is especially true when one has induced others to invest money on the strength of his opinion, or where he profits by the exploitation of it.

Naturally, if the pharmacologist and the clinician are debarr'd from profiting by the results of their favorable opinions, they must be protected against loss of position and other disadvantages as the consequence of them; in other words, they should be insured entire freedom of action in the broadest sense of the word.

These conditions entail difficulties, and it has been whispered more than once that the near relatives of eminent scientists have profited financially through the successful exploitation of remedial agents, and not a few men of eminence have been suspected of profiting by the sale of preparations, their faith in the virtues of which was not shared by the majority of physicians. Of course, the difficulties presented offer no argument against the establishment of such an institute, but they do call for most careful consideration, and they render it imperative that such an institute shall be under the direction of an independent, conscientious, capable director.

Everyone is familiar with the fact that several of the great chemical firms engaged in the manufacture of dyestuffs in Europe have introduced great numbers of synthetic drugs that have proved profitable in the extreme, but, on the other hand, this exploitation has gone far toward creating a condition of therapeutic chaos, in which physicians and writers of textbooks have been largely dependent on the statements of those who were directly or indirectly interested in the exploitation of these drugs.

It is suggestive, to say the least, that when the Council on Pharmacy and Chemistry of the American Medical Association undertook to prepare a list of all of the really essential drugs used in the treatment of the sick it included only about a score out of the many hundreds of synthetic drugs which have been introduced within the past thirty years with such optimistic therapeutic claims.

Dr. Abel had this in mind when he formulated the two conditions that were requisite for such an institution: "(1) A sufficient endowment to make the institute independent of outside influences. (2) The Board of Trustees of this institute must see to it that those selected for the leading positions are men of ability and promise, whose one interest is research of a high order, whether in the field of pure or of applied science."

It is hardly necessary to say that I realize that the plan for

such an institute involves a great deal of study and that one can do no more in a brief discussion of this sort than call attention to some of the phases of the problem that must be given most thoughtful consideration if the institute is to become a great force for good rather than merely a means for securing the exploitation of synthetic products that offer means of making money.

There is one point that I do not feel inclined to pass over without a word of comment, though I am not in a position to enter into a complete discussion of it at this time. I refer to the cooperation of the several departments of existing medical schools. There is no inherent reason why there should not be the freest cooperation between the institute and such departments of medical schools; on the contrary, it would be an evidence of weakness should it be impossible to secure such cooperation. It is quite true, however, that pharmacologists in medical

schools often feel impelled to refuse to investigate proposed remedies, because experience has shown that a favorable opinion might be used in the exploitation of the substance, while equally important disadvantages were ignored.—ROBT. A. HATCHER, Department of Pharmacology and Materia Medica, Cornell University Medical College, New York City.

The institute, especially according to the draft of Professor Abel, would promise to facilitate the sort of cooperation between research and industry that is absolutely necessary for the national development of the field: a cooperation which is very difficult without some such mechanism.

I should be very glad to help to further the plan to the extent of my ability.—TORALD SOLLMAN, Pharmacological Laboratory, Medical Department, Western Reserve University, Cleveland, Ohio.

SCIENTIFIC SOCIETIES

REPORT OF THE COMMITTEE ON THE ANALYSIS OF COMMERCIAL FATS AND OILS¹

To the Division of Industrial Chemists and Chemical Engineers, American Chemical Society:

Your Committee on the Analysis of Commercial Fats and Oils, begs leave to report as follows:

This Committee has been meeting regularly, holding, as a rule, one meeting each month, for the past several years, and has adopted methods of analysis, after much cooperation work, on September 22, 1916, January 13, 1918, and September 4, 1918.

The methods adopted on September 22, 1916, and January 13, 1918, were published as TENTATIVE STANDARD METHODS FOR THE SAMPLING AND ANALYSIS OF COMMERCIAL FATS AND OILS, in the *Journal of Industrial and Engineering Chemistry*, 10, (1918), 315.

The Committee begs leave to present herewith a reprint of the TENTATIVE STANDARD METHODS FOR THE SAMPLING AND ANALYSIS OF COMMERCIAL FATS AND OILS already published, with corrections, and also a typewritten copy of the methods adopted September 4, 1918, which have not as yet been published.

The Committee desires that all of these methods be now referred to the *Supervisory Committee on Methods of Analysis*, of which Dr. W. F. Hillebrand is chairman, for final recommendation and adoption by the AMERICAN CHEMICAL SOCIETY, as standard methods.

The membership of this Committee is at present as follows:

W. D. Richardson, <i>Chairman</i>	P. Rudnick
W. J. Gascoyne	L. M. Tolman
H. J. Morrison	J. J. Vollertsen
J. R. Powell	

As the Committee is still working on further methods of analysis, which are important to the fat and oil industry, it requests that it be continued in existence by the Division until this work is completed.

SWIFT AND COMPANY
CHICAGO, ILL.

W. D. RICHARDSON
Chairman

CORRECTIONS TO TENTATIVE STANDARD METHODS FOR THE SAMPLING AND ANALYSIS OF COMMERCIAL FATS AND OILS

To September 4, 1918

SAMPLING:

2. SAMPLING FROM CAR ON TRACK—(b) *When contents are liquid.*
Add to this paragraph the following sentence: "In place of the device described above, any sampler capable of taking a

sample from the top, bottom, and center, or from a section through car, may be used."

ANALYSIS

SOLUBLE MINERAL MATTER

In the sentence reading "ASH the residue in a muffle, to constant weight, taking care that the decomposition of carbonates is complete, etc.," insert the words "alkaline earth" before the word "carbonate."

UNSAPONIFIABLE MATTER

Under DETERMINATION strike out the last sentence reading, "When the unsaponifiable matter runs over 5 per cent, etc." Add immediately after the sentence which now reads, "Repeat extraction at least four more times, using 50 cc. petroleum ether each time," the following: "More extractions than five are necessary where the unsaponifiable matter runs high, say over 5 per cent, and also in some cases where it is lower than 5 per cent, but is extracted with difficulty."

WIJS METHOD FOR THE DETERMINATION OF IODINE VALUE

Change heading to read IODINE NUMBER—WIJS METHOD.

Under PREPARATION OF REAGENTS—Wijs Iodine Solution—

(2). The sentence "Or dissolve 6.5 g. of resublimed iodine," should read "13 g. of resublimed iodine."

Add under PREPARATION OF REAGENTS—Wijs Iodine Solution, a third paragraph, reading as follows: "There shall be no more than a slight excess of iodine, and no excess of chlorine. When the solution is made from iodine and chlorine, this point can be ascertained by not quite doubling the titration."

METHODS OF ANALYSIS ADOPTED SEPTEMBER 4, 1918

MELTING POINT

APPARATUS—Capillary tubes made from 5 mm. inside diameter thin-walled glass tubing drawn out to 1 mm. inside diameter. Length of capillary part of tubes to be about 5 cm. Length of tube over all 8 cm.

Standard thermometer graduated in tenths of a degree.
600 cc. beaker.

DETERMINATION—The sample should be clear when melted and entirely free from moisture, or incorrect results will be obtained.

Melt and thoroughly mix the sample. Dip three of the capillary tubes above described in the oil so that the fat in the tube stands about 1 cm. in height. Now fuse the capillary end carefully by means of a small blast flame and allow to cool. These tubes are placed in a refrigerator over night at a temperature of from 40 to 50° F. They are then fastened by means of

¹ Presented at the Cleveland Meeting of the American Chemical Society, September 10 to 13, 1918.

² THIS JOURNAL, 10 (1918), 315.

a rubber band or other suitable means to the bulb of a thermometer graduated in tenths of a degree. The thermometer is suspended in a beaker of water (which is agitated by air or other suitable means) so that the bottom of the bulb of the thermometer is immersed to a depth of about 3 cm. The temperature of the water is increased gradually at the rate of about 1° per minute.

The point at which the sample becomes opalescent is first noted and the heating continued until the contents of the tube becomes uniformly transparent. The latter temperature is reported as the melting point.

Before finally melting to a perfectly clear fluid, the sample becomes opalescent and usually appears clear at the top, bottom, and sides before becoming clear at the center. The heating is continued until the contents of the tube become uniformly clear and transparent. This temperature is reported as the melting point. It is usually only a fraction of a degree above the opalescent point noted. The thermometer should be read to the nearest $1/3^{\circ}$ C., and in addition this temperature may be reported to the nearest degree Fahrenheit if desired.

CLOUD TEST

PRECAUTIONS—(1) The oil must be perfectly dry, because the presence of moisture will produce a turbidity before the clouding point is reached.

(2) The oil must be heated to 150° C. over a free flame, immediately before making the test.

(3) There must not be too much discrepancy between the temperature of the bath and the clouding point of the oil. An oil that will cloud at the temperature of hydrant water should be tested in a bath of that temperature. An oil that will cloud in a mixture of ice and water should be tested in such a bath. An oil that will not cloud in a bath of ice and water must be tested in a bath of salt, ice, and water.

DETERMINATION—The oil is heated in a porcelain casserole over a free flame to 150° C., stirring with the thermometer. As soon as it can be done with safety, the oil is transferred to a 4 oz. oil bottle, which must be perfectly dry. One and one-half ounces of the oil are sufficient for the test. A dry Fahrenheit thermometer is placed in the oil, and the bottle is then cooled by immersion in a suitable bath. The oil is constantly stirred with the thermometer, taking care not to remove the thermometer from the oil at any time during the test, so as to avoid stirring air bubbles into the oil. The bottle is frequently removed from the bath for a few moments. The oil must not be allowed to chill on the sides and bottom of the bottle. This is effected by constant and vigorous stirring with the thermometer. As soon as the first permanent cloud shows in the body of the oil, the temperature at which this cloud occurs is noted.

With care, results concordant to within $1/3^{\circ}$ C. can be obtained by this method. A Fahrenheit thermometer is sometimes used because it has become customary to report results in degrees Fahrenheit.

The oil must be tested within a short time after heating to 150° C. and a re-test must always be preceded by reheating to that temperature. The cloud point should be approached as quickly as possible, yet not so fast that the oil is frozen on the sides or bottom of the bottle before the cloud test is reached.

NOTES ON THE ABOVE METHODS

MELTING POINT

A melting point is the temperature at which a solid substance assumes the liquid condition. If the solid is a pure substance in the crystalline condition the melting point is sharp and well defined for any given pressure. With increased pressure the melting point is lowered or raised, depending on whether the substance contracts or expands in melting. The lowering or raising of the melting point with pressure is very slight and ordinarily is not taken into consideration. Melting point determina-

tions are commonly carried out under ordinary atmospheric pressures without correction. The general effect of soluble impurities is to lower the melting point, and this holds true whether the impurity has a higher or lower melting point than the pure substance (solvent). Thus if a small amount of stearic acid be added to liquid palmitic acid and the solution frozen, the melting point of this solid will be lower than that of palmitic acid. Likewise the melting point of stearic acid is lowered by the addition of a small amount of palmitic acid. A eutectic mixture results when two components solidify simultaneously at a definite temperature. Such a mixture has a constant melting point and because of this and also because both solid and liquid phases have the same composition, eutectic mixtures were formerly looked upon as compounds. The phenomenon of double melting points has been observed in the case of a number of glycerides. Such a glyceride when placed in the usual capillary tube and subjected to increasing temperature quickly resolidifies only to melt again and remain melted at a still higher temperature. This phenomenon has not yet been sufficiently investigated to afford a satisfactory explanation.

Non-crystalline substances such as glass, sealing wax and various other waxes and wax mixtures, and most colloidal substances do not exhibit a sharp melting point but under the application of heat first soften very gradually and at a considerably higher temperature melt sufficiently to flow. This phenomenon of melting through a long range of temperature may be due to the amorphous nature of the substance or to the fact that it consists of a very large number of components of many different melting points.

The fats and oils of natural origin, that is, the animal and vegetable fats and oils, consist of mixtures of glycerides and, generally speaking, of a considerable number of such components. These components are crystalline and when separated in the pure state have definite melting points, although some exhibit the phenomenon of double melting point. For the most part the naturally occurring glycerides are mixed glycerides. In the natural fats and oils there are present also certain higher alcohols of which cholesterol is characteristic of the animal fats and oils and phytosterol of many of the vegetable fats and oils. In addition to the crystalline glycerides and the higher alcohols present in neutral fats, there are in fats of lower grade, fatty acids, which are crystalline, and also various non-crystalline impurities of an unsaponifiable nature, and the presence of these impurities tends to lower the melting point. They also tend to induce undercooling when the liquid fat or oil is being chilled for purposes of solidification or in determination of titer.

The presence of water, especially when this is thoroughly mixed or emulsified with a fat or oil, also influences the melting point to a marked extent, causing the mixture to melt through a longer range of temperatures than would be the case if the water were absent. This is particularly true of emulsified fats and oils, such as butter and oleomargarine, both of which contain, besides water, the solids naturally present in milk or cream and including casein, milk sugar, and salts. The melting point method recommended by the Committee is not applicable to such emulsions or other watery mixtures and the Committee has found it impossible to devise an accurate method for making softening-point or melting-point determinations on products of this nature. Not only the amount of water present but also the fineness of its particles, that is, its state of subdivision and distribution, in a fat or oil influences the softening point or melting point and causes it to vary widely in different samples.

As a consequence of the foregoing facts, natural fats and oils do not exhibit a definite melting point, composed as they are of mixtures of various crystalline glycerides, higher alcohols, fatty acids, and non-crystalline substances. Therefore, the term melting point when applied to them requires further definition. Various methods have been devised to determine the so-called melting point of fats and oils. Most of these methods, how-

ever, determine, not the melting point, but the softening point or the flow point of the fat and the great difficulty has been in the past to devise a method which would determine even this point with reasonable accuracy and so that results could be easily duplicated. It has been the aim of the Committee to devise a simple method for the determination of the melting point of fats and oils, but it should be understood that the term melting point in the scientific sense is not applicable to natural fats and oils.

BICHROMATE SOLUTION

The Committee calls attention to the fact that occasionally potassium bichromate is found containing sodium bichromate, although this is of rare occurrence. If the operator suspects that he is dealing with an impure potassium bichromate, the purity can be ascertained by titration against re-sublimed iodine. However, this is unnecessary in the great majority of cases.

GLACIAL ACETIC ACID

The glacial acetic acid used for preparation of the Wijs solution should be of 99.5 per cent strength or higher and should have a freezing point of 14.7 to 15° C. (m. p. 16.7°). In case of glacial acetic acids of somewhat lower strength, the Committee recommends freezing and centrifuging or draining as a means of purification.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

The 11th Annual Meeting of the American Institute of Chemical Engineers will be held in Chicago, Ill., January 15 to 18, 1919 headquarters at the Congress Hotel. The preliminary program follows:

WEDNESDAY, JANUARY 15

9 : 30 A.M.—Registration.

Address of Welcome.

Business Session, including canvass of ballot for officers.

10 : 30 A.M.—Address of President Thompson, "Our Chemical Industries Made Permanent."

11 : 00 A.M.—Symposium on Maintenance and Preservation of Our Chemical Industries:

Dr. Grinnell Jones, of the United States Tariff Commission.

Dr. Louis Matos, of the National Aniline and Chemical Company.

Dr. L. C. Jones, of the Smet Solvay Co.

Mr. Wm. H. Rollin, of the Rollin Chemical Company, "Future of the Barium Industry."

2 : 00 P.M.—Dr. A. A. Veillon, of the Monsanto Chemical Works.
Dr. Edw. Gudeman, "Reconstruction Aspects of Some Chemical Industries in the United States."

General Discussion by representatives of other chemical industries.

8 : 00 P.M.—Reading of Papers:

Dr. F. W. Frerichs, "Reinforced Concrete Tanks for Storing Ammonia Liquors."

Dr. David Wesson, "Some Wild Engineering I Have Known."

9 : 00 P.M.—Smoker.

THURSDAY, JANUARY 16

9 : 00 A.M.—All day excursion to the Argo Plant of the Corn Products Refining Company.

8 : 00 P.M.—Joint Meeting with the Chicago Section of the American Chemical Society.

FRIDAY, JANUARY 17

9 : 30 A.M.—Business Session.

10 : 30 A.M.—Reading of Papers.

1 : 30 P.M.—Excursion to the plant of the Lindsay Light Company and the Underwriters' Laboratories.

7 : 00 P.M.—Subscription Dinner.

SATURDAY, JANUARY 18

Choice of two excursions:

(1) Standard Oil Company Plant at Whiting, Ind.

(2) Plant of the Newport Hydrocarbon Company near Milwaukee, Wis.

THE JOHN SCOTT LEGACY MEDAL AND PREMIUM

The City of Philadelphia, acting on the recommendation of The Franklin Institute, recently awarded the John Scott Legacy Medal and Premium to Ernest J. Sweetland, of Upper Montclair, N. J., for the Sweetland Filter Press.

This invention is to provide a self-dumping filter press, which will reduce to a minimum the labor involved in discharging the solid residue left in the press after filtration and, also, the labor of cleaning the press by hand.

THE PERKIN MEDAL AWARD

The Perkin Medal for 1918 has been awarded to Dr. F. G. Cottrell for brilliant and useful research and development work in bringing about the practical and successful commercial operation of his method for smoke, fume, and dust abatement.

The Medal will be presented at a meeting of the New York Section of the Society of Chemical Industry to be held in Rumford Hall, Chemists' Club, New York City, on January 17, 1919.

THE NICHOLS MEDAL

On account of the large number of research men who have been engaged during the year past on war problems to which publicity could not be given, the Nichols Medal Committee has decided to make no award of the Medal this year.

NOTES AND CORRESPONDENCE

DON'TS FOR WOULD-BE WRITERS OF SCIENTIFIC ARTICLES FOR THE PUBLIC PRESS

As an aid to the development of popular presentation of matters chemical by the members of the AMERICAN CHEMICAL SOCIETY, Dr. Edwin E. Slosson, a member of the Publicity Committee of the Society, has upon request prepared the following suggestions. Dr. Slosson's successful experience in this art amply qualifies him as a sound guide.—[EDITOR.]

Don't overestimate the reader's knowledge and don't underestimate the reader's intelligence. He may not know as much as you about this particular thing—let's hope not, but otherwise he may be as bright as you are—let's hope so.

Don't try to tell all you know in 500 words. Leave some over for another time. The clean-plate rule does not apply here.

Don't think that because a thing is old to you it is known to the public. Many of your readers are living in the nineteenth century; some of them are in the eighteenth.

Don't imagine that the readers of a popular periodical are, like pupils in a class, obliged to pretend to pay attention to you no

matter how dull you may be. "First catch your reader" is the rule of successful writing.

Don't leave out the human interest. Your reader is a human being even if you are merely a scientist.

Don't forget that your reader is interrupting you every ten lines to ask, "Why?" "What for?" "Well, what of it?" and if you don't answer his tacit questions he will soon stop reading.

Don't think that you can make your topic more attractive by tricking it out with fairy lore or baby talk or irrelevant jokes or extravagant language. Bring out its real and intrinsic interest as forcibly as you can. Set off as much red fire as you like but be sure it lights up the object instead of drawing the attention away from it.

Don't say, "This discovery is interesting" unless you can prove that it is. And if you can prove it, you don't have to say it.

Don't suppose that you must give bibliographical references to all the literature of the subject, but don't fail to give a clue by which the interested reader can get on its trail.

Don't fail to put your best foot forward. Otherwise you won't have a chance to use the other foot. Note the construction of the news story in any first-class paper. It is built up on the same logical system as the symphony or opera. The opening paragraph gives in succinct fashion the main point of interest, the gist of the story, just as the first movement or overture of a musical composition expresses the main theme or motif.

Don't expect the editor to explain why he rejects your manuscript. He is probably right in his verdict, but if you make him give a reason for it he will have to invent one and it would probably be wrong.

Don't say you can't find anything to write about. This number of the *Journal of Industrial and Engineering Chemistry*—and every other—contains at least \$15 worth of good popular science stuff. Chesterton says: "There are no uninteresting subjects, there are only uninterested people."

Don't regurgitate undigested morsels. It is a disgusting habit.

Don't refer to notes or books while writing. Read up on the subject as thoroughly as you can, and take as many notes as you need. Then put away all your notes and books out of reach and next day, or at least an hour later, lay a clean sheet of paper on a clean desk and write out what you know about it in your own way. Afterwards, preferably next day, read over your manuscript critically, verify your facts, correct your data, revise your English, and add any essential points you may have forgotten. But don't expect the reader to be interested in what is so uninteresting to you that you cannot keep it in mind a single hour.

Don't define a hard word by a harder one. Vladivostok is a hard word, but when the war correspondent arrives at Vladivostok he says so and goes right on inland without stopping to explain that "this is a city south of Khabarovsk and east of Tsitsikhar." So you, if you want to say "calorie" say it but don't make it worse by "explaining" it as "the quantity of heat necessary to effect a rise of temperature of one degree centigrade of a cube of water, each dimension of which is one tenth part of the length of a bar of platinum and iridium alloy lying in the observatory of St. Cloud if it has not been smashed up by a shell from the Big Bertha." If you think you must define the calorie say casually that 100 calories of energy can be derived from four lumps of sugar (Hoover size) or from a one inch cube of butter, or explain that a man needs to expend a hundred calories an hour all day to keep his body running and 160 calories if he is working hard.

Don't think you must leave out all technical terms. Use them, whenever necessary, without apology and, if possible, without formal definition. People are not so easily scared by strange words as you may think. They rather like 'em. Kipling is read with delight by old and young, yet his prose and verse are crammed with technical terms. Having exhausted the military, nautical, and mechanical vocabularies he invented a new and unknown nomenclature for his story "With the Night Mail." In his "Just-So" stories for the kiddies he sticks in long names like plums in a pudding. A Kipling dictionary has been published but even the editors could not run down all the peculiar words Kipling has picked up. But the ordinary reader does not need the dictionary. He gets the meaning from the run of the story, for the story is so written that he will get the meaning. Observe that the war correspondent writes without hesitation:

At zero hour the barrage was raised and the poilu and the doughboy sprang over the top, sticking their bayonets into the boche.

And the man in the street reads it without batting an eye although the sentence contains half a dozen words not to be found in his vocabulary four years ago, or in the dictionary yet. But if this sentence was being written by one of our conscientious scientists he would word it in this fashion:

At zero hour—to use the military term for the time set for the beginning of an offensive—the barrage—that is to say the line on which the artillery fire is directed—was raised and the poilu—this is a French slang term for soldier meaning "hairy" and corresponding to our "roughneck"—and the doughboy—this is an American slang term for infantryman derived either from the round buttons worn in the civil war, or the dome huts inhabited in the Mexican war or the pipelayed belts of the Revolutionary war—sprang over the top—that is to say surmounted the parapet of the entrenchments—sticking their bayonets—a weapon invented at Bayonne, France, in 1650—into the boche—a contemptuous term referring to the Germans, probably an abbreviation of *caboche* or blockhead originally applied to Alsatians.

EDWIN E. SLOSSON¹

CHEMICAL NOMENCLATURE

The resolution² passed by the Division of Organic Chemistry at the Cleveland meeting of the AMERICAN CHEMICAL SOCIETY, in which the use is encouraged of "the pure English terms 'benzene,' 'toluene,' and 'xylene,' including all of their derivatives, in place of the hybrid forms 'benzol,' 'toluol,' 'xylol,' etc.," suggests a few remarks. The recommendation is worthy to be heeded by all English-speaking people, as it appeals to me, not so much because the discredited forms are used by the Germans, although an appearance of aping the German is of course distasteful to us all, but because the forms favored are good English chemical nomenclature. As is well known, in careful usage the endings in the names of chemical compounds often have special meanings. They designate classes of compounds. The "-ol" ending in organic nomenclature, *e. g.*, is reserved for hydroxyl derivatives of hydrocarbons (alcohols) and the "-ene" ending is used for certain classes of hydrocarbons. The unsuitability of the name "benzol" for C_6H_6 is obvious. Although "benzene" is a good English word, as shown by usage, and by its conformity to approved nomenclature rules, it is interesting to note that it, as well as "benzol," was first suggested as the name for C_6H_6 by a German. "Benzol" is Liebig's name; Hofmann suggested "benzene."

Both in Great Britain, where, by the way, efforts have also been made to discourage the use of "benzol" in favor of "benzene," and in the United States the use of "benzol" has been more common among industrial men. The fact is significant that these men are more frequently speaking not of the pure compound C_6H_6 but of the commercial mixture of hydrocarbons of the benzene series obtained in the refinement of coal tar. There is some question as to whether or not it is suitable to give this mixture, which may contain less than 50 per cent of C_6H_6 , the same name as given to the pure compound; some favor the use of "benzene" for the compound and "benzol" for the commercial mixture. (The "-ol" ending rule only applies to definite compounds.) In the office of *Chemical Abstracts* we recognize that there are arguments for such a differentiation and for a while tried to apply the two names accordingly, but we have finally decided in favor of the use of "benzene" in both cases, with such modifications as crude, 90 per cent, 50 per cent, etc., in suitable cases. This has seemed better particularly in view of the fact that the rather common use of both names for the pure compound would lead to confusion.

There are other chemical words and names more or less commonly used incorrectly in the United States. Many of the incorrect names are corruptions due to German influence, often bad translations; this makes them seem particularly undesirable now, but there are other better reasons for avoiding them. Good nomenclature is important for its own sake. A correct name of a compound frequently serves to tell the nature of the compound and often its structure also. Correct usage avoids confusion and aids in indexing. In scientific matters it is important to be exact in words and phrases used just as it is im-

¹ Literary Editor of *The Independent* and associate in the School of Journalism, Columbia University.

² THIS JOURNAL, 10 (1918), 944.

portant to be exact with figures. Our experience in editing *Chemical Abstracts* proves this assertion over and over again. Good English in chemical literature, particularly in naming compounds, needs cultivation.

The Organic Division chose a good time to start a movement for better nomenclature and it seems to me that while correcting ourselves in regard to the benzene hydrocarbons we would do well to give thought to other needed reforms. It seems as though such a statement should be accompanied by some specific recommendations. I am not an authority, but possibly the accumulated experience from the constant effort which has been made in the office of *Chemical Abstracts* to keep the abstract journal an example of good nomenclature justifies the statement of a few preferences. The subject has been carefully studied, particularly by those who preceded the present editor and later in connection with the Decennial Subject Index,¹ and the advice of those who seemed best able to help has often been sought. I believe that there will be no disagreement concerning the preferences stated below although frequent divergence from them is observable. They are abridged from "Directions for Assistant Editors and Abstractors of *Chemical Abstracts*." The nomenclature rules in these directions have come to be known, it seems, as representing the forms approved by the AMERICAN CHEMICAL SOCIETY. Requests for information as to the forms so approved are not infrequent. To make our list of nomenclature rules, perhaps after modification, more authoritative, or to formulate a new one and to settle points of disagreement (a number of other preferences could be stated but the chances of disagreement would be greater with reference to them), it would seem to me that a revival of the Society's dismissed Committee on Inorganic Nomenclature and its Committee on Organic Nomenclature would be opportune. Such a suggestion will be made.

In naming a compound so as to indicate that oxygen is replaced by sulfur the prefix *thio* and not *sulfo* should be used (sulfo denotes the group SO_3H); thus HCNS , thiocyanic acid; H_2AsS_4 , thioarsenic acid; $\text{Na}_2\text{S}_2\text{O}_3$, sodium thiosulfate; $\text{CS}(\text{NH}_2)_2$, thiourea. Note particularly that *thiocyanate* is preferable to *sulfocyanide* for salts of HCNS .

The word *hydrate* should not be used for a compound with OH ; it is reserved for compounds with H_2O . Thus, chlorine hydrate, $\text{Cl}_2 \cdot 10\text{H}_2\text{O}$; barium hydroxide, $\text{Ba}(\text{OH})_2$.

Salts of chloroplatinic acid are *chloroplatinates* (not *platinichlorides*). Similarly salts of chlorauric acid are to be called *chloraurates*.

Hydroxyl derivatives of hydrocarbons are to be given names ending in *-ol*, as *resorcinol*, *pinacol* (not *pinacone*), *mannitol* (not *mannite*). There may be objection to the form *glycerol* rather than *glycerin* because the latter is so well established.

German names ending in *-it* should be translated *-ite* rather than *-it*, as *permutit*. If it seems desirable to retain the original form of a trade name it should be placed in quotations, as "*permutit*." Alcohols such as $\text{C}_6\text{H}_5(\text{OH})_3$ (German *Dulcit* = *dulcitol*) are exceptions.

The German ending "*-carbonsäure*" should never be translated "*-carbonic acid*."

It is desirable that in the case of organic compounds the connective *o* be used invariably in such names of substituent radicals as *amino-*, *bromo-*, *chloro-*, *cyano-*, and *iodo-*; thus *bromobenzene*, *chloroacetic*, *nitroaniline*. This conforms to the demands of euphony and also makes for uniformity in indexing. The use of this connective makes for better English; its omission is German-like. There are a few apparent exceptions to this rule as *cyanamide*, *chloraurate*.

The names of the groups NH_2 , NHR , NR_2 , NH , or NR should end in *-ido* only when they are substituents in an acid group, otherwise in *-ino*; thus $\text{MeC}(\text{NH})\text{OEt}$, ethyl imidoacetate; $\text{NH}_2\text{CH}_2\text{CH}_2\text{CO}_2\text{H}$, β -aminopropionic acid (not *amidopropionic acid*); $\text{NHPhCH}_2\text{CH}_2\text{CO}_2\text{H}$, β -aminopropionic acid; $\text{CH}_3\text{C}(\text{NH})\text{CO}_2\text{H}$, α -iminopropionic acid.

Hydroxy-, not *oxy-*, should be used in designating the hydroxyl group; as *hydroxyacetic acid*, $\text{CH}_2(\text{OH})\text{CO}_2\text{H}$, not *oxyacetic acid*. *Keto-* is to be preferred to *oxy-* to designate the group -CO- . This is a case in which it is particularly bad to follow German practice.

The term *ether* should never be used for compounds which are properly called *esters*.

Salts of organic bases with hydrochloric acid should be called *hydrochlorides* (not *hydrochlorates* or *chlorhydrates*). Similarly *hydrobromide* and *hydriodide* (not *hydroiodide*) are preferable.

Sucrose is preferable to *saccharose* or *cane sugar*.

A rather common practice among American chemists and one which does not seem good is the use of the word *body* when *chemical compound* or *chemical substance* is meant. It is desirable to distinguish between a physical body and a chemical substance or compound. The fact that the Germans rather frequently use "*Körper*" for "*chemical compound*" has probably influenced this not incorrect but undesirable use of "*body*" in English.

OHIO STATE UNIVERSITY
COLUMBUS, OHIO

E. J. CRANE

AN INTERNATIONAL SUGAR SCALE

Editor of the *Journal of Industrial and Engineering Chemistry*:

As one whose regular work calls for frequent use of the polariscope, I wish to express my approval of the proposition made by C. A. Browne in your issue of November 1, that this is an opportune time to adopt an international sugar scale and that the Sidersky and Pellet scale based on a normal weight of 20 g. instead of the French and German scales now in use. The arguments advanced in favor of the proposed scale are convincingly stated and certainly no more favorable time can arrive than the present critical time for the proposed change.

I would suggest that no time be lost in bringing the matter to the attention of polariscopists in Great Britain, France, and Italy.

Would it not be an advantage to have every polariscope equipped with both the angular scale and the sugar scale, with the outer edge of the vernier reading on one scale and the inner edge fitted to read fractional parts on the other? The expense would not be serious.

Now that many polariscopists are using as a standard light filter a bichromate of potash filter in which the thickness in centimeters multiplied by the percentage of crystals = 9, we have a standard of approximately monochromatic light which is more conveniently reproduced than the sodium flame, now that electric lights are in use everywhere. It should not be difficult to secure standard glass plates whose absorption as filters would equal in every respect that of the bichromate filter.

With the new scale, the standard light filter, and the standard quartz control plate adopted universally, international polariscopy would seem to have been placed on a very desirable footing.

REGINA, CANADA
November 15, 1918

W. W. ANDREWS

THE 1918 DIRECTORY—AMERICAN CHEMICAL SOCIETY

The 1918 Directory of the AMERICAN CHEMICAL SOCIETY is now available for members. It contains 422 pages as compared with the 1916 Directory's 289 pages, and it exceeds by approximately 4,000 the number of members listed in the 1916 issue. The Directors have voted that it may be obtained by members from the Secretary on payment of \$1.00 to cover partial cost of printing and upon their written statement that it is desired for their personal use only and will not be loaned or disposed of to any firm with which they may or may not be connected or to any individual to be used for advertising purposes.

WASHINGTON, D. C.
December 10, 1918

CHARLES L. PARSONS

RAMSAY MEMORIAL FUND

Over \$3,000 has been contributed to the Ramsay Memorial Fund in the United States up to date. The committee will be glad to receive further American subscriptions. Checks should be made payable and sent to the Ramsay Memorial Fund Committee, W. J. Matheson, Treasurer, 21 Burling Slip, New York City.

¹ See Patterson and Curran, *J. Am. Chem. Soc.*, 39, (1917), 1623-35.

WASHINGTON LETTER

By PAUL WOOTON, Union Trust Building, Washington, D. C.

With practically all government restraint removed, officials here are very generally of the opinion that the chemical industries are adjusting themselves to a peace-time basis with unexpected facility. Little difficulty is being experienced in placing with private concerns the chemists who have been engaged in war work. In fact, practically all employers are taking on more chemists than they employed in normal times. Dr. Charles L. Parsons, the secretary of the AMERICAN CHEMICAL SOCIETY, who is in very close touch with the situation, despite some early misgivings, now feels assured that all chemists engaged in war work will be absorbed by the industry.

The Government is rapidly concluding its war-time arrangements for chemical supplies. This is particularly true of those entering into gas warfare. The situation, speaking generally, is made much easier of solution by the fact that most chemical supplies were being used nearly as rapidly as produced. For this reason, stocks are not great. Such surpluses as exist will be disposed of, it has been announced officially, in such manner as to produce the least possible effect on the market.

Producers of manganese, pyrites, chrome, and tungsten have been in Washington the past month seeking what they term a square deal from the Government. Consumers and importers of these commodities also have been consulted. Government officials are very generally of the opinion that some relief should be extended to producers who took unusual risks to mine materials needed in the war. They are faced, however, by the most intricate problem in determining a safe and equitable manner for granting the relief. The Secretary of the Interior has refused positively to use any of the appropriation carried by the War Minerals Act. His position is that the Act was intended to aid the Government in securing these mineral supplies for war purposes. With the change in conditions, Secretary Lane will use none of the money, despite the fact that the bill technically places it within his power, to attempt to straighten out the manganese-pyrites-chrome situation. He will take this action, he states, if instructed to do so by the President or if Congress can indicate in some way that it would approve of such a course. There is little hope, however, that any relief to the producers of war minerals will come without new legislation.

Chemical manufacturers, who are carrying large stocks of war minerals, are not disposed to take up any additional supplies. This they indicated at conferences with officials. Along with the steel manufacturers, they declined to become parties to several plans which included the absorption of a considerable portion of the over-production.

While there is no denying that the Government has incurred a certain amount of moral obligation in the stimulation of the production of the war minerals, it also is a fact that some responsibility rests on the producers and the consumers. Take chrome, for instance. When the War Industries Board called the producers and consumers into conference, the consumers stoutly maintained that their requirements would be 160,000 tons. The producers, when asked as to their maximum amount of additional production, placed it at 10,000 tons. Instead of using 160,000 tons, the consumers took only 97,000 tons. On the other hand, the producers more than doubled their estimate and produced 25,000 tons in excess of the normal chromite production.

The situation is rapidly coming to a head. The next few weeks will determine, in all probability, just what may be expected. The problem is greatly complicated by the fact that it ramifies into practically every industry.

Important developments in the sulfur situation are expected in the near future. A situation which has been restrained by the desire of the Union Sulfur Co. not to interfere with the sulfur production during the war, is expected to come to a focus quickly. The Union Sulfur Co. contends that the essential features of the Frasch patents date from 1905. The original Frasch patents, however, were granted in 1901. Acting on the assumption that the essential features of the Frasch process date from 1901, and consequently have expired, competitors of the Union Sulfur Co. are utilizing certain features of the Frasch process. The claim of the Union Sulfur Co. has been upheld in the District Court in Delaware. Thus encouraged and with the crisis

passed in the sulfur situation, active proceedings by the Union Sulfur Co. are expected. Not only is the Freeport Sulfur Co. affected, but the Gulf Sulfur Co. also will be involved. The Gulf Sulfur Co. is expected to begin producing sulfur in January from what is regarded as the most promising sulfur deposit which has been discovered in the United States. The deposit is situated at Matagorda, Texas. It was not the intention of the owners to open the property at this time but largely at the insistence of the Government, a plant of great capacity has been installed. This step was taken to insure sulfur supplies, had the war continued. With the turn that world affairs have taken, it now probably will be necessary for the owners to operate the property so as to be reimbursed for their expenditures.

The sulfur producers are coming in for warm praise for the effective manner in which they contributed to the war program. The Union Sulfur Co., it is understood, was able to triple normal output.

In his report to Congress, the Commissioner of Internal Revenue has the following to say in regard to synthetic glycerin:

The facilities of the Bureau for chemical experimentation were utilized in part during three months of the year on the undertaking, which proved successful, of developing a new process for the production of glycerin. The ordinary method of recovering from fats this essential constituent of explosives might conceivably fail to produce an adequate supply for military requirements. In the enemy countries this situation occurred, but was overcome by employing a synthetic process developed by the German chemists. To insure the military program of this Government and of its associates in the war against the contingency of such a shortage of fats, it was deemed advisable to discover a method of securing glycerin from an alternative source.

The Bureau's chemists succeeded, after three months, in developing a practicable process for recovering from the fermentation of sugar any quantity of glycerin which might be required. By a large-scale experiment, later conducted in an industrial plant, it was established that the process not only provided a practicable means of manufacturing glycerin in a military emergency, but also was capable of profitable commercial exploitation. The process was secured to the United States through letters patent and made available for use by the associated governments. Interested manufacturers in this country were given detailed descriptions enabling them to install plants and proceed at once with the manufacture of synthetic glycerin.

The Secretary of War in his annual report to Congress enumerates a number of very interesting facts with regard to the Chemical Warfare Service. In part, he says:

The surprise use of gas by the Germans in 1915 forced upon the allied armies a new form of warfare. The chemical work thus necessitated in the United States Army was at first undertaken by a number of governmental agencies. At the very outset of our participation in the war Dr. Van. H. Manning offered the services and facilities of the Bureau of Mines to the War Department for research work in problems of gas warfare. The Bureau was particularly fitted to perform this highly important pioneer work because of its exhaustive studies of poisonous gases and protection by means of masks made, in connection with mining problems. Similar work was soon started at the American University laboratories. The development and production of gas masks and other articles of defense were shortly undertaken by the Medical Department. The production of toxic gases, containers, and the mechanical apparatus necessary for their active employment was made the task of the Ordnance Department. The Corps of Engineers sent the first men into service as gas and flame troops.

The first consolidation of these separate operations was made for our forces in France early in September 1917, when the Gas Service of the American Expeditionary Force was established. The uniting of the various agencies in the United States came about by executive order June 28, 1918, with the creation of the Chemical Warfare Service under Maj. William L. Sibert. In addition to the development, production, and testing of articles of gas offense and defense, the Chemical Warfare Service is in charge of the training of gas officers, the training of all troops in gas defense, and the organization of gas troops. On November 1, 1918, the personnel of this service included 1,654 commissioned officers and 18,027 enlisted men.

Gas is employed in offensive operations in various ways. Attacks are made by the concentration of artillery fire in which gas-filled shell and mortar bombs are used. Effective attacks are also made with the so-called Livens projectors. A thousand or more of these long, narrow tubes containing gas-filled drums are placed underground in groups of about 25, from 50 to 100 yards apart, and are set off instantaneously by means of electrical connection. Grenades filled with gas and smoke preparations

are used by the infantry in trench fighting. The production of these projectiles and mortars and the various types of containers is under the jurisdiction of the Ordnance Department. The production of toxic gases and the filling of all containers is the work of the Chemical Warfare Service. Gases are produced at Edgewood Arsenal, Edgewood, Md., and at a number of auxiliary plants which have been erected since the war. The progress made in gas production has been so satisfactory that it has been possible not only to fill all shell and containers available and to ship quantities of gas to our forces overseas, but also to make large sales to the Allies. At the signing of the armistice we were equipped to produce gases at a more rapid rate than France, England, or Germany.

Through the cooperation of the various governmental agencies an American type of mask has been developed which affords twenty times the protection of the German mask. Not a case is on record of an American soldier who has fallen victim of a gas attack when protected by the American mouthpiece type of mask. Recently production has commenced on the American Tissot mask, an adaptation of the French type, which, while equally effective, affords the wearer greater comfort than in the case of the mouthpiece mask by enabling him to breathe both through the nose and the mouth.

Production of gas masks started in July 1917. To November 9, 1918, the total production of all types was over 5 1/4 million, of which over 4 1/4 million were suitable for overseas use and nearly 4 million had been shipped to the American Expeditionary Force. In October 1918, 925,000 were completed and inspected. It was expected that a maximum monthly production of 1,200,000 masks would be attained beginning in December.

The greater part of this production has been at the government gas defense plant at Long Island City, N. Y. The average daily production there in October was approximately 24,260.

The serious shortage of carbon for gas-mask canisters in the summer of 1918, due to the scarcity of coconut shells, was relieved in a large measure by the cooperation of the American Red Cross in the vigorous campaign throughout the country for the saving of fruit pits and nut shells.

When it is considered that the Chemical Warfare Service, as such, has been in existence for less than five months, its achievements may be truly considered remarkable.

One of the heritages which came to the Bureau of Mines from the War Industries Board was the difficult problem of "emancipating the American farmer from the grip of Germany's monopoly on potash." At first the Bureau of Mines entertained the hope that money carried by the War Minerals Act could be used in an effort to build up a domestic potash industry, which in a few years would be able to hold its own against the German product. Later it was decided that no War Minerals money should be used for that purpose. Any special activity to stimulate potash production probably will have to wait until after the signing of the peace treaty, as it is understood that the German potash deposits must be looked to for a portion of the indemnity. In turning potash matters over to the Bureau of Mines, the War Industries Board made the following statement with regard to potash:

Before the signing of the armistice, the War Industries Board had already attacked the problem. Chairman Baruch himself had appeared before the congressional committee in behalf of an amendment to the revenue bill which would give encouragement to private industries which would undertake the task of establishing potash production in this country. The Chemicals Division, on the other hand, in cooperation with other departments of the Government, had turned its attention to the specific task of extracting potash from waste products. A committee of experts, representing the steel and iron industry of the country and certain scientific departments of the Government, was in process of formation, under the auspices of the Chemicals Division, at the time hostilities ceased. Its purpose was to determine as quickly as possible the feasibility, from a commercial standpoint, of extracting potash from the fumes of blast furnaces.

Prior to the outbreak of the war, Germany, by reason of her monopoly of the potash supply, had gradually extended her arm around the food crops of the world. It was to Germany that the farmers of this and other countries had to look for the principal ingredient of their fertilizers. Nowhere else were to be found the vast potash deposits which insured to the German potash exporters a natural supply sufficient to meet the demands of the world for several thousands of years to come.

When the outbreak of the European war suddenly cut off this supply the situation of the American farmer was for a time desperate. Under the stimulus of necessity, efforts were launched by private industries to meet the situation, and in consequence there has been a considerable development in the amount of potash produced in this country. By no means, however, has this development approached the requirements of the country. Before the war the American imports of pure potash from Germany for the year ending July 1914 amounted approximately to 250,000 tons. Last year there were produced in the United States 32,000 tons, and this year it is estimated that the output will amount to about 60,000 tons.

The War Industries Board undertook to approach the problem in a larger way, and it is now proposed by arrangement between the Chemicals

Division and the Department of the Interior that the program be carried forward by the latter department.

The suggestion of extracting potash from blast furnace fumes is based on the fact that potash in varying quantities is found not only in the iron ores, but in the coke and lime used in reducing the ores. In Alabama the ores are particularly rich in potash. At present this potash is allowed to escape during the processes in the blast furnaces. Divided into microscopic particles of dust it is volatilized and carried off with the waste fumes.

Several methods of saving this potash have been suggested by scientists. Of these the most feasible appears to be the electric precipitation process devised by Dr. Fred D. Cottrell, of the Bureau of Mines. This involves cooling the gases as they emerge from the blast furnaces and passing them through a series of sheet steel tubes, eight to twelve inches in diameter. Through the center of these tubes is run a wire, or chain, carrying a high voltage charge of static electricity. This electric charge tends to electrify the fine particles of potash dust, causing them to consolidate, or "colonize," and drop down the sides of the tubes. A fair-sized installation for this process requires as many as 400 of these tubes through which to pass the gases. It is this process which the Bethlehem Steel Company has experimented with on a small scale.

Another method tried out involves the spraying of the gas fumes with water and passing them through moist bags, which retain the potash. This method has been tried out in extracting potash from the fumes given off in the manufacture of cement. Its first practical application took place when a cement plant located near Redlands, California, undertook, in response to neighborhood protests, to cut down the volume of fumes emitted from its chimneys. Other cement plants have tried it out, and in the East the Security Cement and Lime Company at Hagerstown, Md., has been foremost in the recovery of potash from cement dust. Cement mixture contains potash in proportions varying from 1 per cent to 1 1/4 per cent. When calcining cement clinkers the addition of salt to the coal that is burned in the kiln renders the potash soluble in water.

At a conference of experts recently held in the office of C. H. MacDowell, director of the Chemicals Division of the War Industries Board, the opinion prevailed that it would be entirely feasible to commercially develop a method of extracting the potash from blast furnace fumes, particularly in regions where the blast furnaces are located near ores in which potash occurs in quantities sufficient to insure substantial recoveries. The problem presents many technical difficulties since care must be taken in developing a by-product process not to interfere with the primary output.

The potash deposits in Germany resulted from the crystallization of sea water. In all of the 202 mines in that country, the potash is found in water-soluble form and for certain purposes can be used just as it comes from the mines without further refining. At Searles Lake, California, potash in this water-soluble form has been found in small quantities, and two factories have been established there to extract it. In Nebraska it has been possible to recover potash in fair quantities from certain alkali lakes located in that state. In Utah, Mr. MacDowell himself established a plant at which pure potash is recovered from alunite.

Elsewhere experiments have been made in recovering potash from certain by-products, such as beet-root molasses and wool scourings. Other sources of supply being studied are the potash shales of Alabama and Georgia, the greenlands of New Jersey, and the leucite deposits of Wyoming. There is, in fact, a considerable development now under way in the production of potash from leucite; and production likewise has been undertaken in Utah from certain brines contained in salt deposits west of Salt Lake City.

Unquestionably it is going to cost much more to produce potash in Germany and Alsace. War taxes, high food costs, and other fundamentals will bring this about so that it will be a long time before European potash is brought to this country at the low cost prevailing before 1914.

The Secretary of Agriculture, in his report to Congress, tells of the purchase and distribution of nitrate of soda as follows:

The Food Control Act, which authorized the President to procure and sell nitrate of soda to farmers at cost for the purpose of increasing production, appropriated \$10,000,000 for that purpose. By direction of the President, the War Industries Board made arrangements for the purchase of the nitrate, and the Secretary of Agriculture for its sale and distribution. The Bureau of Markets was designated as the agency to handle the work for the Department.

Contracts were made for the purchase of about 120,000 short tons of nitrate, and arrangements were effected through the Shipping Board to secure tonnage for transporting it from Chile. A selling price of \$75.50 on board cars at port of arrival was announced in January 1918, and farmers were given an opportunity to make applications through the county agents and committees of local business men appointed for the purpose. Applications for amounts totaling more than 120,000 tons were received from 75,000 farmers, who asked for lots ranging from one-tenth of a ton to more than 100 tons. On account of the lack of available shipping it was possible to bring in, up to June 30, 1918, only about 75,000 tons, practically all of which actually was sent to farmers by that date.

Some of the nitrate was shipped direct to farmers, but the greater part was consigned to county distributors in the counties requiring large quantities. These distributors were appointed when it became evident

early in the year that, on account of the lack of vessels, sufficient nitrate would not arrive in time to make complete delivery during the period of greatest need. Through them it was possible to make quick and equitable distribution and to save farmers the interest on deposits required for payments, since shipments for the county were made to the distributors on sight draft with bill of lading attached and distribution was made by them to the farmers. On June 30, there remained in Chile between 39,000 and 40,000 short tons of nitrate for which the Department had been unable to secure transportation to this country from the Shipping Board.

The Federal Trade Commission has ordered The Consolidated Oil Company, of Cleveland, Ohio, and two of its officers, Nathan Weisenberg and Aaron Bernstein, the Eastland Linseed

Company, of Cleveland, Ohio, and David Bernstein to cease and desist from unfair methods of competition, admitted by them.

Among the prohibited practices was the using of stationery and letterheads bearing pictures of extensive manufacturing plants which do not in fact exist; adulteration of linseed and other oils with low-grade mineral oils and acids; and publication of representations that the Ohio Food and Drug Commission had made a ruling requiring that all linseed oils, spirits of turpentine, and the like, not used as food, must be labelled "adulterated."

The Commission's orders were issued on agreement with the concerns which waived right to introduce testimony in support of their practices.

PERSONAL NOTES

Dr. Harry Percival Corliss, until recently an Industrial Fellow in the Mellon Institute of Industrial Research, University of Pittsburgh, died at Ray, Arizona, on November 16, 1918, of pneumonia following influenza.

Dr. Corliss was born at Thornton, N. H., October 21, 1886. He attended Brewster Academy at Wolfeboro, N. H., and graduated in 1910 from New Hampshire State College with the degree of Bachelor of Science in Chemical Engineering. He then continued the study of chemistry at the University of Toronto, specializing in physical and organic chemistry. In July 1912 he accepted a position as Industrial Fellow at the Mellon Institute and in 1913 received the degree of Doctor of Philosophy from the University of Pittsburgh. Dr. Corliss' work at the Mellon Institute extended over a period of five years, during most of which time he was engaged in physical, chemical, and metallurgical research.

This research resulted in the development of several important improvements upon the flotation process for the recovery of metals. Perhaps his greatest contribution to this industry was the discovery of alpha-naphthylamine as a flotation agent. It is too early as yet to estimate the full value of this discovery, but the excellent practical results already following its use warrant the belief that the work of Dr. Corliss will eventually be recognized as being of first importance in this field.

In July 1917 he accepted a position as chemical and metallurgical engineer with the Metals Recovery Company in order to initiate the large scale application of his discoveries in the flotation mills of the southwest. In this work he was uniformly successful and was rapidly making for himself an enviable reputation as a metallurgical engineer when death called him.

From his boyhood up, Dr. Corliss' associates have recognized in him the qualities of marked intellectual brilliancy and very real moral worth. All through his student days the highest scholastic honors came to him without conscious effort on his part, because he loved the study of chemistry in all its branches. He brought the same qualities of mind and spirit to his research work at the Mellon Institute and to its extension in the wider fields of industrial application.

His many friends will feel that by his death the world was deprived of a life which held unusual possibilities for useful work and high accomplishment.

Mr. R. S. Buhrman, formerly chief chemist for the Haynes Stellite Company of Kokomo, Ind., died of influenza, November 1, 1918.

Dr. Frank O. Amon, who was connected with the Mellon Institute at Pittsburgh, as Research Fellow, for some months in 1917, and who enlisted in the U. S. Gas Defense work in 1917, died of pneumonia, at Souilly, France, on October 12, 1918. Dr. Amon was a graduate of Allegheny College at Meadville, Pa., and later took his doctorate at New York University. He was a young man of much ability and promise.

Major William A. Hamor, Chemical Warfare Service, who returned from France on November 17, 1918, after ten months' service in the American Expeditionary Forces, has resumed his work at the Mellon Institute of Industrial Research as Assistant Director. Major Hamor served as Assistant Chief of the Technical Division, C. W. S., A. E. F., until the conclusion of hostilities.

Mr. D. R. Pinnock, formerly chief chemist and works manager for the Nucoa Butter Co., is now chief castor bean inspector in the Bureau of Aircraft Production. He is engaged in working out the details of a new method of milling castor beans for the production of castor oil for airplane lubrication which bids fair to result in a saving of more than a million dollars on the 1919 crop.

Mr. Stephen G. Simpson, formerly chemist for the Great Northern Paper Co., Millinocket, Me., was called for military service and then granted an indefinite furlough in order to act as instructor in chemistry in the S. A. T. C. at the Massachusetts Institute of Technology.

J. Brevet, a lieutenant in the Holland army reserves, employed by the Portland Gas and Coke Company at its plant at Portland, Oregon, has been placed in charge of the Y. M. C. A. class in chemistry. For two years he was control chemist for the Royal Dutch Oil Co., of Java.

Mr. Delbert Brown has been granted an indefinite furlough in order to take charge of the chemistry department at Olivet College, Olivet, Mich.

Mr. John Gaub, in charge of the laboratories at the Filtration Plant, Washington, D. C., has resigned to become Health Officer and Examiner of Foods for the town of Montclair, N. J.

Mr. Theodore E. Kendrick, research chemist with the Electro-metallurgical Co., after his entrance into the army in August, was sent to the Franklin Institute U. S. Army Training Detachment, Boston, Mass., to learn the trade of sheet metal worker. Upon application of his former employer he was granted an indefinite furlough and returned to his former concern, where he is doing work on the preparation of a military explosive.

Mr. W. W. Hodge has resigned his position as instructor in chemistry at the University of North Dakota in order to accept a position as assistant professor of organic chemistry in the Oregon Agricultural College.

Mr. Archibald F. Borbeck has been commissioned Second Lieutenant in the Chemical Warfare Service and has been detailed for work in France.

Mr. A. J. Phillips, formerly chief chemist for the Western Alkali Refining Co., is now research chemist with the Aetna Explosives Co., Emporium, Pa.

Mr. C. F. Landsaft has been transferred from the Olean, N. Y., Tannery of the Cattaraugus Tanning Company to the J. H. Ladew Company Tannery, Newark, N. J., to become assistant to the general superintendent of the two concerns.

Mr. R. T. Will, president of the Will Corporation, who discontinued his business because of the war, was commissioned Captain in the Chemical Warfare Service and has been stationed at the Long Island laboratory of the Gas Defense Division.

Mr. R. P. Tucker, formerly chief chemist of the Leigh Hunt Engineering Co., is now with the Armour Fertilizer Company.

Mr. Leon S. Ward, formerly instructor in chemistry in the Greeley High School, Greeley, Col., is now employed as chemist by the Hercules Powder Company at the U. S. Explosives Plant "C," Nitro, W. Va.

Mr. Montgomery R. Trimmer, formerly manager of the Chemical Department of the S. S. White Dental Manufacturing Co., Prince Bay, N. Y., is now supervisor of manufacture with the Du Pont Engineering Co., Jacksonsville, Tenn.

Captain J. L. Brown has been transferred from the E. I. du Pont de Nemours & Company Barksdale plant, located near Washburn, Wis., where he was Acting Quartermaster and Inspector of Ordnance for the U. S. Ordnance Dept., to the Toronto District Ordnance Office, to take charge of the inspection and manufacture of all powder and high explosives in Canada for the U. S. Ordnance Department.

Mr. W. O. Gordon, formerly with the U. S. Bureau of Chemistry, and recently with the Industrial Appliance Co., Chicago, has accepted a position as chief chemist with Mead Johnson and Co., Evansville, Ind., who are manufacturers of dextro-maltose and other malt products.

Dr. R. W. Hess, formerly chemist in the dyestuff department at the Chicago plant of the Sherwin-Williams Co., has recently accepted a position as senior research chemist with the National Aniline and Chemical Co., Buffalo, N. Y.

Mr. Sidney Davis has been commissioned Captain in the Chemical Warfare Service and is stationed in Washington representing the Development Division which has its headquarters in Cleveland.

Dr. Arthur R. Hitch, formerly chief chemist of the Storage Battery Factory of the National Carbon Co., Inc., Cleveland, Ohio, is now chief chemist of the Ashland Iron and Mining Co., Ashland, Ky.

Miss V. L. Gibbons, Ph.D., formerly research chemist for the National Carbon Co., Inc., has accepted a similar position with the National Aniline and Chemical Co., Buffalo, N. Y.

Mr. J. M. Janitchek, formerly chief chemist of the Tallassee Power Company, Batin, N. C.—a subsidiary of the Aluminum Company of America—is now connected with the Aluminum Company of America Research and Laboratory Department, New Kensington, Pa.

Captain J. Herbert Hunter has recently been promoted to the rank of Major and now has charge of high explosives and research work in the Ordnance Department.

Mr. Rudolph Gahl, formerly metallurgist of the Inspiration Consolidated Copper Co., has recently taken up general practice as a consulting metallurgist.

The chemistry department of the University of Nebraska announces the following additions to its teaching staff: Mr. T. J. Thompson, of Kansas Wesleyan University, as instructor in organic chemistry; Dr. Horace G. Deming, of the University of Illinois, as professor of chemistry in charge of general and physical chemistry; Mr. B. Clifford Hendricks, of Peru, Neb., State Normal School, as assistant professor of chemistry.

Mr. K. R. Morgan has recently accepted the position of chief chemist and assistant superintendent at the Reserve factory of the Leon Godchaux Co., Reserve, La.

Mr. R. D. Kehoe, formerly of the Machinery Utilities Co., Inc., has announced the formation of the Technical Products Co., Inc., with offices in New York, Chicago, and St. Louis. The new company is organized for the purpose of purchasing idle equipment and placing this in essential industries.

Mr. Charles W. Mudge, for many years chemist in the N. Y. State Department of Agriculture, now called the Department of Farms and Markets, Albany, N. Y., has accepted a position as chemist with the Standard Oil Company, N. J., and is located at their new chemical research laboratory at Bayway, N. J.

Mr. Sarangadhar Das has resigned his position as chief chemist for the Maui Agricultural Company in order to complete some special work at the University of California.

Mr. Theodore W. Fowle has been released from his work as inspector of smokeless powder for the Ordnance Department at the Howard plant of the Aetna Explosives Co., in order to take up work with the General Chemical Company on the manufacture and testing of catalyst for direct ammonia synthesis at Laurel Hill, L. I.

Mr. F. R. McLean, formerly chief chemist for the Brooklyn Rapid Transit Co., is now chief chemist for the Lehigh Navigation Electric Co., Allentown, Pa.

The School of Chemistry of the University of Pittsburgh announces the following additions to its staff: Dr. Alexander Lowy, assistant professor of organic chemistry; Mr. Leon E. Jenks, assistant professor of analytical chemistry; Mr. Blaine B. Westcott, instructor in inorganic chemistry.

Mr. Morgan F. Rogers, formerly chemical engineer with the Independent Lamp and Wire Co., Weehawken, N. J., is now an engineer of tests with the Ordnance Department and is located at the plant of the Gorham Manufacturing Co., Providence, R. I.

Dr. D. J. Brown, formerly assistant professor of chemistry at the Agricultural and Mechanical College of Texas, has for the past year been at the University of Texas during the absence of Dr. J. R. Bailey.

Mr. Clarence Huckle, formerly chemist for the Douglas Packing Co., Rochester, N. Y., is now at the Jackson laboratory of E. I. du Pont de Nemours & Co., Wilmington, Del.

Dr. Harrison E. Patten, of the Bureau of Chemistry, Department of Agriculture, has been commissioned Captain in the Quartermaster's Corps.

Mr. George A. Rankin, of the American University Experiment Station, has been commissioned Captain in the Chemical Warfare Service.

Mr. G. L. McDonough, formerly connected with the Scientific Materials Co., Pittsburgh, has accepted a position as chemist with the American Alloy and Chemical Co., Los Angeles, Cal.

Mr. B. E. Broadwell, formerly connected with the Aluminum Company of America, Niagara Falls, N. Y., has been engaged as general superintendent of the new factory being erected by the Republic Carbon Company.

Mr. Henry P. Walters, Syracuse, N. Y., in charge of the picric acid department of the Split Rock plant of the Semet-Solvay Co., will be placed in charge of the new plant now being constructed at Grand Rapids, Mich., to be operated for the Government for the production of picric acid.

Mr. Louis S. Potsdamer, for the past five years chemist in the employ of Toch Bros., is now a Sergeant in the Gas Defense Service, U. S. A., located at the Philadelphia Control Laboratory, Philadelphia, Pa.

Mr. H. G. Osborn has given up his position as chief chemist of the City of East Chicago, and is now with Morris and Co., U. S. Yards, Chicago.

Dr. Oscar Harder has resigned his position in the research department of N. K. Fairbanks Co., Chicago, Ill., to accept a fellowship at the Mellon Institute of Industrial Research, Pittsburgh, Pa.

Lafayette College, Easton, Pa., announces the following appointments to instructorships in the chemistry department: Mr. Landon A. Sarver, a private in the Chemical Warfare Service and formerly instructor in chemistry at Johns Hopkins University, and Mr. Walter G. Kleinspehn, a graduate of Lafayette in the class of 1918.

Dr. H. H. Hodgson has been appointed head of the department of coal-tar color chemistry at the Huddersfield Technical College. He has for nearly three years been chief chemist to one of the largest firms of chemical manufacturers in England, and was previously head of the chemical department at the Northern Polytechnic Institute in London.

Mr. D. Forest Hungerford, professor of chemistry at the University of Arkansas, has accepted a position with the United States Department of Agriculture, with headquarters at Athens, Ga.

Mr. David E. Wait, formerly connected with the Tindell, Morris Co., Eddystone, Pa., as assistant to the metallurgist, having charge of the metallographic and chemical laboratory, has, since February 1918, been attached to the Worcester District Physical Laboratory of the American Steel and Wire Company as a metallurgist.

Mr. Thomas E. Keitt, formerly of Clemson College, Clemson, S. C., has been appointed chemist at the Georgia Experiment Station, Experiment, Ga.

Wm. M. Barr, consulting chemist of the Union Pacific System, now has charge of all water supply problems on the Union Pacific Railroad, the Oregon Short Line Railroad, the Oregon-Washington Railroad & Navigation Lines, the Los Angeles & Salt Lake Railroad, and the St. Joseph & Grand Island Railroad.

Lieut. Alvin R. Lamb, Sanitary Corps, Division of Food and Nutrition, formerly of the chemistry section, Iowa Agricultural Experiment Station, is now stationed at Ft. Oglethorpe, Georgia.

Dr. A. Richard Bliss, Jr., professor of pharmacology in the School of Medicine of Emory University, Atlanta, was one of those recommended by the Rockefeller Institute of Medical Research for commission in the corps of chemists organized by that institution at the request of the War Department to take charge of the work in clinical chemistry in the cantonment hospitals here and abroad, and received an appointment as a Lieutenant in the medical department early in September.

Mr. E. Wertheim, recently in the Graduate Department, University of Chicago, is now assistant professor of chemistry in the University of Kansas.

Mr. Edward G. Pugh, formerly of the research laboratory of the Pennsylvania Salt Manufacturing Co., in Philadelphia, has been transferred to their plant at Wyandotte, Mich., to take charge of the erection of a zirconia plant there.

Mr. Harry Fawley is now in charge of research work at the Wyandotte, Mich., plant of the Pennsylvania Salt Manufacturing Company, having been transferred from their research laboratory at Philadelphia.

Mr. James Chester Ashby, formerly instructor in chemistry at Lehigh University, South Bethlehem, Pa., is now working in the research laboratory at the Buffalo Works of the National Aniline and Chemical Co., Buffalo, N. Y.

Mr. J. Miller has returned to his former position with the Western Canada Flour Mills Co., Winnipeg, Man., his position with the Department of Inspection, Imperial Ministry of Munitions at Moncton, N. B., having been only of a temporary nature during the munitions rush.

Mr. F. L. Woods, formerly assistant superintendent at the Bradley Fertilizer Works of the American Agricultural Chemical Company at North Weymouth, Mass., has just been appointed superintendent of the Tygett-Allen Works of the same company at Philadelphia, Pa.

Mr. William A. Kirk, formerly chemist at the Los Angeles Laundry Company, is now chemist at the Wyoming Sugar Co., Worland, Wyoming.

Mr. Charles L. Bliss has recently taken a position as chemist in the State Board of Health of Michigan and is located in Lansing.

Mr. Horace A. Shonle, now in the Chemical Warfare Service, on furlough from the Bureau of Chemistry for the period of the war, has been transferred to the laboratory section of the Sanitary Corps, stationed at Rockefeller Institute, New York City.

Mr. J. J. Brennan has been assigned to duty in the office of Col. Marston T. Bogert, Chief, Relation Sections, Chemical Warfare Service, U. S. A., Washington, D. C.

Mr. Andrew M. Fairlie, consulting chemical engineer, has opened an office for general consulting practice at 1204 Third National Bank Building, Atlanta, Ga.

Professor Hilton Ira Jones has just been elected head of the department of chemistry at the Oklahoma Agricultural and Mechanical College to succeed Dr. L. Chas. Raiford who becomes associate professor in organic chemistry in the University of Iowa. Dr. Jones was formerly head of the department of chemistry at Dakota Wesleyan University, Mitchell, South Dakota.

Mr. Arthur H. Johnson, formerly at Carney's Point, N. J., as civilian inspector for the Ordnance Dept., U. S. A., is now in the Chemical Warfare Service and stationed at Cleveland, Ohio.

Mr. Lester Yoder, formerly with the chemical section of the Agricultural Experiment Station of Iowa State College, is now at the U. S. Technological School, Carney's Point, N. J.

Dr. S. B. Kuzirian, assistant chemist for the chemical section of the Agricultural Experiment Station, and Prof. J. S. Coye, chief of the chemical section of the Engineering Experiment Station of Iowa State College, have entered the employ of the General Chemical Company, and will be located at their Laurel Hill Works, New York.

Priv. Ralph E. Brewer, Chemical Warfare Service, has been furloughed back to Iowa State College where he will again teach chemistry.

Professor B. B. Freud, of Armour Institute, B. S., University of Chicago, 1904, and candidate for the degree of Ph.D., has been appointed Captain in the Chemical Warfare Service and is now in France.

Miss E. T. Foster, formerly with Roben and Haas, is now with the Dearborn Chemical Company.

Mr. Joseph C. Winslow, formerly in the research division of the insulation department of the Westinghouse Electric & Manufacturing Co., has accepted a position as chemist with the Redmanol Chemical Products Company.

Mr. R. J. Carr, president of the Dearborn Chemical Company, is a Major on the general staff at Washington, D. C.

Mr. C. A. Tibbals, Jr., of Armour Institute, has a Captain's commission and is in charge of the research laboratory at the Picatinny Arsenal.

Mr. Arden R. Johnson has been appointed instructor at Northwestern University, Evanston, Ill.

Mr. E. F. Heizer, formerly with the Dearborn Chemical Company, is now in the Ensign School at the Municipal Pier, Chicago, Ill.

Mr. Wm. M. Corse, formerly general manager of the Titanium Bronze Co., Niagara Falls, N. Y., has accepted a position as manufacturing engineer with the Ohio Brass Co., Mansfield, Ohio.

Mr. C. L. Brickman, formerly chief chemist for the Rex-Hide Rubber Mfg. Co., East Brady, Pa., has assumed the position of chief chemist with the Dreadnaught Tire and Rubber Co., Baltimore, Md.

Mr. Wilbur F. Brown, formerly Chief Chemist of the Ball Brothers Glass Co., at Muncie, Ind., is now in the research division of the Chemical Warfare Service and is devoting his attention to the problems connected with the manufacture of optical glass.

INDUSTRIAL NOTES

The Air Reduction Co., N. Y., has bought a site at Richmond, Va., for the establishment of a plant to make oxygen, nitrogen, and acetylene gas. It is probable that other gases and also storage batteries will be made.

The Northern Alkali and Chemical Co., Huntington, W. Va., recently incorporated with a capital of \$60,000, has perfected its organization, and is planning to commence the production of caustic potash at an early date.

One of the many Canadian industries directly promoted by the war is the manufacture of chemicals. The demand has been enormously increased and prices obtained have been for the most part unprecedented. It is believed that through the war the industry has been so firmly established that it will be in a favorable position to meet competition after the war.

E. M. De Souza and Co., of Rangoon, India, have decided to commence the manufacture of chemicals on a large scale. They have engaged the services of Dr. H. K. Len and four other qualified chemists. The new venture will be known as the Rangoon Pharmaceutical and Chemical Works.

Experiments in Norway with a view to extracting salt from ocean water by means of electricity have been successful, and two salt factories will be started for this purpose under the name of De Norske Saltverkter.

The *Frankfurter Zeitung* recently announced that M. France, head of the Biological Institute of Munich, had discovered a new source of fat from plants growing in waste lands. This oil called "edaphon" has been found by test to be equal to coconut oil.

The Reduction and Concentration Corporation of Birmingham, manufacturers of fertilizers, has been incorporated under the laws of New Jersey with a capital of \$200,000.

The detonator-assembling building of the du Pont Cap Works, at Pompton Lakes, N. J., was destroyed by explosions and fire on December 5, 1918.

At a meeting of the directors of the Pennsylvania Salt Manufacturing Company held at Philadelphia, General R. Dale Benson retired from the board. R. G. Wood, president of the Allan Wood Iron and Steel Co., was elected his successor.

The Machinery and Metal Sales Company is erecting a factory in Brazil for the manufacture of caustic soda and other chemicals. The total capital involved is reported to be \$500,000, and the estimated daily production 15 tons of caustic soda, 15 tons of chloride of lime, 600 kilos of muriatic acid, and 600 kilos of potassium chlorate.

According to a recent report issued by the Treasury Department, chemists in the Internal Revenue Bureau have developed a synthetic process for the making of glycerin by the fermentation of sugar. The process was tried out at a chemical plant in Aurora, Ill., and found commercially profitable.

"There are at present only two mills in operation in this country for the manufacture of potato flour," Major S. C. Prescott, chief of the Dehydration Division, Bureau of Chemistry, Dept. of Agriculture, stated in a recent address, "but others will be in operation in a few weeks in Minnesota, Maine, Nebraska, and South Carolina. I expect to see potato flour mills spring up in every potato-growing district. The potato crop is approximately 360,000,000 bushels yearly."

The War Trade Board has revoked the restriction on the importation of tanning materials and extracts, and applications will be considered for licenses to import these products, except quebracho wood, in an amount not to exceed 12,000 tons per month.

An Associated Press despatch from Rhenish Prussia states that the German potash production in November was 70 per cent below normal.

Exports of coconut oil from the Philippine Islands during the first eight months of 1918 were valued at \$16,180,371, against \$7,036,710 in the same time last year.

LIST OF APPLICATIONS MADE TO THE FEDERAL TRADE COMMISSION FOR LICENSES UNDER ENEMY-CONTROLLED PATENTS PURSUANT TO THE "TRADING WITH THE ENEMY ACT"

YEAR	PAT. NO.	PATENTEE	ASSIGNEE	PATENT	APPLICANT
1909	943,600	Wilhelm Jahns, Offenbach-on-the-Main, Germany		Centrifugal regulators	Massey Machine Company, Watertown, N. Y.
1917	1,214,941	Frank Fairchild Morris, Pittsburgh, and Frederick Melchior Luchs, Wilkinsburg, Pa.	Firm of Drägerwerk, Heintz and Bernh. Dräger, Lübeck, Germany	Resuscitating device	The Draeger Oxygen Apparatus Company, Wilkinsburg, Pa.
1905	807,666	Johann Heinrich Lübeck, Germany	Dräger,	Apparatus for respiring within spaces full of smoke or noxious gases	The Draeger Oxygen Apparatus Company, Wilkinsburg, Pa.
1911	1,005,816	Alexander Bernhard Lübeck, Germany	Dräger, Firma of Drägerwerk, Heintz and Bernh. Dräger, Lübeck, Germany	Portable breathing apparatus	The Draeger Oxygen Apparatus Company, Wilkinsburg, Pa.
1912	1,033,681	Alexander Bernhard Lübeck, Germany	Dräger, Firma of Drägerwerk, Heintz and Bernh. Dräger, Lübeck, Germany	Universal coupling	The Draeger Oxygen Apparatus Company, Wilkinsburg, Pa.
1914	1,085,674	Alexander Bernhard Lübeck, Germany	Dräger, Drägerwerk, Heintz & Bernh. Dräger, Lübeck, Germany	Battery for absorbing carbonic acid such as used in breathing apparatus	The Draeger Oxygen Apparatus Company, Wilkinsburg, Pa.
1913	1,049,346	Johann Heinrich Lübeck, Germany	Dräger, Firma of Drägerwerk, Heintz & Bernh. Dräger, Lübeck, Germany	Artificial breathing apparatus	The Draeger Oxygen Apparatus Company, Wilkinsburg, Pa.
1912	1,044,031	Johann Heinrich Lübeck, Germany	Dräger,	Method of causing artificial respiration	The Draeger Oxygen Apparatus Company, Wilkinsburg, Pa.
1915	1,136,517	Johann Heinrich Lübeck, Germany	Dräger, Firma of Drägerwerk, Heintz & Bernh. Dräger, Lübeck, Germany	Artificial breathing apparatus	The Draeger Oxygen Apparatus Company, Wilkinsburg, Pa.
1913	Trade-mark No. 94,620	Drägerwerk, Heintz & Bernh. Dräger, Lübeck, Germany		Pulmotor for mechanical respiratory apparatus and devices for administering oxygen	The Draeger Oxygen Apparatus Company, Wilkinsburg, Pa.
1903	741,029	Richard Gley and Otto Siebert, Berlin, Germany	Actien-Gesellschaft für Anilin Fabrikation, Berlin, Germany	Red azo lake (dyes)	The Ault & Wiborg Company, Cincinnati, Ohio
1905	782,739	Emil Fischer, Berlin, Germany	E. Merck, a co-partnership, Darmstadt, Germany	C-C-Dialkylbarbituric acid and processes of making same	Rector Chemical Company, 2 Rector Street, New York, N. Y.
1913	1,075,171	Albrecht Thiele and Georg Wichmann, Berlin, Germany	Chemische Fabrik auf Actien (vorm. E. Schering), Berlin, Germany	Process for the manufacture of 2-phenylquinolin-4-carboxylic acid	Sunbeam Chemical Company, Chicago, Ill.
1911	Trade-mark Atopian, No. 84,596	Chemische Fabrik auf Actien (vorm. E. Schering), Berlin, Germany		Remedies for treatment of gout and rheumatism	Sunbeam Chemical Company, Chicago, Ill.

Ambrine Laboratories of Manhattan, drugs, medicines, etc., has been incorporated under the laws of New York with a capital of \$250,000 by H. O. Berg, H. V. Dunham, and G. W. Jackson, 347 Madison Ave., New York City.

The Fatty-Acid Reduction Company of Syracuse has been incorporated under the laws of New York State with a capital of \$200,000.

According to a special cable to the *New York Times* from Paris, dated December 3, 1918, the Compagnie Nationale des Matières Colorantes et des Produits Chimiques has been incorporated, with a capital of 40,000,000 f. for the manufacture of all kinds of chemicals. It already has a factory capable of producing 2000 tons of indigo annually. This corporation is allied with the Société des Produits Chimiques et Colorantes, which has a capital of 31,000,000 f. and was formed in 1918 for the manufacture of intermediary dye products.

According to the annual report of the Secretary of the Treasury approximately 32,487,117 proof gallons of alcohol were specially denatured during the last fiscal year in this country for the production of explosives and other military purposes. Distilled spirits from materials other than fruit amounted to 173,476,473.7 gallons. This was a decrease of 104,357,892.9 gallons compared with a year ago, a falling off of 37.56 per cent during the year ending June 30, 1918.

The Department of Commerce has received notice of the formation of the British Metals Corporation, capitalized at the English equivalent of \$24,330,000, to promote and develop empire trade in all the non-ferrous metals, especially copper, lead, zinc, and tin. "The corporation," according to Commercial Attaché Philip B. Kennedy, "will provide machinery for carrying on a form of control over the metal industry. Prior to the war the German metal combine was represented in Great Britain by Henry Merton and Company. This firm has been refused a license under the Non-ferrous Metals Act and, it is understood, will go into liquidation. All German control of the metal industry in the British Empire has been destroyed."

A new industry, developed by the war, is the exploitation of the coihue nut, a tropical product, similar in shape and properties to a dwarf coconut. The kernel contains approximately 70 per cent of vegetable fat, which has become of great importance in the manufacture of fine soaps and nut butters. During the war the shells have been used as the source of a superior grade of carbon for gas masks, and it has been discovered that they may be used for the production of producer gas of excellent quality, or as fuel for steam production.

The Industrial Accident Commission of California has recently issued a pamphlet entitled *How to Store and Use Explosives*, compiled by J. J. Rosewell, construction engineer, Department of Safety. The pamphlet sets forth the Federal and State requirements regarding the storage and use of explosives, and contains chapters on the sale of fuse and blasting materials.

The Texas Gulf Sulfur Co., Austin, Texas, has increased its capital stock from \$75,000 to \$3,000,000, and is preparing to develop a large underground sulfur deposit near Matagorda, Texas.

A number of Danish soap factories have combined in a company called Dansk Sæbeindustri, with a capital of \$335,000, with the head office in Copenhagen.

The War Trade Board of the United States, Russian Bureau, Inc., has been incorporated under the auspices of the War Trade Board, at the direction of the President. Its capitalization is \$5,000,000, and the company will engage in exporting needful commodities to Russia and bringing back Russian and Siberian raw materials, including platinum and raw materials necessary for the chemical industries.

Dr. Van H. Manning, director of the Bureau of Mines, has been instructed by Secretary Lane, of the Interior Department, to whom the task of stimulating domestic production of potash has been entrusted by a Presidential order dated November 11, 1918, to make a survey of the domestic resources specified in the Minerals Bill recently passed by Congress.

Reports recently received by the U. S. Geological Survey show that domestic mines now supply nearly one-third of the high-grade manganese ore needed in this country, whereas in 1917 the domestic mines supplied only one-sixth of the amount needed.

The Canadian Industrial Alcohol Co., Ltd., has been incorporated at Montreal, Canada, with a capital of \$5,000,000.

A large phosphate washing, drying, and grinding plant is being built near the Century mines, Maury County, Tennessee, by the J. Ogden Armour Fertilizer Company of Chicago.

Mesothorium has been developed by the Bureau of Mines as a substitute for radium used in the manufacture of luminous paints.

According to recent advices, pyrites mines have been opened in Cuba by prominent American sulfuric acid interests, with the expectation that the material will replace former importations from Spain.

According to a recent tabulation by the Pulp and Paper Division of the War Industries Board the annual production of paper and paper products in the United States in 821 pulp and paper mills amounts to about 5,658,000 tons. Of this amount, the production of strictly chemical products amounted to 1,287,000 tons.

The Price Fixing Committee of the War Industries Board has authorized the announcement that the maximum prices on sulfuric and nitric acids were discontinued on December 30, 1918. The Committee expressed its appreciation of the hearty cooperation received from the industry.

Secretary Baker told the Congressional Appropriations Committee on December 6, 1918, that the operation of the Muscle Shoals nitrate plants will probably be continued, and that the Neville Island plant, under construction in the Ohio River, will be used for the making of powder and guns.

The H. W. Johns-Manville Co., of New York, manufacturers of magnesia products and asbestos, are planning the erection of a \$3,000,000 plant at Waukegan, Ill.

The new refractory and abrasive material, called corindite, has been patented in France. The material is a vesicular mass containing many small crystals of alumina obtained when bauxite is melted by mixing it with anthracite and blowing air through the mixture.

According to the *Weekly Bulletin* of the Canadian Department of Trade and Commerce, a company in Milan, Italy, has been formed for the manufacture of white lithopone. The product has previously been obtained from Germany, but Italy possesses the necessary raw materials, and a promising start has already been made in the factory at Brescia.

A solder in which cadmium has been substituted for tin is being developed by the U. S. Bureau of Standards. Laboratory tests indicate that a material composed of 80 per cent lead, 10 per cent tin, and 10 per cent cadmium will prove practical.

The entire capital stock of the Bayer Company, Inc., was sold at public auction on December 12, 1918, by Alien Property Custodian, A. Mitchell Palmer, to the Sterling Products Company, of Wheeling, W. Va. The price paid was \$5,310,000. On December 15, H. F. Behrens, president of the Sterling Products Company, gave out the statement that the chemical end of the business of the Bayer Chemical Company had been sold by his company to the Grasselli Chemical Company, of Cleveland, for \$2,500,000.

The scarcity of potassium cyanide has brought about the use of a so-called cyanide mixture composed of sodium cyanide and potassium chloride, which when dissolved forms potassium cyanide and sodium chloride. An equivalent of 98 per cent potassium cyanide can be obtained, and this reagent is found to answer the same purpose as the true potassium salt.

The American Potash and Nitrate Corporation has been formed under the laws of Delaware with a capitalization of \$500,000. The incorporators are Robert Hobart, C. Fash, James F. Starek, and Elisha W. Kelly, of New York.

Manufacturers of cement, road oils, and other road-building materials have been advised by the Bureau of Foreign and Domestic Commerce that there is a promising field for their product in the Far East. China is especially strong in the purpose to build up a system of good roads for the development of natural resources.

The Air Reduction Company, of New York City, is erecting an \$80,000 chemical plant in Jersey City, N. J.

The Marden, Orth and Hastings Corporation has moved into its new quarters at 136 Liberty St. The following allied companies have their offices at the same address: Calco Chemical Co., United Oil and Chemical Co., Buttercup Oil and Tar Corporation, Edible Oil Co., Inc., Ruhm Phosphate Mining Co., and M. O. H. of the West Indies.

The Rector Chemical Company has opened a new factory in Brooklyn, N. Y., where it will manufacture pharmaceutical preparations.

GOVERNMENT PUBLICATIONS

By R. S. McBRIDE, Bureau of Standards, Washington

NOTICE—Publications for which price is indicated can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. Other publications can usually be supplied from the Bureau or Department from which they originate. Commerce Reports are received by all large libraries and may be consulted there, or single numbers can be secured by application to the Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington. The regular subscription rate for these Commerce Reports mailed daily is \$2.50 per year, payable in advance, to the Superintendent of Documents.

CONGRESSIONAL COMMITTEES

Minerals and Mineral Lands. The following five reports of congressional committee activities relate to various phases of this subject.

(1) Report of hearings on H. R. 11259, which provides for encouragement in the production, conservation, and control of distribution of ores, metals, and minerals which have formerly been largely imported, or of which there is or may be inadequate supply for war purposes. 672 pp.

(2) Report to accompany H. R. 11259, made as Senate Report 558; submitted to the Senate on September 5 by Mr. Henderson. 4 pp.

(3) Conference report on H. R. 11259; submitted as Senate Document 281 on September 26. 5 pp.

(4) Conference report to the House of Representatives on H. R. 11259; submitted as House Report 803 on September 23. 7 pp.

(5) Report to accompany Senate Joint Resolution 156, which suspends requirements of annual assessment work on mining claims during the continuation of the war; submitted in House Report 766, September 2. 1 p.

TARIFF COMMISSION

Census of Dyes and Coal-Tar Chemicals, 1917. Tariff Information Series 6. 73 pp.

Glass Industry. Tariff Information Series 5. 147 pp. This is a report on the influence of the war upon the glass industry, including a discussion of new branches of industry, changes in manufacture and trade due to war conditions, holding of export and domestic trade after the war, a discussion of glass trade conditions in European countries, including testimony of leading American glass manufacturers.

NATIONAL MUSEUM

Power, Its Significance and Needs. C. G. GILBERT AND J. E. POGUE. Bulletin 102, Part V. 53 pp. Paper, 10 cents. This is the fifth portion of a report on the mineral industries of the United States.

Petroleum: A Resource Interpretation. C. G. GILBERT AND J. E. POGUE. Bulletin 102, Part VI. 76 pp. "This paper makes an economic study of the resource and the industry engaged in its development, and traces the causes of waste to certain maladjustments in the economic situation, pointing out how these may be remedied by a constructive economic policy applied to the matter. The desirability of developing shale oil to replace petroleum as it becomes incapable of meeting the demand is gone into and the advisability of using benzol and alcohol as substitutes for gasoline is considered. The natural gas industry is also treated."

GEOLOGICAL SURVEY

Gypsum in 1917. R. W. STONE. Being a Separate from Mineral Resources of the United States, 1917, Part II, pp. 85-95. Published July 11, 1918.

The quantity of crude gypsum mined in the United States

in 1917 was slightly less than that mined in 1916, owing largely to a reduction in building operations in the last quarter of the year. The output nevertheless exceeded that of any year previous to 1916.

On the other hand, the total value of the crude and calcined gypsum produced in the United States in 1917 far surpassed that of any other year. In 1916, for the first time, the total value of gypsum products of the United States in a single year exceeded \$7,000,000, but in 1917 they exceeded \$10,000,000. The increase in 1917 was \$2,536,311, or 32 per cent over the total value in 1916, as compared with an increase of \$3,000,000 in the ten years from 1907 to 1916.

Mineral Resources of Alaska. Report on Progress of Investigations in 1916. A. H. BROOKS AND OTHERS. Bulletin 662. 469 pp.

Asphalt Deposits and Oil Conditions in Southwestern Arkansas. H. D. MISER AND A. H. PURDUE. Bulletin 691-J. Contributions to Economic Geology, 1918, Part II, pp. 271-292. Published August 16, 1918. "Seven asphalt deposits, three of which are in Pike County and four in Sevier County, in southwestern Arkansas, were examined by the writers during the progress of the field work for the DeQueen-Caddo Gap folio, which is now in preparation. These deposits are all found at or near the same horizon in the Trinity formation. Only one has so far been developed into a mine from which asphalt has been shipped in commercial quantity. This deposit, which has been described by Hayes, is about $2\frac{1}{2}$ miles south-south-east of Pike, in Pike County. Of the other six deposits only three have been prospected.

"There is no possibility that either oil in commercial quantities or gas in large pools will be found in the Ouachita Mountain region of west-central Arkansas or in most of this region in Oklahoma. The carboniferous and older rocks have been so highly tilted and so much fractured and metamorphosed that if oil or gas were ever present in them the gas and much of the oil would have made their escape to the surface and the remainder of the oil would have been distilled to asphalt."

Coal in 1916. C. E. LESHER. Mineral Resources of the United States, 1916, Part II, pp. 901-991. Published August 17, 1918.

Tin in 1917. A. KNOPF. Mineral Resources of the United States, 1917, Part I, pp. 63-72. Published September 16, 1918.

The metallic tin estimated as recoverable from ore of domestic origin mined in 1917 was 90 short tons, a decrease of 50 short tons from the output of 1916. As in recent years, the bulk of the tin-bearing concentrate was obtained by dredges in Alaska, whose working season is limited by climatic conditions to less than 100 days a year. Part of the concentrate was shipped from Seattle to Singapore to be smelted and part was sent to the smelter at Perth Amboy, N. J.

The tin imported in 1917 as metal and metal in concentrate reached the record quantity of 77,866 short tons, or 57 per cent of the world's output for the year. The metal imported and entered for consumption was 72,166 short tons, and the domestic smelter output was 6,000 tons. The total supply of new tin available for consumption was, therefore, 78,000 tons. It is estimated that an additional 17,500 tons of tin became available by recovery from drosses and waste metals.

The unprecedentedly high prices of tin that prevailed during the latter part of 1917 and that still prevail have stimulated interest in the deposits of tin ore in the United States. References to the most recent published information on these deposits are given on pages 71-72. The known deposits are unfortunately small in number, and but few of these are commercially promising. Governmental stimulation, therefore, is not likely to add significantly to the domestic supply of tin. It is not probable that the country will achieve in 1918 an output much

in excess of 200 tons of metallic tin from ores of domestic origin. The largest amount heretofore produced in any one year was 140 tons, or 0.2 per cent of the imports for that year.

Silver, Copper, Lead, and Zinc in the Central States in 1917. J. P. DUNLOP AND B. S. BUTLER. Mines Report. Mineral Resources of the United States, 1917, Part I, pp. 73-130. Published October 24, 1918.

Fuller's Earth in 1917. J. MIDDLETON. Mineral Resources of the United States, 1917, Part II, pp. 253-255. Published September 18, 1918.

The quantity, value, and average price per ton of fuller's earth sold in 1917 were the largest ever recorded by the United States Geological Survey, the increase in quantity being 5,048 short tons, or 7 per cent, and in value \$69,681, or nearly 10 per cent, over 1916, the previous leading year. Almost from the beginning of the industry in this country the quantity and value and the average price per ton of the domestic product have exceeded those of the imports. The quantity and the value of the earth produced in the United States in 1917 were more than four times as great as those of the earth imported, and the average price per ton of the domestic earth was 28 cents more than that of the imported earth. The apparent consumption—production plus imports—increased from 84,623 short tons in 1916 to 89,864 tons in 1917, and the domestic fuller's earth formed 81 per cent of the consumption in 1917, against 80 per cent in 1916.

The imports of fuller's earth for consumption in 1917 showed a small increase in quantity—193 tons—and a considerable increase in value—\$36,753, or 26 per cent, compared with 1916. The increase in quantity was entirely in the unwrought or unmanufactured earth, the wrought or manufactured earth showing a decrease. Both varieties showed large increase in value. The average price per ton for all imported earth increased \$2.07, for unwrought earth \$1.29, for wrought earth \$2.16.

Asbestos in 1917. J. S. DILLER. Mineral Resources of the United States, 1917, Part II, pp. 197-204. Published September 18, 1918.

The total quantity of domestic asbestos reported to the Geological Survey as sold in 1917 was 1,683 short tons, valued at \$506,056, an increase in quantity of 204 short tons and in value of \$57,842, representing about 13 per cent in both quantity and value of the product marketed in 1916.

The average price for the whole country of all grades of asbestos, both crude and mill fiber, was \$301 a short ton, practically the same as the average price for 1916. This average price is in strong contrast to the corresponding price of Canadian fiber, which in 1916 was \$38.97, and in 1917 was \$50.04 a short ton. This marked difference in the average price in the two countries is due to the larger proportion of crude fiber shipped without milling in the United States. In the United States nearly half of the total output is crude fiber, but in Canada less than a twentieth part is crude fiber.

The chief source of supplies for the large manufacturers of asbestos in the United States is in imports mostly from Canada. The total imports of unmanufactured asbestos in 1917 were 134,108 short tons, an increase of 15 per cent over the imports of 1916 and nearly eighty times the production of the United States in 1917.

On account of the increased demand for asbestos, prices have continued to advance, especially for the Canadian fiber, the prices for which in New York are given below.

RANGE OF NEW YORK PRICES PER TON FOR CANADIAN CHRYSOTILE FIBER		
	IN 1917	
	1917	
No. 1 crude.....	\$700-	\$1,500
No. 2 crude.....	500-	900
No. 1 fiber.....	150-	450
No. 2 fiber.....	75-	150
Shorter fibers.....	18-	75

Silica in 1917. F. J. KATZ. Mineral Resources of the United States, 1917, Part II, pp. 207-211. Published September 13, 1918.

The reports to the United States Geological Survey on the production in 1917 of silica for various uses considered in this chapter are summarized in the following table. The combined output of these materials increased 187 per cent in quantity and 68 per cent in value in 1917, as compared with 1916.

SILICA SOLD FOR POTTERY, PAINTS, FILERS, POLISHERS, ABRASIVES, AND OTHER USES IN 1917

MATERIAL	1917	
	Quantity Short Tons	Value Dollars
Quartz (vein quartz, pegmatite, and quartzite) ...	142,673	318,069
Sand and sandstone ⁽¹⁾	532,434	1,195,142
Tripoli.....	26,069	92,416
Diatomaceous earth ⁽²⁾	3,033	31,368
	704,229	1,636,995

⁽¹⁾ Includes only finely ground material. Figures probably incomplete.

⁽²⁾ Excludes California product used for filters and as insulating and fireproofing material.

So far as can be learned no true flint or chert has been produced for consumption as crushed or ground silica in grinding mills in the United States. The manufacture of flint, chert, and quartzite blocks for tube-mill lining is reported in the chapter on abrasive materials.

Quartz from quartz veins, pegmatite, and quartzite, amounting to 142,673 short tons, valued at \$318,069, was sold in 1917. This was an increase of 61 per cent in quantity and 31 per cent in value as compared with 1916. The increase in quantity was entirely in the quantity sold crude or merely crushed and graded.

The prices of crude quartz in 1917 ranged from \$2 to \$5.10 a long ton and (exclusive of large quantities used in copper smelting and foundry work, valued at between 45 and 85 cents a ton) averaged \$3.25, as compared with \$2.37 in 1916 and \$3.30 in 1915. Prices for ground quartz ranged from \$6 to \$14 a short ton and averaged \$12.25, as compared with \$9.09 in 1916 and \$10.56 in 1915.

Abrasive Materials in 1917. F. J. KATZ. Mineral Resources of the United States, 1917, Part II. 20 pp. Published September 24, 1918.

The total value of the abrasive materials which are considered in this report and which entered into trade in 1917 was \$11,085,147. This was an increase of \$5,929,049, or 115 per cent as compared with 1916. There was an increase in the value of domestic production of natural and artificial abrasives amounting to nearly 30 and to more than 177 per cent, respectively, and imports increased about 46 per cent in value.

Among the natural abrasives a large gain was shown in production of grindstones and pulps, and there were gains also in production of oilstones, scythestones, emery, pumice, pebbles for grinding, and tube-mill lining ("flint liners"). The reported output of diatomaceous earth and tripoli and of garnet and millstones was less than in 1916. The total estimated value of different abrasive materials imported into the United States for consumption in the last four years is given in the following table:

Millstones and hurstons.....	\$18,227
Grindstones and pulps.....	57,950
Hones, oilstones, and whetstones.....	10,636
Emery and corundum.....	210,602
Diatomaceous earth, tripoli, and rottenstone.....	17,864
Pumice.....	147,278
Diamond dust and bort.....	349,746
	812,303

The artificial abrasives considered are of three kinds: (a) Metallic abrasives, manufactured by the Pittsburgh Crushed Steel Co., Pittsburgh, Pa., and including "diamond crushed steel" (crushed crucible steel), "angular grit" (crushed chilled iron), and "crushed cast iron;" (b) Silicon carbides—carborundum, manufactured by the Carborundum Co., at Niagara Falls, N. Y.; crystolon, manufactured by the Norton Co., at

Chippewa, Ontario; and carbolon, manufactured by the Exolon Co., at Thorold, Ontario, and Blasdell, N. Y.; (c) Aluminum oxides—aluminum, manufactured by the Norton Co., at Niagara Falls, N. Y., and Chippewa, Ontario; aloxite, manufactured by the Carborundum Co., at Niagara Falls, N. Y., Niagara Falls, Ontario, and Shawinigan, Quebec; exolon, manufactured by the Exolon Co., at Blasdell, N. Y., and Thorold, Ontario; lionite, manufactured by the General Abrasives Co., Inc., at Niagara Falls, N. Y.

Besides the firms just mentioned which manufactured abrasives in 1917, the D. A. Brebner Co., Ltd., and the National Abrasive Company have plants at Hamilton, Ontario, for the manufacture of aluminum oxide abrasives. The product of the Brebner Company is named coralex.

So far as known to the Geological Survey these are the only artificial abrasives manufactured in North America. Artificial abrasives sold under other names are merely the above-named products marketed under special trade names or are imported products.

ARTIFICIAL ABRASIVES PRODUCED IN THE UNITED STATES AND CANADA IN 1917

ARTIFICIAL ABRASIVES	1917	
	Quantity Short Tons	Value
Silicon carbide(a).....	8,323	\$1,074,152
Aluminum oxide(b).....	48,463	6,969,387
Metallic abrasive(c).....	1,125	93,703
	57,911	8,137,242

(a) "Carborundum," "crystolon," "carbolon."
(b) "Alundum," "aloxite," "exolon," "lionite."
(c) "Diamond crushed steel," "angular grit," "crushed cast iron."

Bibliography of North American Geology for 1917. J. M. NICKLES. Bulletin 684. 154 pp.

Structure and Oil and Gas Resources of the Osage Reservation, Oklahoma. W. B. EMERY. Bulletin 686-B. 9 pp.

Geology and Oil and Gas Prospects of the Lake Basin Field, Montana. E. T. HANCOCK. Bulletin 691-D. Contributions to Economic Geology, 1918, Part II. 47 pp. Published July 17, 1918.

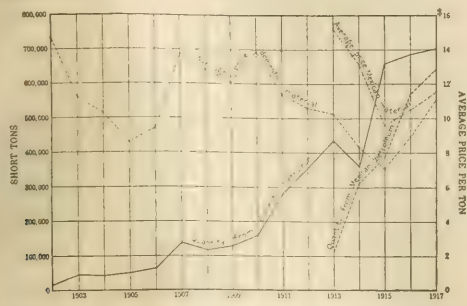
Asphalt, Related Bitumens, and Bituminous Rock in 1917. J. D. NORTHOPE. Mineral Resources of the United States, 1917, Part II. 20 pp. Published October 22, 1918.

The quantity of native bitumens, pyrobitumens, ozokerite, and bituminous rock produced and sold at mines and quarries in the United States in 1917 was 80,904 short tons. This quantity was less by 17,573 tons, or 18 per cent, than the output of corresponding materials in 1916.

The average price received for this material at the sources of production was \$9.10 a ton and the market value of the entire production was \$735,924, a loss of 27 cents a ton in average unit price and of \$187,357, or 20 per cent, in gross market value, compared with 1916. At the mines, gilsonite sold in 1917 for an average of \$14.43 a ton, elaterite for \$88.68 a ton, grahamite for \$8 a ton, bituminous sandstone for \$3.31 a ton, and bituminous limestone for \$2 a ton. An analysis of the statistics of production in 1916 and 1917 shows gain in 1917 of 32 per cent in the output of gilsonite and of 350 per cent in the output of ozokerite, but loss of 51 per cent in the combined output of maltha, elaterite, and grahamite and of 34 per cent in the output of bituminous sandstone and bituminous limestone.

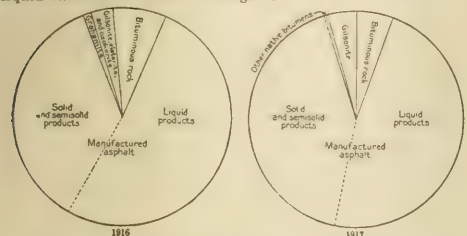
The gain in the output of gilsonite is ascribed to several factors, including the increased demand for marine paints and protective coatings for steel work, of which that mineral forms the base, the increasing demand for automobile tires and other rubber products, in which gilsonite is used as a filler, and presumably to a slight extent to increased utilization of gilsonite fluxed with petroleum in the manufacture of paving cements. The decreased output of elaterite and grahamite was undoubtedly due to the cost of mining and marketing these materials and to the strength of the market competition with certain grades of oil asphalt.

The gross sales of manufactured asphalt derived from Mexican petroleum included 338,485 tons of solid and semi-solid products, valued at \$4,657,152, an average of \$13.76 a ton, and 307,128 tons of liquid products, valued at \$2,784,661, an average of \$9.07 a ton.



ASPHALT FROM DOMESTIC AND FROM MEXICAN PETROLEUM MARKETED IN THE UNITED STATES, 1902-1917

Compared with the prices received in 1916 for corresponding products those received in 1917 for the solid and semisolid varieties averaged \$1 a ton higher, and those received for the liquid varieties 66 cents a ton higher.



PROPORTION OF EACH PRINCIPAL VARIETY OF DOMESTIC ASPHALTIC MATERIAL, INCLUDING MATERIAL MANUFACTURED FROM CRUDE PETROLEUM OF DOMESTIC ORIGIN, MARKETED IN THE UNITED STATES IN 1916 AND 1917

The accompanying figures show graphically the trend of the market for manufactured asphalt in the United States since 1902.

Structure and Oil and Gas Resources of the Osage Reservation, Oklahoma. K. C. HEALD. Bulletin 686-E. 17 pp.

Barytes and Barium Products in 1917. J. M. HILL. Mineral Resources of the United States, 1917, Part II. 7 pp. Published October 14, 1918.

During 1917 the domestic crude barytes marketed amounted to 206,888 short tons, valued at \$1,171,184. As will be seen from the table below, this was a decrease in quantity of 15,064 tons, or about 7 per cent, from the very large production of barytes in 1916, but an increase in value of \$159,952, or nearly 16 per cent. The average price of \$5.66 a short ton in 1917 exceeded by \$1.10 the price in 1916 and by a still larger amount the price in any preceding year. With the exception of South Carolina, all producing states showed a marked increase in price. In Missouri the average price was approximately \$6.60 a ton, but in the other states the averages ranged from \$4.50 to \$5.80 a ton. The smallest advance was 12 cents a ton, in Virginia; the greatest was \$1.58 a ton, in Georgia.

As will be seen from the following table, the sales of barium chemicals and lithopone were larger in 1917 than in 1916, the expansion of the barium chemical industry being particularly marked. The sales of ground barytes, however, declined considerably.

BARIUM PRODUCTS OF DOMESTIC MANUFACTURE SOLD, 1915-1917

PRODUCT	1915	1916	1917
	Quantity Short Tons	Quantity Short Tons	Quantity Short Tons
Barium chemicals(a).....	8,823	16,792	22,503
Ground barytes.....	51,557	65,440	52,694
Lithopone.....	46,494	31,291	63,713
	106,874	133,523	138,910

(a) In order to avoid duplication of figures, barium chemicals manufactured from secondary products bought in open market are not included in table.

According to statistics collected by the Bureau of Foreign and Domestic Commerce, Department of Commerce, and compiled by J. A. Dorsey, of the United States Geological Survey, the imports of barium products in 1917 were valued at only \$53,150, a decrease of more than \$400,000, or 88 per cent, from the imports in 1916. As is shown in the following table, the larger part of the imports consisted of lithopone and natural barium carbonate, though some ground barytes, precipitated barium carbonate, and blanc fixe were imported. It is believed that imports of barium products can be further restricted if necessary to release more shipping.

VALUE OF BARIUM PRODUCTS ENTERED FOR CONSUMPTION IN THE UNITED STATES, 1917

Manufactured barytes(a).....	\$1,743
Lithopone.....	29,199
Barium carbonate:	
Natural.....	17,321
Manufactured.....	1,554
Barium biniodide.....	
Barium chloride.....	
Blanc fixe or artificial barium sulfate.....	3,333
	53,150

(a) "Manufactured barytes" as given by the Bureau of Foreign and Domestic Commerce, is believed to be the equivalent of ground and roasted barytes as used by the Geological Survey.

BARIUM CHEMICALS OF DOMESTIC MANUFACTURE SOLD, 1915-1917

CHEMICAL	1915	1916	1917
	Quantity Short Tons	Quantity Short Tons	Quantity Short Tons
Barium biniodide.....	(a)	1,980	(a)
Barium carbonate.....	2,746	6,844	8,238
Barium chloride.....	2,106	3,643	4,870
Barium nitrate.....	971	446	165
Barium sulfate (blanc fixe).....	(a)	3,337	6,314
Other barium chemicals(b).....	3,000	542	2,916
	8,823	16,792	22,503

(a) Included under "other barium chemicals."

(b) Includes, 1915: Biniodide, hydrosulfate, sulfate, sulfide, and other barium chemicals not specified; 1916: Hydroxide and sulfide; 1917: Biniodide, hydroxide, and sulfide.

Gold, Silver, Copper, and Lead in Alaska in 1917. G. C. MARTIN. Mineral Resources of the United States, 1917, Part I. 15 pp. Published November 21, 1918.

Structure and Oil and Gas Resources of the Osage Reservation, Oklahoma. D. E. WINCHESTER. Bulletin 686-C. 5 pp.

Relations of Late Paleozoic and Early Mesozoic Formations of Southwestern Montana and Adjacent Parts of Wyoming. D. D. CONDIT. Professional Paper 120-F. Shorter contributions to General Geology, 1918. 11 pp. Published October 21, 1918.

A Description of the Quantitative Classification of Igneous Rocks with Tables for the Calculation of the Norm. H. S. WASHINGTON. Extract from Professional Paper 99. Appendices 1-5. 35 pp.

BUREAU OF MINES

Efficiency in the Use of Oil Fuel. J. M. WADSWORTH. 86 pp. Paper, 15 cents. Published August 1918. A handbook for boiler-plant and locomotive engineers.

How to Improve the Hot-Air Furnace. C. W. BAKER. Technical Paper 208. 20 pp. Paper, 5 cents. Published October 1918.

Economic Operation of Steam Turbo-Electric Stations. C. T. HIRSHFELD and C. L. KARR. Technical Paper 204. 29 pp. Paper, 5 cents. Published June 1918.

Saving Coal in Boiler Plants. H. KREISINGER. Technical Paper 205. 24 pp. Paper, 5 cents. Published July 1918.

Gold Dredging in the United States. C. JANIN. Bulletin 127. 226 pp. Paper, 50 cents. Published May 1918.

Use of the Hydrogen-Volatile Matter Ratio in Obtaining the Net Heating Value of American Coals. A. C. FIELDNER AND W. A. SELVIG. Technical Paper 197. 13 pp. Paper, 5 cents. Issued September 1918.

Production of Explosives in the United States during the Calendar Year 1917. A. H. FAY. Technical Paper 192. 21 pp. Paper, 5 cents. Issued July 1918. Contains notes on coal-mine accidents due to explosives and list of permissible explosives tested prior to April 30, 1918.

Low-Rate Combustion in Fuel Beds of Hand-Fired Furnaces. H. KREISINGER, C. E. AUGUSTINE AND S. H. KATZ. Technical Paper 139. 54 pp. Paper, 10 cents. Issued June 1918.

The Tars Distilled from Bituminous Coal in Hand-Fired Furnaces. S. H. KATZ. Technical Paper 195. 20 pp. Paper, 5 cents. Issued March 1918.

Methods for Routine Work in the Explosives Physical Laboratory of the Bureau of Mines. S. P. HOWELL AND J. E. TIFFANY. Technical Paper 186. 63 pp. Paper, 10 cents. Issued May 1918.

DEPARTMENT OF AGRICULTURE

Neufchatel and Cream Cheese: Farm Manufacture and Use. K. J. MATHESON AND F. R. CAMMACK. Farmers' Bulletin 960. 35 pp. Contribution from the Bureau of Animal Industry.

Typical Specifications for Bituminous Road Materials. P. HUBBARD AND C. S. REEVE. Department Bulletin 691. 60 pp. Paper, 10 cents. Issued July 10, 1918. Contribution from the Office of Public Roads and Rural Engineering.

Articles from the Journal of Agricultural Research

Influence of Humidity upon the Strength and the Elasticity of Wool Fiber. J. I. HARDY. 14, 285-296 (August 19).

Availability of Potash in Some Common Soil-Forming Minerals and Effect of Lime upon Potash Absorption by Different Crops. J. K. PLUMMER. 14, 297-316 (August 19).

Influence of Reaction on Nitrogen-Assimilating Bacteria. E. B. FRED AND A. DAVENPORT. 14, 317-334 (August 19).

Acidity of Silage Made from Forage Crops. R. E. NEIDIG. 14, 395-410 (September 2).

Comparative Toxicity of Cottonseed Products. W. A. WITHERS AND F. E. CARRUTH. 14, 425-451 (September 2).

Variations in the Moisture Content of the Surface Foot of a Loess Soil as Related to the Hygroscopic Coefficient. F. J. ALWAY AND G. R. MCDOLE. 14, 453-480 (September 9).

BUREAU OF FOREIGN AND DOMESTIC COMMERCE

Standard Specifications for Structural Steel for Buildings. Industrial Standards Series. 21 pp. Paper, 5 cents.

COMMERCE REPORTS—NOVEMBER 1918

A summary is given of measures taken in Great Britain to develop the manufacture of **optical glass and chemical glassware**. Strict government control was exercised, both over raw materials, glass pots, and finished products. During the first quarter of 1918 the output of optical glass in England was 90 times that in the same period in 1913 and 10 times the total consumption for the 1913 period. Seventy-five kinds of optical glass are being made in England. (Pp. 441-443)

Exports of Chinese wood oil from China to the United States are again increasing. Through the Browne heat test, adulteration of the oil has been almost eliminated. The oil is shipped in kerosene cans, as loss arose from shipping in casks. (P. 476)

The first shipment of **hematite** from British Columbia to the United States has just been made to the smelter at Irondale, Wash. (P. 484)

In order to furnish oils for edible and industrial uses, and cattle food as well, efforts have been directed in Denmark to the cultivation and pressing of mustard, sunflower, flax, and poppy seed, and beech nuts. (P. 486)

In connection with the British control of the **acid and fertilizer industries**, the supply, price and distribution of pyrites and pyrite cinder, sulfuric acid, niter cake, phosphate rock, superphosphate, ammonia, ammonium sulfate, and basic slag are controlled by a system of licensing. Great economies have been effected by elimination of long hauls and by utilization of the niter cake. (Pp. 502-505)

Recently there was held in London a "Key Industries Exhibition" to illustrate the progress in those industries which, while not large, are essential to other and greater industries. It is interesting to note that most of these key industries are **chemical industries**, *e. g.*, dyes, optical glass, tungsten, lead, graphite, spelter, rubber, and antimony. (Pp. 513-514)

The production of **coconut fiber, copra, and coconut oil** in Trinidad is described in detail. (Pp. 535-543)

A new plant has been erected in Argentina for the manufacture of **argols and grape-seed oil**. (P. 546)

The United States High Commission has recommended the adoption of the **metric system** to improve commercial relations with other American republics. (P. 628)

The Bureau of Foreign and Domestic Commerce has published in Spanish and English standard **steel specifications** of the A. S. T. M. for use in Latin-American countries. (P. 633)

White arsenic is being manufactured successfully from mispickel in Rhodesia. It is used principally in sodium arsenite and arsenical dips for South Africa. (P. 643)

Extensive explorations for **oil** are being conducted in Great Britain with American equipment and under the direction of an American superintendent. (P. 658)

The mineral output of **Burma** is increasing. It includes petroleum and ores of tungsten, lead, silver, tin, zinc, iron, gold, molybdenum, bismuth, antimony, platinum, and copper. (P. 684)

The output of **chromium ore** in Canada has increased and the production of **ferrochrome** has been started. (P. 769)

A detailed report is given on numerous **Chinese mineral products**, including alum, antimony, arsenic, asbestos, borax, copper, gold, iron ore, jade, lead potash, mercury, arsenic, salt, silver, soapstone, tin, tungsten ore, and zinc. (Pp. 785-792)

Switzerland's dependence on Germany for **iron and steel** arises from the lack of coal and iron deposits. Only one small blast furnace and a few small steel works are operated in Switzerland. (P. 810)

SPECIAL SUPPLEMENTS

GREECE—7b	PANAMA—35a
SPAIN—15c	COLOMBIA—42a
SWITZERLAND—17b	AUSTRALIA—60b
ENGLAND—191	BRITISH EAST AFRICA—65b
MEXICO—32c	
STATISTICS OF EXPORTS TO THE UNITED STATES	
ENGLAND—Sup. 191	SWITZERLAND—Sup. 17b
Fuller's earth	Chicle
Nips	Copra
Iron ore	Hides
Sal ammoniac	Logwood
Oxalic acid	Rubber
Alum	Gold
Barium carbonate	Silver
Carbolic acid	Copper
Creosote	Lead
Naphthalene	Sugar
Glue	Wax
Gum copal	Mercury
Custor oil	Antimony
Palm kernel oil	Cottonseed oil
Refine seed oil	
Bluing	CHROME—Sup. 7b
Paris white	Opium
Driers	Magnesite
Ultramarine	Saffron
Rubber	Tanning materials
Antimony	
Barium peroxide	
Strontium carbonate	
Fluorspar	
	AUSTRALIA—Sup. 60b
	Chrome ore
	Copra
	Hides
	Nickel matte
	Coconut oil
	Eucalyptus oil
	Osmiridium
	Tin

BOOK REVIEWS

The Treasures of Coal Tar. By ALEXANDER FINDLAY, M.A., Ph.D., D.Sc., F.I.C., Professor of Chemistry in the University of Wales and Director of the Edward Davies Chemical Laboratories, Aberystwyth. 138 pp. D. Van Nostrand Company, New York, 1918. Price, \$2.00.

The author, in the preface, sets forth his object of publishing this small book as being a promotion of the better understanding by the people as a whole (in England) of the nature and complexity of the problems involved in the utilization of coal tar, with special emphasis on the subject of dyes which, he states, are so necessary for the maintenance of the textile industry.

The same situation as exists in England exists also in the United States, and the call for a book on the production and utilization of coal tar in language intelligible to the layman is a very real one.

It is also quite true of America, as of England, that a more general appreciation of the ultimate results of work in pure research should be fostered, and the author brings out this point in relation to England most clearly in his preface. It was, therefore, with a great deal of anticipation that the book was received.

Chapters 1, 2, and 3 deal, respectively, with the production of coal tar, the distillation of coal tar, and the constituents of coal tar and their application in the raw state. In these chapters are contained the outlines of the history of the production of gas, coke, and coal tar as well as a general description of present-day practice. Scattered through the descriptive matter are numerous statistics. The separation of coal tar into its various fractions is outlined, and the fractions briefly described. All of this matter is given with substantial accuracy and in language which should be readily understood by any reader.

In the beginning of Chapter 3, the author lays emphasis on the fact so frequently overlooked by those not connected with the industry, that although the dyestuffs, drugs, and explosives made from the constituents of coal tar appeal more to the imagination of the layman, yet "there are other industries dependent on the distillation products of coal tar * * * * * which * * * * * together make up a large part of the wealth derived from coal tar. Indeed, it is probably to these industries which depend on the use of coal-tar products in the raw state that the tar distiller mainly looks for the maintenance of his profits."

Chapter 3, therefore, deals with the uses of the benzols and naphthas as solvents, phenol and cresol as disinfectants, creosote oil as a wood preservative, and refined tars and pitch for road work, saturating felt, etc.

So far, the intention of dealing with the subject without the use of technical terms has been carried out, but in Chapter 4 the author endeavors to lead the reader into making a mental effort to grasp the distinction between atom and molecule, the meaning of valency, the difference between saturated and unsaturated hydrocarbons, the chemist's means of depicting substances by their formulas, and the theory of molecular structure, with several other explanations, such, for instance, as isomerism.

While there is no denying that the subjects covered are well treated and condensed, yet the impression conveyed when coming on this chapter is that the author after further consideration decided it was easier to educate the reader in the rudiments of chemistry than to explain the relation of dyestuffs to coal-tar products without the aid of formulas and symbols. In fact, the author devotes the last two pages of the chapter to the justification of urging the layman to endeavor to understand formulas. However, it can hardly be denied that the character of the book changes from this point on, and it becomes rather

an elementary description of the coal-tar dyes, drugs, and explosives for those who have specialized in other lines of chemistry, and can refresh the studies they made of the aromatic compounds in younger days, or for those who, in their training, received a little instruction in chemistry and are anxious to increase their elementary knowledge. It is impossible to conceive that more than one in ten of the average readers who might very well be seekers after some deeper information on this topic would come through the chapters on dyes with other than a confusion of ideas.

It is, therefore, necessary to view the balance of the book from a slightly different angle.

There are four chapters on the subject of dyes. The first is a general chapter containing some interesting historical notes and relating more particularly to the so-called aniline dyes. The second chapter is devoted to azo dyes; the third to anthracene and vat dyes; and the fourth to indigo and its derivatives.

The chapter on "The Production of Dyes from Coal Tar," the first of the four, is quite elementary, and gives a good view of the simpler dyes, and is especially full of historical data. It also explains the relation of chromophores to the dyes.

The chapter on azo dyes is fairly elementary, but each chapter becomes less so, until the chapter on indigo appears not unlike the usual technical description.

The chapter on "Drugs, Perfumes, and Photographic Developers" is a particularly interestingly condensed history of these products of coal tar.

The last chapter, that on "Explosives," is of particular attraction in these war times, and could be read with interest and profit by any chemist who has not specialized in explosives, as well as laymen. There is more familiarity among the people at large with the explosives, such as picric acid and TNT, than with the chemical names of dyes and their intermediates, and no doubt this chapter could be absorbed to better advantage than the previous ones.

Let us hope, however, that familiarity with chemical names and processes will become more and more universal, and we believe that many more can appreciate this book now than could a few years back. If the majority of readers, however, in England, can absorb the facts presented in this book to-day, then they have advanced farther than we have in the United States, and we hope the time will come with us when such a book will be generally understood. D. H. JAYNE

Metallurgical Calculations. By JOSEPH W. RICHARDS, A.C., Ph.D., Professor of Metallurgy in Lehigh University. xxiii + 675 pp. McGraw-Hill Book Company, Inc., New York, 1918. Price, \$5.00 net.

This volume is the collection, re-arrangement, and enlargement of a series of papers first printed serially, subsequently issued in three separate parts, and now published in a single volume. The book as a whole may be considered a study of energy changes, thermo and electric, as applied to metallurgical operations. In Part I the author discusses Chemical and Thermal Principles, Problems in Combustion, and Radiation and Conduction of Heat; in Part II, Application to the Metallurgy of Iron and Steel; in Part III, Applications to Other Metals (non-ferrous). Under each part is a series of chapters in each of which is discussed a great variety of metallurgical reactions bearing upon some phase of the subject, and under each chapter a series of problems. As an example of the variety of subjects covered, the titles under Part III are here quoted: Balance Sheet of the Blast Furnace, Calculation of Furnace Charge, Utilization of Fuel in the Blast Furnace, Heat Balance Sheet of the Blast Furnace, Rational of Hot Blast and Dry Blast, The

Bessemer Process, Thermo-Chemistry of Bessemer Process, Temperature Increment in the Bessemer Converter, Open-Hearth Furnace, Thermal Efficiency of Open-Hearth Furnace, Electrometallurgy of Iron and Steel, Problems for Practice.

It will be seen that the book is made up of a multiplicity of detail, of an infinite mass of data, collected and arranged in logical order.

Each subject is studied thoroughly and the book should lead to a more intelligent understanding of quantitative metallurgy.

HENRY FAY

The Metallurgists' and Chemists' Handbook. By DONALD M. LIDDELL. Second Edition. McGraw-Hill Book Company, Inc., New York, 1918. Price, \$4.00 net.

The additions made in this second edition of Liddell's Handbook have been, as stated in the author's preface, "largely those bearing on war activities such as additional information on alloys and toxic gases." The arrangement is practically the same as in the first edition, a short chapter having been added "to serve as a reminder of simplest formulas and properties of the more common organic compounds."

The sections are as follows:

- Section I—Mathematics
- Section II—Price and Production Statistics
- Section III—Physical Constants
- Section IV—Chemical Data
- Section V—Sampling, Assaying and Analysis
- Section VI—Ore Dressing
- Section VII—Cyanidation
- Section VIII—Fuels and Refractories
- Section IX—Mechanical Engineering and Construction
- Section X—General Metallurgy
- Section XI—Organic Chemistry
- Section XII—First Aid

The main criticism that may be made of the book is the inadequate treatment of some divisions. The author forestalls criticism in this respect in his preface to the first edition thus: "This book is a * * * collection of tables, those which my own experience * * * have led me to believe were most necessary to the chemist and metallurgist * * *. Certain sections will probably be criticised for their brevity, but these treat of those processes where there are no tables of constants, and the matter must either be descriptive or else non-existent." Certain sections which are now somewhat disappointing, notably that on copper leaching, will doubtless be amplified in later editions.

The Handbook is well worth buying, and is especially valuable in that it contains, in addition to the usual tables and data, a mass of tabulated data of value to the student and professional man, and not collected or easily accessible elsewhere.

The author, nevertheless, displays some unnecessary pessimism regarding the fruits of his labors, in stating in his preface: "He (Mr. Barbour) is doubtless the only man beside the author who will ever read the entire book." Also it is evident in the chapter on First Aid that Mr. Liddell accepts no responsibility as to the efficacy of the antidotes for poisons, since he gives as the last step in the treatment of cyanide poisoning: "Then call the undertaker."

G. D. VAN ARSDALE

Colour and Its Relation to Chemical Constitution. By E. R. WATSON. 197 pp. Longmans, Green & Company, New York and London, 1918. Price, \$4.00.

This book is one of a series of Monographs on Industrial Chemistry, which is being edited by Sir Edward Thorpe, C.B., LL.D., F.R.S., Emeritus Professor of General Chemistry in the Imperial College of Science and Technology, South Kensington, England. It fortunately appears at a time when it is very

essential that the more important theoretical speculations bearing on the subject of color chemistry should be presented for the guidance of our future investigators in this rich field of work. We have no good summary of this subject in our language and this work of Watson's not only opens up a new subject to us and meets a long-felt want, but also should serve as a guide and stimulus for young researchers to interest themselves in a field which offers great possibilities. The time is now ripe for new developments in this field in this country.

The work is based on a course of lectures delivered at the University of Leeds in 1917, which have been expanded into a readable book giving a connected and simple account of the most important lines of color research and the fundamental theories which have hitherto been proposed to explain the cause and nature of color. A most valuable feature of the book is an excellent and very complete bibliography of works of reference which has been incorporated. The book should be in every chemical library and especially on the bookshelf of our graduate schools for the reading of advanced students who are working for advanced degrees in chemistry.

TREAT B. JOHNSON

Nomon: Sugar Technologists' Edition. An adaptation of the Nomon designed by Horace G. Deming. By A. F. BLAKE, Chief Chemist, Atlantic Sugar Refineries, Limited, St. John, N. B. In 6 sections. For reading purity exponents from Brix and polarization. The Nomon Sales Agency, Urbana, Ill. Price, \$1.50.

Mr. A. F. Blake, chief chemist of the Atlantic Sugar Refineries Limited of St. John, N. B., Canada, has arranged a special form of nomon, i. e., nomographic reckoner, for calculating the purities of sugar solutions from the observed density in degrees Brix and the polarization.

This tabular arrangement is a modification of the original general tables invented by Dr. Horace G. Deming of the University of Illinois and described in the *Journal of the American Chemical Society*, 39 (1917), 2137.

Ordinarily the exponent of purity is calculated by the Casamajor method employing the formula, $\text{Exp.} = \frac{\text{Pol.} \times 26}{\text{Sp. Gr.} \times \text{Brix}}$, and while this formula is ordinarily simplified

by use of a table of factors covering the values of $\frac{26}{\text{Sp. Gr.} \times \text{Brix}}$ for every degree Brix, it still is cumbersome, requiring reference to the table of factors and a multiplication for each test, or else the calculation and printing of extremely extended tables to cover the possible range of degrees Brix and all the polarizations.

The sugar nomon as published consists of a few heavy sheets of cardboard, $9\frac{1}{2} \times 12$ in., on each of which is printed a set of eleven accurately subdivided scales all arranged vertically except the one at the extreme right, which inclines outward toward the top, at an angle of about 30 degrees. The others are placed at very precisely varying distances from each other. Their graduations are so arranged that if a straight edge is laid upon the figure representing the degrees Brix in the left-hand column and is swung around until it also crosses the right-hand column at the figure representing the second and third numbers in the polarization, the purity of the solution may be read immediately at the point of intersection with that vertical column whose position in the series corresponds with the first digit in the polarization.

The design is so clever and its operation so simple it must commend itself to all who see it and it will prove a very acceptable help in all sugar laboratories.

As any ordinary calculation may be made on the nomon that can be made on the slide rule and with greater ease and accuracy, it will be found very serviceable by chemists generally.

W. D. HORNE

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MARKET REPORT—DECEMBER, 1918

WHOLESALE PRICES PREVAILING IN THE NEW YORK MARKET ON DECEMBER 16, 1918

INORGANIC CHEMICALS

Acetate of Lime, Basis 80%.....	100 Lbs.	4.00	4.25
Alum, ammonia, lump.....	100 Lbs.	7.00	
Aluminum Sulfate, (iron free).....	Lb.	4 50 @	4.75
Ammonium Carbonate, domestic.....	Lb.	nominal	
Ammonium Chloride, white.....	Lb.	19 @	20
Aqua Ammonia, 26%, drums.....	Lb.	nominal	
Arsenic, white.....	Lb.	9 1/4 @	17
Barium Chloride.....	Ton	70.00 @	80.00
Barium Nitrate.....	Lb.	12 @	14
Barytes, prime white, foreign.....	Ton	30.00 @	35.00
Bleaching Powder, 35 per cent.....	Lb.	2 1/4 @	3
Blue Vitriol.....	Lb.	9 1/4 @	9 1/4
Boric acid, crystals, in bags.....	Lb.	7 1/4 @	10 1/4
Boric acid, powdered crystals.....	Lb.	7 1/4 @	8 1/4
Brimstone, crude, domestic.....	Long Ton	nominal	
Bromine, technical, bulk.....	Lb.	75 @	
Calcium Chloride, lump, 70 to 75% fused.....	Ton	20.00 @	22.00
Caustic Soda, 76 per cent.....	100 Lbs.	3.90 @	4.10
Chalk, light precipitated.....	Lb.	4 1/4 @	5
China Clay, imported.....	Ton	20.00 @	30.00
Feldspar.....	Ton	8.00 @	15.00
Fuller's Earth, foreign, powdered.....	Ton	nominal	
Fuller's Earth, domestic.....	Ton	20.00 @	30.00
Glauber's Salt, in bbls.....	100 Lbs.	2.10 @	3.00
Green Vitriol, bulk.....	100 Lbs.	2.00 @	2.25
Hydrochloric Acid, commercial, C. P.....	Lb.	nominal	
Iodine, resublimed.....	Lb.	4.25 @	4.30
Lead Acetate, white crystals.....	Lb.	17 @	18
Lead Nitrate, C. P.....	Lb.	85	
Litharge, American.....	Lb.	14 @	15
Lithium Carbonate.....	Lb.	1.50	
Magnesium Carbonate, U. S. P.....	Lb.	20 @	30
Magnesite, "Calcinad".....	Ton	60.00 @	65.00
Nitric Acid, 40%.....	Lb.	7 1/4 @	
Nitric Acid, 42%.....	Lb.	8 1/4 @	
Phosphoric Acid, 48/50%.....	Lb.	7 1/4 @	9
Phosphorus, yellow.....	Lb.	1.10 @	1.15
Plaster of Paris.....	Bbl.	2.00 @	2.50
Potassium Bichromate.....	Lb.	40 @	41
Potassium Bromide, granular.....	Lb.	1.25 @	1.30
Potassium Carbonate, calcined, 80 @ 85%.....	Lb.	35 @	
Potassium Chlorate, crystals, spot.....	Lb.	40 @	41
Potassium Cyanide, bulk, 98-99 per cent.....	Lb.	nominal	
Potassium Hydroxide, 88 @ 92%.....	Lb.	60 @	70
Potassium Iodide, bulk.....	Lb.	3.75 @	4.00
Potassium Nitrate.....	Lb.	27 @	30
Potassium Permanganate, bulk, U. S. P.....	Lb.	1.50 @	1.75
Quicksilver, flask.....	75 Lbs.	120.00 @	125.00
Red Lead, American, dry.....	100 Lbs.	11.25 @	11.50
Salt Cake, glass makers'.....	Ton	17.50 @	22.00
Silver Nitrate.....	Oz.	63 1/4 @	65
Soapstone, in bags.....	Ton	10.00 @	12.50
Soda Ash, 58%, in bags.....	100 Lbs.	2.25 @	2.35
Sodium Acetate, broken lump.....	Lb.	20 @	21
Sodium Bicarbonate, domestic.....	100 Lbs.	4.10 @	4.25
Sodium Bichromate.....	Lb.	18 @	18 1/2
Sodium Chlorate.....	Lb.	25 @	25 1/2
Sodium Cyanide.....	Lb.	30 @	32
Sodium Fluoride, commercial.....	Lb.	17 @	18
Sodium Hyposulfite.....	Lb.	2.60 @	3.60
Sodium Nitrate, 95 per cent, spot.....	100 Lbs.	4.42 1/4 @	5.00
Sodium Silicate, liquid, 40° Bé.....	Lb.	2 @	2 1/2
Sodium Sulfide, 60%, fused in bbls.....	Lb.	6 @	6 1/2
Sodium Bisulfite, powdered.....	Lb.	12 @	14
Strontium Nitrate.....	Lb.	25 @	30
Sulfur.....	100 Lbs.	2.25 @	4.60
Sulfuric Acid, chamber 66° Bé.....	Ton	16.00	
Sulfuric Acid, oleum (fuming).....	Ton	25.00	
Talc, American white.....	Ton	15.00	
Terra Alba, American, No. 1.....	100 Lbs.	1.17 1/2 @	
Tin Bichloride, 50°.....	Lb.	28 @	30
Tin Oxide.....	Lb.	90 @	1.00
White Lead, American, dry.....	Lb.	10 @	10 1/4
Zinc Carbonate.....	Lb.	18 @	20
Zinc Chloride, commercial.....	Lb.	15 @	15 1/2

ORGANIC CHEMICALS

Acetanilid, C. P., in bbls.....	Lb.	65 @	70
Acetic Acid, 56 per cent, in bbls.....	100 Lbs.	9.30 @	9.55
Acetic Acid, glacial, 99 1/4%.....	100 Lbs.	19.50 @	19.70
Acetone, drums.....	Lb.	25 1/2 @	
Alcohol, denatured, 180 proof.....	Gal.	68 @	69

Alcohol, sugar cane, 188 proof.....	Gal.	4.90 @	4.95
Alcohol, wood, 95 per cent, refined.....	Gal.	9 1/2 @	92
Amyl Acetate.....	Gal.	4.20 @	4.50
Aniline Oil, drums extra.....	Lb.	28 @	30
Benzoic Acid, ex-toluol.....	Lb.	2.40 @	2.70
Benzene, pure.....	Gal.	22 @	22 1/2
Camphor, refined in bulk, bbls.....	Lb.	1.24 1/2 @	1.25
Carbolic Acid, U. S. P., crystals, drums.....	Lb.	40 @	43
Carbon Bisulfide.....	Lb.	9 @	10
Carbon Tetrachloride, drums, 100 gals.....	Lb.	18 @	20
Chloroform.....	Lb.	63 @	70
Citric Acid, domestic, crystals.....	Lb.	1.12 @	1.20
Cresote, beechwood.....	Lb.	2.00 @	2.10
Cresol, U. S. P.....	Lb.	18 @	20
Dextrine, corn (carload, bags).....	Lb.	8 @	9
Dextrine, imported potato.....	Lb.	nominal	
Ether, U. S. P. 1900.....	Lb.	27 @	30
Formaldehyde, 40 per cent.....	Lb.	16 1/4 @	Gov't price
Glycerine, dynamite, drums extra.....	Lb.	60 @	62
Oxalic Acid, in casks.....	Lb.	40 @	41
Pyrogallie Acid, resublimed, bulk.....	Lb.	3.25 @	3.50
Salicylic Acid, U. S. P.....	Lb.	80 @	85
Starch, corn (carload, bags) pearl.....	100 Lbs.	6.00 @	7.00
Starch, potato, Japanese.....	Lb.	13 @	14
Starch, rice.....	Lb.	12 1/2 @	13
Starch, sago flour.....	Lb.	9 1/4 @	10 1/4
Starch, wheat.....	Lb.	nominal	
Tannic Acid, commercial.....	Lb.	65 @	80
Tartaric Acid, crystals.....	Lb.	85 @	87

OILS, WAXES, ETC.

Becawax, pure, white.....	Lb.	63 @	65
Black Mineral Oil, 29 gravity.....	Gal.	24 @	25
Castor Oil, No. 3.....	Lb.	31 @	8
Ceresein, yellow.....	Lb.	17 @	15
Corn Oil, crude.....	100 Lbs.	16.75 @	17.7
Cottonseed Oil, crude, f. o. b. mill.....	Lb.	17 1/2 @	—
Cottonseed Oil, p. a. y.....	100 Lbs.	nominal	
Menhaden Oil, crude (southern).....	Gal.	1.10 @	1.15
Neat's-foot Oil, 20°.....	Gal.	3.00 @	3.10
Paraffin, crude, 118 to 120 m. p.....	Lb.	9 1/2 @	9 1/4
Paraffin Oil, high viscosity.....	Gal.	40 @	41
Rosin, "P" Grade, 280 lbs.....	Bbl.	15.10 @	15.20
Rosin Oil, first run.....	Gal.	75 @	76
Shellac, T. N.....	Lb.	67 @	68
Spermaceti, cake.....	Lb.	31 @	33
Sperm Oil, bleached winter, 38°.....	Gal.	2.23 @	2.25
Spindle Oil, No. 200.....	Gal.	38 @	40
Stearic Acid, double-pressed.....	Lb.	24 @	25
Tallow, acidless.....	Gal.	1.62 @	1.65
Tar Oil, distilled.....	Gal.	36 @	38
Turpentine, spirits of.....	Gal.	79 @	80

METALS

Aluminum, No. 1, ingots.....	Lb.	33 @	34
Antimony, ordinary.....	Lb.	13 1/4 @	14
Bismuth, N. Y.....	Lb.	3.50 @	3.65
Copper, electrolytic.....	Lb.	26 @	
Copper, lake.....	Lb.	26 @	
Lead, N. Y.....	Lb.	7.05	
Nickel, electrolytic.....	Lb.	55 @	56
Platinum, refined, soft.....	Oz.	nominal	
Silver.....	Oz.	1.01 1/4 @	
Tin, Straits.....	Lb.	nominal	
Tungsten (Wo).....	Per Unit	20.00 @	24.00
Zinc, N. Y.....	100 Lbs.	9.40 @	9.60

FERTILIZER MATERIALS

Ammonium Sulfate.....	100 Lbs.	4.75 @	—
Blood, dried, f. o. b. New York.....	Unit	7.25 @	7.30
Bone, 3 and 50, ground, raw.....	Ton	37.00 @	37.50
Calcium Cyanamide.....	Unit of Ammonia	nominal	
Calcium Nitrate, Norwegian.....	100 Lbs.	—	
Castor Meal.....	Unit	—	
Fish Scrap, domestic, dried, f. o. b. works.....	Unit	7.75 and	20c
Phosphate, acid, 16 per cent.....	Ton	17.00 @	18.00
Phosphate rock, f. o. b. mine.....	Ton	nominal	
Florida land pebble, 68 per cent.....	Ton	5.00 @	6.00
Tennessee, 78-80 per cent.....	Ton	7.00 @	8.00
Potassium "muriate," basis 80 per cent.....	Ton	320.00 @	330.00
Pyrites, furnace size, imported.....	Unit	nominal	
Tankage, high-grade, f. o. b. Chicago.....	Unit	7.35 @	7.50

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EDITORIALS

SAFEGUARDS OF CHEMICAL INDEPENDENCE

A great structure, the American chemical industry, filled with all possible potentialities of good to this country, has been brought near to completion during the past four years. Shall it now be jeopardized? The answer lies largely with the Congress of the United States.

Chemists have done their part by the nation during this period of stress and trial. This statement is made in no spirit of idle boasting. Abundant testimony to its correctness is found constantly in the columns of the daily press; the subject has become a matter of household talk; the outward evidences of the service performed are found annually displayed at the National Exposition of Chemical Industries.

During the period in which the war was confined to European countries an economic miracle was performed in America. From hitherto wasted material, and with incredible speed, an industry of coal-tar chemicals (dyestuffs and medicinals) sprang into existence almost as if by magic. Factories threatened with the necessity of closing their doors continued to operate uninterruptedly, wage earners received constant employment, and the sick were supplied with medicinals.

When we entered the war the skill acquired in supplying these peace needs constituted the logical and ample equipment for the great task of furnishing our own armies with adequate high explosives. This was a small part, however, of the service the chemist was called upon to perform. Gas warfare, introduced by the enemy, had to be met both as to offense and defense. That our soldiers, every man of them, were provided with the best masks known, and that the output of our poison gas plants exceeded the combined output of all of the Allies, these are ample proofs that another critical situation has been fully met. Optical glass of highest quality has been developed and supplied in quantity for the field instruments of both Army and Navy. In countless ways the skill of the chemist has been evidenced throughout the vast and varied preparations for war.

At the present moment we are upon the eve of important economic changes, for the peace treaty will soon be signed, embargoes will be lifted, and normal international trading will be resumed. Are we prepared for this new period?

Fully cognizant of the importance of the great problems now engaging the attention of the Congress, it nevertheless seems reasonable to express the hope that certain matters of legislation seriously affecting the chemical industries may enlist favorable consideration and enactment before adjournment.

First: Upon the joint request of consumers and producers, and for the avowed purpose of creating a coal-tar dyestuff and medicinal industry in this country, there was added a section to the Revenue Act of 1916. This legislation, framed in utter lack of

such an industry, has now been carefully examined by the Tariff Commission following a complete survey of the newly developed industry. It has found unevenness and inadequacy in certain features of that legislation, shortcomings which will prove comforting and helpful to those with whom we have been at war. The Commission has made definite suggestions which are intended to insure the continuance of the domestic industry and to protect the revenues of the Government from losses by subterfuge and evasion. Hearings are not needed on such legislation, political differences find no place in its consideration. Prompt action will safeguard the future.

Second: For a number of years educational institutions have been given under congressional authority the privilege of importing, duty-free, apparatus and chemicals for use in instruction. This is an indirect subsidy to education. It has proved a curse in disguise, for it resulted in a serious disturbance of university affairs when through the blockade of German ports former sources of supplies became unavailable. Conditions fully paralleled those in the textile industry, hitherto dependent on foreign dyes. Naturally manufacture of such articles had not proved attractive to capital in this country, nor can we hope for its development so long as this law exists.

But the greatest evil resulting from this legislation is its psychological effect upon the students who are being trained to furnish America's industrial needs. It blights the spirit of American self-reliance.

Frankly, we do not expect that the privilege will any longer prove of financial benefit to the educational institutions. Germany will have to make the fullest possible use of all export trade to pay war indemnities, higher prices will therefore be charged, and we believe it is safe for American manufacturers to go ahead. Our confidence in that conviction is, however, rudely shaken when we ask ourselves the question: "Would you be willing to put your own funds into such undertakings?"

The Council of the AMERICAN CHEMICAL SOCIETY has recently expressed its conviction in no uncertain terms in favor of rescinding this legislation. If Congress will act favorably upon this recommendation, American enterprise and skill will bring us another step nearer to economic independence.

CHLORINE MANUFACTURE IN GERMANY

"If any one dares to touch the west bank of the Rhine or Danzig (Baltic port of Prussian Poland), Germany will rise as one man and make war again, even if we had no weapon left except poison gas."

Thus spoke Theodore Wolff, editor of the *Berlin Tageblatt*, on December 21, 1918, in an interview in the *Politiken* of Copenhagen. Strange words from a citizen of a defeated country which has accepted the most stringent armistice terms known in military history! Those terms included surrender of battle-

ships, submarines, aeroplanes, artillery, railway cars, and locomotives; indeed all kinds of instruments of war except that most fearful of modern developments, poison gas, which the enemy introduced. In the terms of neither the original armistice nor of the several extensions has there been noted any requirement of cessation of production of poison gas.

The means of controlling its production are very simple. Prohibit the manufacture of chlorine in Germany. This would prove immediately effective, for chlorine enters into all of the substances used on a large scale in this method of fighting—mustard gas, phosgene, chlorpicrin, etc.

Doubtless further extensions of the armistice will be required. If so, chlorine manufacture in Germany should receive the serious consideration of those formulating the terms of the extension. This is the tactical aspect of chlorine manufacture.

There is, however, an economic aspect which is full worthy of consideration by the Peace Commissioners. Through the necessities of poison gas warfare, world production of chlorine has been largely over-stimulated. In the period of economic readjustment, who is to scrap apparatus and machinery for chlorine production—the Germans who inaugurated gas warfare or the American manufacturer who responded to the call of his Government for the maximum output of chlorine to meet the German menace?

PENNY WISE AND POUND FOOLISH

Ignorance is not always bliss. Note the following quotations from an article contributed to the *Journal of the United States Artillery* by the late Dr. William LeRoy Broun, superintendent of the Confederate Armories in Richmond, Va., during the Civil War, and later the successful pioneer in technical education in the South.

"Steel guns were not made. We had no facilities for making steel."

Yet the troops for which these guns were needed were composed in part of men from the Birmingham, Ala., district where a great steel industry now flourishes!

"Near the close of the war the supply of mercury became exhausted. Here was a most serious difficulty. We had not and could not obtain the mercury, an essential material with which to manufacture fulminate of mercury, and without caps the army could not fight, and must be disbanded. This was an extremely serious situation, and no mercury could be obtained in the limits of the Confederacy."

And the most beautiful specimen of cinnabar we have ever seen came from a Texas mine!

"The Confederacy had neither lead nor sulfur to spare."

Though the sulfur of Louisiana and Texas has been the sole reliance of the United States in a war of such colossal requirements as that just ended!

The agricultural South of Civil War days is now becoming a manufacturing section. In the development of latter-day knowledge of the natural resources of the southern states the railroads have played a conspicuous part. While much of the industrial development by these organizations was for a period logically confined to immigration and agriculture, the trend had changed in recent years when through the stimulation of the National Exposition of Chemical

Industries a new era seemed about to dawn. Railroads throughout the South were seeking additional chemists, not for routine testing of everyday supplies, but for the preparation of thorough surveys of natural resources which, viewed through the chemist's eyes, lead to the establishment of new industries whose output of manufactured products contributes to the nation's wealth and security.

Foundations of these surveys were being laid on broad lines, well-equipped laboratories were in process of establishment, and deeper grew the conviction that the next great step in development was well under way, when—*bang*—came the order from the Railroad Administration to stop all such activities. Protests from the press fell on deaf ears; requests for continuance of this service from a group of twenty United States senators were denied.

What was the result? Laboratories were closed. The technical staffs sought positions elsewhere, and it is feared that in some cases, at least, valuable records of work partly accomplished have been lost. The new Director of Railroads has just announced that he will continue the policies of his predecessor.

The dark days are on us still. Well, at any rate, the people of the country seem to be pretty clearly convinced that the railroads shall soon return to private ownership and management. The darkness will not be eternal.

THE MEASURE OF OUR DEPENDENCE

It is a glorious sensation to witness the materialization of a vision. That experience was ours a few nights ago. There before us was the manuscript of the census of our chemical imports (exclusive of finished dyes) in the fiscal year just preceding the war.

It was a huge document, carefully and thoroughly compiled from the official records of the Treasury Department by the special staff of the Bureau of Foreign and Domestic Commerce. 6500 items were listed. That is the measure of our chemical dependence! Our duty to this country is to reduce the number of the items on that list as rapidly as possible.

But how are we to know what progress is being made? Machinery is to-day rapidly being built to give reasonable and prompt information. The Bureau of Foreign and Domestic Commerce intends to increase largely the details of statistics of imports and exports of chemicals. Mr. G. B. Roorbach of that Bureau is preparing a classified list which will constitute the form and extent of this information in the future. That list is being mailed to a number of manufacturers. It will be published in full in the March issue of *THIS JOURNAL*. Mr. Roorbach invites suggestions from all as to omissions. The work will be closed about the middle of March.

Now is the time to insure your getting the information you desire for your business. When this list reaches you, whether by letter or through our March issue, it will pay to go over it promptly and carefully in order to see if your needs are included. If not, write promptly to Mr. Roorbach.

BACK TO THE COLLEGES AND UNIVERSITIES

These are troublous days for many chemists. A sudden release of a large percentage of chemists by the War Department has occurred just when the chemical industry is practically at a standstill. The result is that many of the men who have been loyally serving the Government in technical capacities find themselves without a chemical job and in many cases with but little prospects of early relief. On January 10, 1919, one-twelfth of the A. E. F. had been demobilized and approximately one-ninth of the entire army, but that one-ninth included 80 per cent of the chemists in uniform. The extent of demobilization of chemists already equals that which is expected of the army-at-large next June.

The sight of the constant stream of young men in uniform pouring into the office of the Bureau of Employment of the Chemists' Club led us to make a study of the extent of the training those men had received and to endeavor to ascertain their point of view; in other words, to gather sufficient facts from which some kind of generalization could be drawn. Through the courteous and sympathetic cooperation of the executive secretary, the following facts were compiled:

Total recent registrants 576

As to training, these were distributed as follows:

29 have taken the doctor's degree

50 have taken the master's degree

70 have had post-graduate work but received no higher degree

232 have the bachelor's or chemical engineer's degree

129 are undergraduates

53 have completed technical courses in Pratt Institute, Cooper Union, College of Pharmacy, International Correspondence School, etc.

13 have completed only a high school course

As to the point of view:

1—Few care to consider analytical work but desire research, plant work, or business openings. Practically none desire to teach.

2—For financial reasons many claim that they are unable to return to their colleges or universities to finish their courses.

3—Men from a distance who have been temporarily located in the neighborhood of New York, Pittsburgh, and Washington desire to remain in this section for a while.

4—No one could be found south of Washington, and at present without employment, who would consider a position for less than \$1500 per year.

These are the facts. We hesitate to discuss them for it is dangerous ground; but that is a part of our job, so here goes.

It is evident that there is too great a congestion of chemists in the East. This condition is the result of voluntary decision, for demobilized men are given their traveling expenses to their homes. It will eventually remedy itself, for man must live upon bread even if he can't live upon it alone. And to think of the many problems throughout this broad land of ours that await the chemist's hand!

That none desire to undertake teaching is a serious matter, and one demanding most earnest consideration, for this is the foundation work of chemistry.

Financial inability to complete unfinished courses

is a matter of opinion, not of fact. We know that exception will be taken to this last sentence, but we stick to it. The measure of ability to complete an education to-day is the intensity of the desire to do so. Sacrifices can be made, funds can be borrowed, self-help in college or university can be resorted to if the determination is sufficiently great, and this brings us to the main point we wish to state. To every man who is without employment to-day and whose course is unfinished, we would urge: *Complete your training, no matter how great the burden or the sacrifice may be.* Do not be satisfied simply with the bachelor's degree. Look forward to the end of the next twenty-year period. Figure out in dollars and cents the income of a thoroughly trained chemist as compared with the incompletely trained. We have made an actual study of this kind, covering only a ten-year period, of the young men we have taught, comparing the relative advance of the bachelors and the doctors, and if we could speak here in personalities the results of that study would be conclusively convincing. Picture to yourself the joy of a life with unlimited possibilities ahead, and on the other hand, the deadening effect of a future with definite limitations. The 29 doctors listed above are chiefly those who are seeking change from one field of chemical work to another better suited to their tastes as they now know them. True, the holding of a doctor's degree does not necessarily insure a successful future, for personality enters into the problem, but one thing is certain—if, during the next five years, there issues from our universities a largely increased number of doctors, thoroughly trained in the methods of research, the future of chemistry is assured in America.

Back to the colleges and universities!

NOTES

"The fertilizer industry has suffered extremely during the war through hearty cooperation with the Federal authorities."—*Oil, Paint and Drug Reporter*, January 6, 1919.

That's going some!

The Government has already dumped chemists galore upon the market. Please call a halt upon a similar method of disposing of the apparatus, chemicals, and plants on hand. Somebody is entitled to a living.

Why doesn't someone get into the synthetic camphor game, using spirits of turpentine as raw material. Unsuccessful efforts in this direction were made at a time when spirits of turpentine was selling at 50 to 60 cents a gallon and camphor at 42 cents a pound. It's a very different proposition with turpentine at the same price and camphor at \$2.50 a pound.

The Advisory Committee held a protracted meeting at the residence of President Nichols on January 11, 1919. The minutes of the meeting, containing the committee appointments, requested by the Council, will be found on page 161 of this issue. Upon the thoroughness of the work performed by these committees between now and the Spring Meeting will depend the character of the contribution of the AMERICAN CHEMICAL SOCIETY to the reconstruction period.

CONTRIBUTIONS FROM THE CHEMICAL WARFARE SERVICE, U. S. A.

THE RESEARCH DIVISION, CHEMICAL WARFARE SERVICE, U. S. A.

By GEORGE A. BURRELL, Colonel, C. W. S., Chief, Research Division

Received December 21, 1918

It is possible at this time to describe, in more detail than could be done heretofore, the work of the Research Division, Chemical Warfare Service, beginning with its inception by Mr. Van H. Manning, Director of the Bureau of Mines, before war was declared by this country, and covering the development of the Division—including its personnel, location of various parts of the work, and some of the problems which were attacked and solved. Details of the latter will be published by members of the staff who did the work. The Director of the Chemical Warfare Service has ordered that the research work of an industrial application or of scientific interest, not too highly confidential, shall be published.

The chemical fraternity of this country is probably interested in knowing something about the workings of a research organization containing a maximum staff of 1900 people, consisting of 1200 technical men and 700 service assistants. The latter included stenographers, clerks, accountants, purchasing agents, machinists, instrument makers, etc.

It was possible to do a large amount of experimental work in a short space of time only because of the large number of research men on the staff and their plentiful supply of assistants. The chemists, chemical engineers, chemical industries, and universities have responded whole-heartedly to the last ounce of their efforts in furthering the chemical warfare program of the country, and this article may be considered as an accounting to them through the pages of their Journal of some of the work accomplished in the Research Division.

The amount of money expended from June 1, 1917, to June 1, 1918, was \$2,500,000; the appropriation for the fiscal year beginning July 1, 1918, was about \$5,000,000. Of course, much of the latter sum was unexpended, due to the cessation of hostilities.

The outstanding results of the Chemical Warfare Service, of which the Research Division is a part, are: (1) Every American soldier had an American-made gas mask; (2) gas masks were the first American-made equipment for the American soldier to arrive in France; (3) more American toxic gas was being made at the time of the signing of the armistice than French or English gas; and (4) no War Department bureau met its obligations and program better than the Chemical Warfare Service.

The Bureau of Mines, for its work on mining problems, had maintained, since its beginning in 1908, a staff of investigators studying poisonous and explosive gases, the use of rescue apparatus and masks of various kinds for entering and exploring noxious atmospheres in mines, methods of treatment of gassed men, and other similar matters pertaining to mining problems. It was the writer's privilege to be intimately concerned with this work from 1908 to 1916, at which time he left the Bureau of Mines to engage in commercial work. In February of 1917, war between the United States and Germany seemed inevitable, so the Director of the Bureau of Mines, Mr. Van H. Manning, called the attention of the War Department to the already existing technical organization in the Bureau for the study of poisonous gases in mines, and offered the facilities of the Bureau to the War Department for work on poisonous gases in warfare. A meeting was arranged between representatives of the Bureau and the War College, the latter organization being represented by Brigadier General Kuhn and Major L. P. Williamson. At

this conference the War Department enthusiastically accepted the offer of the Bureau of Mines and agreed to support the work in every way possible.

The writer was summoned to Washington in April by Mr. Manning, and placed in charge of the work, which was carried on with the funds of the Bureau of Mines until July 1, 1917. The first work was done on the development of gas masks.

At the first meeting called by Mr. Manning for the technical solution of some of the problems, there were present:

Mr. Van H. Manning, Director, Bureau of Mines
Mr. Geo. S. Rice, Chief Mining Engineer, Bureau of Mines
Mr. J. W. Paul, Mining Engineer, Bureau of Mines
Mr. A. C. Fieldner, Chief Chemist, Pittsburgh Station, Bureau of Mines
Dr. Vandell Henderson, Consulting Physiologist, Bureau of Mines
Prof. W. E. Gibbs, Mechanical Engineer, Bureau of Mines
Major L. P. Williamson, War College
Mr. Geo. A. Burrell.

It was appreciated by all those present that the task ahead was of no small proportions, although no one felt that the work would grow to the size which it eventually did.

I want to pay a special tribute to Mr. Manning, the man who started the work. It has been my privilege to work under his general direction for almost ten years. I know him as a man exceedingly sympathetic toward research work, and never too busy to take a hand in straightening out a tangle. He took the keenest interest in the development of the Research Division. Without his valuable counsel and guiding hand, the work would not have started as early and auspiciously as it did. Several or many months' time was undoubtedly gained on the whole chemical warfare program because of his initiative. Research men, who came from all over the country at his call, liked him, and he liked them. His able work in starting and carrying on the problems is one of the most important of his many contributions toward winning the war.

EARLY TECHNICAL WORK

The first tangible work done consisted in rounding up various reports on the subject of gas warfare which had come over from France and England to the War and Navy Departments. Some of these reports were in the hands of Major L. P. Williamson of the War College, who was gathering them together and studying them; some were in the Ordnance Department of the Army; some in the hands of the Military Intelligence Corps; and some in various bureaus of the Navy Department. Some work was being done at Picatinny Arsenal on the subject of gas masks, and some thought was being given to the development of smoke screens. This work was not coordinated, however. The great importance of gas warfare was not fully appreciated in the United States.

In April, the following committee on gases used in warfare was formed by the National Research Council for the purpose of coöperating with the Bureau of Mines:

Mr. Van H. Manning, Chairman, Director, U. S. Bureau of Mines
Colonel E. B. Babbitt, Officer of Ordnance, U. S. A.
Major L. P. Williamson, Medical Department, U. S. A.
Lieutenant T. S. Wilkinson, Bureau of Ordnance, U. S. N.
Medical Director, J. D. Gatewood, Medical Department, U. S. N.
Dr. M. T. Bogert, Professor of Organic Chemistry, Columbia University
Dr. Carl L. Alsberg, Chief, Bureau of Chemistry, U. S. Department of Agriculture

A few months later the committee was re-formed, owing to the reassignment of certain army and navy officers, as follows:

Mr. Van H. Manning, Chairman, Director, U. S. Bureau of Mines
Dr. Geo. E. Hale, Ex-Officio, Director, Mt. Wilson Solar Observatory



CHIEFS, RESEARCH DIVISION, CHEMICAL WARFARE SERVICE, AMERICAN UNIVERSITY EXPERIMENT STATION, WASHINGTON, D. C., NOVEMBER 1918

Major E. A. Millikan, *ex-officio*, Science and Research Division, National Research Council

Dr. Carl L. Alsberg, Chief, Bureau of Chemistry, U. S. Department of Agriculture

Major E. J. Atkinson, Corps of Engineers, U. S. A.

Dr. M. T. Bogert, National Research Council

Major Bradley Dewey, Gas Defense Service, Surgeon General's Office

Lieutenant Commander A. H. Marks, U. S. N.

Lieutenant Joseph R. Phelps, P. A. Surgeon, Bureau of Medicine and Surgery, U. S. N.

Captain Earl J. W. Ragsdale, Bureau of Ordnance, U. S. A.

Lieutenant T. S. Wilkinson, Bureau of Ordnance, U. S. N.

After the literature on gas warfare received in this country from France and England had been digested, definite lines of research were mapped out. It was felt that the most important work had to do with the development of gas masks for the army. This meant work on charcoal, soda-lime, and various mechanical parts of the mask, such as the facepiece, elastics, eyepieces, mouthpieces, noseclip, hose, cans, valves, etc.

PERSONNEL

There was necessary, of course, an immediate increase in the personnel of the organization. One of the first men approached was Mr. Bradley Dewey, then research chemist for the American Tin Plate Company, Pittsburgh, Pa. Although his connection with the new organization would mean giving up important work in Pittsburgh for an indefinite position, the opportunity of being of real service in the crisis appealed very strongly to him, and it did not take him long to decide. Accordingly, from that day, the energy and vitality of Bradley Dewey have been an important factor in the chemical warfare work.

Mr. Dewey had long been a great admirer of Dr. W. K. Lewis, Assistant Professor of Chemical Engineering at the Massachusetts Institute of Technology, and it was on his recommendation that Dr. Lewis joined the staff. It was simply a question of meeting Lewis to be convinced that he was a man to occupy an important post in the work. Lewis' indomitable energy and technical ability have been in evidence in the organization ever since he joined it.

These two men, more than anyone else, mapped out the early course to pursue in the research work. Sufficient laboratories and facilities to carry on the rapidly growing work were not available in Washington, nor in any other one place, so branch laboratories were installed, or taken advantage of, in different parts of the East and Middle West. Lewis went in one direction and Dewey in another, and between them they started work at the National Carbon Company, Cleveland, Ohio; The Forest Products Laboratory at Madison, Wis.; the University of Chicago; the Bureau of Mines, Pittsburgh, Pa.; the Research Laboratory of the American Tin Plate Company, Pittsburgh, Pa.; the Bureau of Chemistry Laboratory, Washington, D. C.; the Yale Laboratory at New Haven, Conn.; the Massachusetts Institute of Technology, Boston, Mass.; the Mellon Institute; and other places.

At some of these places, particularly at the National Carbon Company's laboratories in Cleveland, the University of Chicago, the Forest Products Laboratory, and the Bureau of Chemistry in Washington, there were men who were experts on matters pertaining to charcoal. These men gladly seized the opportunity to be of service, and gave unsparingly of their time and equipment day and night in the preparation of an absorbent charcoal for use in gas masks. In Cleveland, at the National Carbon Company's laboratories, there were H. D. Batchelor and N. K. Chaney, and at the National Electric Lamp Works, F. M. Dorsey—three men prominently identified with charcoal work up to the present time, and largely responsible for the high quality of the material eventually made. These men and their assistants have done a tremendous amount of good work on chemical warfare problems. Chaney and Batchelor everlastingly hammered away at laboratory studies of charcoal. Dorsey worked up their results on a larger scale. Later he commanded

the Development Division of the Chemical Warfare Service on offense and defense problems

Credit must also be given to Dr. C. H. Hudson, of the Bureau of Chemistry, for the preparation of charcoal. Charcoal studies were preëminently in his line, and for weeks he raced neck and neck with the Cleveland contingent on the charcoal problem. The mention of Doctor Hudson brings to mind his highly-esteemed chief, Dr. Carl Alsberg, a member of the original Gas Warfare Committee, and a man who threw his laboratories wide open and gave freely of his facilities and his men, as well as of his sound advice.

THE ADVISORY BOARD

The research work, as well as the work of other divisions of the gas warfare program, was of nation-wide interest. Some of the best men in the country came from universities, colleges, and the industries. The work finally assumed such magnitude that Secretary Lane appointed a board of advisory chemists to assist in the research work. The board was composed of:

Dr. Wm. H. Nichols, <i>Chairman</i>	Dr. H. P. Talbot
Dr. E. C. Franklin	Dr. F. P. Venable
Dr. C. L. Parsons	Dr. T. R. Richards
Mr. Wm. Hoskins	Dr. Ira Remsen

This board met occasionally to inspect the work, discuss the results, and advise concerning future progress. They also gave much assistance individually.

Dr. C. H. Herty, Editor of the *Journal of Industrial and Engineering Chemistry*, has kept in touch with the work by frequent conferences with members of the staff and occasional visits to the station. Enthusiasm, optimism, and good-will radiate from him to such a great extent that he influences for good everybody with whom he comes in contact.

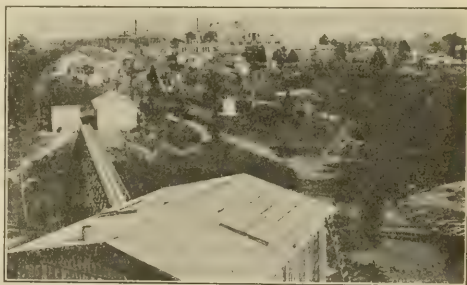
CHARCOAL

Many different substances were carbonized, and the resulting charcoal tried as a gas mask absorbent. Different kinds of wood were tried, and nut shells—including coconut shells—lampblack, carbon black, blood, seaweed, ivory nuts, etc. The first coconut charcoal came from Dr. H. B. Lemon of the University of Chicago. Coconut shells later formed the basis of most of the charcoal used in gas masks. A tremendous amount of experimentation has been done on the preparation of charcoal. The main idea has been to thoroughly clean the pores of the charcoal of hydrocarbons, because any hydrocarbon residue seriously poisons the absorptive power. A simple way to get this hydrocarbon residue out is to burn it out. By letting the charcoal cool in the presence of air and absorb as much oxygen as possible, and then reheating to a comparatively low temperature, it is possible to cleanse the charcoal of its hydrocarbon film and leave the surface active. Oxidizing by means of steam has certain advantages. The latest method of preparing charcoal consists in heating nuts to about 900° C. in a closed retort at atmospheric pressure for about 12 hrs. The charcoal produced is ground to about 8-14 mesh and steam-treated. The latter process is carried out at 950° C. for 7 hrs. Three types of charcoal deserve favorable mention. Ore, Dorsite, made from coconut shells; another, Bachtie, made from anthracite coal; and a synthetic charcoal called Carbonite, made from ground anthracite, pitch, and sulfur.

In Pittsburgh, in the meantime, Mr. A. C. Fieldner, of the Bureau of Mines, was exceedingly busy, having virtually turned over his entire staff to the work. He created a large organization and improvised outdoor laboratories for testing the different charcoals and soda-limes, and for filling experimental canisters, etc. Fieldner worked out most of the methods for analyzing war gases and testing canisters. His section also developed impregnated dugout blankets for protection of dugouts against poison gases, and gas detectors for the quick detection of gases on the battlefield. Not the least important part of his staff was a test-

ing squad for testing gas masks under all sorts of practical conditions. His "man test" chamber was never very popular. In this place the subjects wore gas masks in lethal atmospheres to the breakdown point. When the first trace of gas came through, causing coughing or sneezing, the test was ended. Fieldner gave all of his customary energy and good judgment to the task and has been a "wheel horse" in the organization. The writer can think of no tribute fitting enough to repay him for his services in connection with gas warfare work. He is always in good humor, and has a ready smile and surpassing tact. It is no wonder that he is so much appreciated by his friends.

One good man brought others into the organization. This was true in the case of Dr. R. E. Wilson, one of the assistant professors of chemistry at the Massachusetts Institute of Technology. W. K. Lewis early corralled Wilson and persuaded him to join the staff. Wilson has been interested in so much of the work of the Research Division and has developed so many good things, that it is difficult to pick out one achievement which stands preëminent above the others. Possibly this is true of the soda-lime absorbent in gas masks. He followed the process from the laboratory to the preparation of the material on a large scale, in ton lots, and improved every step of it; a versatile, able, and enthusiastic investigator is R. E. Wilson. The Carnegie Institute of Technology at Pittsburgh offered space



PANORAMIC VIEW OF THE HOME OF THE RESEARCH DIVISION, C. W. S. U. S. A.

for work on war gases, and Wilson, with a small staff, started work at that place, continuing the rest of the summer, until September 15, when he brought his work to Washington. In addition to working on soda-lime, Wilson turned his attention to incendiary materials and smoke screens, and later to ointments for protection against mustard gas, and to protective clothing, impregnated charcoals, etc.

SODA-LIME

The soda-lime finally developed and used in masks contained lime, cement, kieselguhr, caustic soda, sodium permanganate, and water. Each ingredient performed a definite function. The lime furnished the main part of the absorption for acid gases, which it neutralizes, generally with the formation of calcium chloride. The cement is used to make the granules sufficiently hard and yet not decrease the porosity, which is fatal to good absorption. Several other binders give equally good hardness, but all destroy the porosity. The kieselguhr is used to increase the porosity of the granule and thus permit the gas to have access to the interior and utilize the full absorptive capacity of the granule. The caustic soda activates the rate of absorption of most gases, and, in addition, makes the control of the drying process more simple and tends to maintain the proper water content in the finished granule. The sodium permanganate is used primarily to oxidize certain oxidizable gases, which are difficult to absorb in gas masks. The water is

necessary in making up a satisfactory mixture, and, after drying, a fairly definite moisture content is needed to get the best results in the absorption of gases.

It has been found that these materials must be selected with special care and kept under closest control. Careful selection of the best materials has in fact practically doubled the absorptive capacity of the granules without any change in composition since the early days of soda-lime manufacture.

THE FIRST TWENTY THOUSAND

About the first of May 1917, Major L. P. Williamson, acting as liaison officer between the Bureau of Mines and the War Department, put the last ounce of "pep" into the organization by asking us to build 20,000 gas masks for shipment overseas. 20,000 masks did not seem like a very large order. We did not fully appreciate all the conditions which a war gas mask had to encounter, so we readily and willingly accepted the order. Then began a struggle with can manufacturers, buckle makers, manufacturers of straps, rubber facepieces, eyepieces, knapsacks, etc. The country was canvassed from the Atlantic Coast to the Mississippi River for manufacturers who could turn out the different parts acceptably and in a hurry.

Charcoal was made from red cedar at a coking plant in Pennsylvania; soda-lime permanganate was manufactured by the General Chemical Company; knapsacks by the Simmons Hardware Company in St. Louis; facepieces by the Goodrich and Goodyear Rubber Companies at Akron; canisters by the American Can Company; and the assembly made at one of the plants of the American Can Company in Long Island City.

The writer cannot recall all the doubts, fears, optimism, and enthusiasm felt in turn by different members of the organization during the fabrication of those first 20,000 masks. We were performing an important task for the War Department. Night became day. Dewey, Lewis, Henderson, Gibbs, and others stepped from one train to another, and we used the telephone between Washington and St. Louis or Boston as freely as we used the local Washington telephone.

We thought we could improve on the English box respirator on various points. We made the canister larger, and have been glad ever since that we did. We thought the English mouthpiece was too flexible and too small, and made ours stiff and larger, and were sorry we made the change. We tested the fillings against chlorine, phosgene, prussic acid, etc., and had a canister that was all that was desired for absorbing these gases. But, alas, we did not know that chlorpicrin was destined to be one of the most important war gases used by the various belligerents. Further, it was not fully appreciated that the rubberized cloth used in making the facepiece had to be highly impermeable against gases, that hardness as much as anything else was desired in the make-up of the soda-lime granules in order to withstand rough jolting so that the fines would not clog the canister, and raise the resistance to breathing to a prohibitive figure. Neither was it appreciated at that time by any of the allies, that the gas mask really should be a fighting instrument, one that men could work hard in, run in, and wear for hours, without too serious discomfort.

The first 20,000 masks sent over to England were completed by the Research Division in record time. As compared with the French masks, they were far superior, giving greater protection against chlorine, phosgene, super-palite, prussic acid, xylol bromide, etc. The French mask was of the cloth type, conforming to the face, and consisting of twenty layers of cheese-cloth impregnated with sodium phenate and hexamethylene tetramine. Chlorpicrin went through this like a shot. Just before the masks were sent abroad, we received disturbing rumors of the contemplated use of large quantities of chlorpicrin. The French, apparently, had no intention of changing the design of their mask, and did not do so for months to come.

We therefore released the masks, they were sent abroad, and an anxious research group on this side of the water waited expectantly for the verdict. It came. A brief cablegram told us what our English cousins thought of us. It was a subject they had been wrestling with for two years and a half. They had had battlefield experience; they had gone through the grief of developing poor masks into better ones, knew the story better than we did, and after a thorough test "hammered" the American design unmercifully.

This experience put the Research Division on its mettle. Our first attempt had given us the necessary preliminary experience; cablegrams and reports traveled back and forth; an expert or two eventually came to this country from England in response to previous appeals for assistance, and we turned with adequate information to the development of a real mask.

GAS MASK DESIGN

A casual and inexperienced observer can pick up a gas mask and see three or four things: the canister, the facepiece, and the general contour of the assembled device, but he is hopelessly unaware of the minor details of the mask which need the most careful attention in its assemblage. The best is not too good for each and every part of it; the best products the rubber companies can produce are necessary. The latter had problems put up to them to work out in cooperation with the Research Division which were entirely new to them in spite of their years of experience in the rubber industry. Every joint must be absolutely tight, and the sewing first class. The can companies did the best work of their lives. A skilled organization had to be developed out of raw material for the assemblage of the various parts. Almost every other employee in a gas mask factory is an inspector, and there must be inspectors who inspect inspectors.

The latest gas mask which was developed is a triumph in gas mask design. It is as great an improvement over the first mask produced as the modern automobile is over the old one-cylinder vehicle.

The Goodrich and Goodyear companies at Akron, Ohio, were the first people appealed to for assistance on gas mask design. They were an exceedingly important factor in the work. Gas mask work was given preference in their huge organization. Dr. W. C. Geer, second vice president of the Goodrich Company, never relaxed his efforts and interest in the work.

INCREASE IN ORGANIZATION

While the work on gas masks was being vigorously prosecuted, the organization was being rapidly enlarged. By July 1, 1917, it had reached a total of 50 people. The War Department in general was beginning to appreciate the importance of gas warfare and the fact that the Bureau of Mines organization was far ahead of any other group in studying the problems connected with gas warfare.

Up to July first the Bureau of Mines had paid the bills. On that date the War Department made available, by transfer from funds of the Bureau of Ordnance and the Surgeon General's Office, \$125,000. The Navy was also getting interested, and, with its usual foresight, wanted to be considered. For work on chemical warfare problems, they made an appropriation of \$50,000, divided between the Bureau of Construction and Repair and the Ordnance Bureau. The Bureau of Ordnance of the Navy desired work done on protective smoke screens for ships, signal lights, combination toxic and explosive armor-piercing shell, submarine signals, submarine ventilation, gas masks for ship personnel, etc. Lieut. Commander T. S. Wilkinson, progressive assistant and right-hand man to Admiral Earle, Chief of Ordnance for the Navy, kept closely in touch with problems pertaining to his department. He has always had the authority to say "Yes" or "No." He appreciates the difficulties which beset one in prosecuting research, and has the

faculty of getting quickly and unerringly to the heart of a problem. He knows what he wants and usually gets it.

Lieut. Commander A. H. Marks was the pioneer in gas mask development for the Navy. The Bureau of Mines organization found him already on the job, thinking seriously about the problem, with the latter well in hand, and already the possessor of a design he thought would fit the Navy's needs. Commander Marks was a Goodrich Rubber Company man and vice president of that concern before offering his services to the Navy. He therefore had at his command the facilities of his company in his work. He promptly joined forces with the Bureau of Mines organization, and as the work of the latter expanded, leaned more and more heavily upon it for assistance until, finally, the Navy Department depended entirely upon the Research Division for the solution of its gas mask problems.

JOHNS HOPKINS LABORATORY

During this time, in the summer of 1917, the Research Division began to take definite shape. A branch laboratory early on the job was that of Johns Hopkins University, and to Dr. J. C. W. Frazer, Dr. E. E. Reed, Dr. B. F. Lovelace, and Dr. W. A. Patrick of that school, the Research Division is indebted for some of its best work. Their one aim was service. They cheerfully plodded through red tape and War Department procedure, and unremittably kept "grinding the crank and turning out results." J. C. W. Frazer is an exceptional citizen, one of the "salt of the earth," and a man who bites into a problem and never lets go until he has the answer, be it "Yes" or "No." A brilliant piece of work for which he is largely responsible has to do with the development of an absorbent in gas masks for carbon monoxide. It is well known that this problem has baffled scientists for many years. Frazer and his assistants performed a multitude of experiments, finally developing a material, a combination of substances, which removed carbon monoxide from air at ordinary temperatures in a manner largely catalytic. Twenty grams of the substance placed in the U. S. Army canister will for sixty minutes remove carbon monoxide from a mixture of it with air containing one per cent carbon monoxide. This is a signal achievement, capable of industrial application as well as being of importance in war. Frazer was the pioneer on this work. He was later assisted by Bray of the University of California, who divides with Frazer the honor attached to the achievement. This work, in the later phase of its development, was in the Defense Research Section, under the general direction of A. B. Lamb. The latter, in cooperation with C. R. Hoover of Wesleyan University, developed a successful carbon monoxide absorbent: successful, but slightly inferior to the one first mentioned. Thus there were two complete answers to a hitherto baffling problem.

Dr. Patrick early interested himself in the subject of silica gel as an absorbent for war gases, principally because of his early work on this subject at Göttingen when he was a student in Germany. He developed an excellent absorbent, almost as good as charcoal. Silica gel is a hard, transparent substance with a high luster and conchoidal fracture, and possessing a fine porous structure. Its great absorptive powers are due to physical condensation of vapors in the gel pores. It is totally inactive chemically, being different from charcoal and soda-lime in this respect. It has an advantage over charcoal for the absorption of some gases, notably chlorpicrin.

Dr. E. E. Reid did pioneer work in rounding up the organic chemists of the country, getting them interested in the work, and having them make organic preparations for submission to the toxicology section of the Research Division. In addition, he directed a staff of investigators at Johns Hopkins on organic chemistry problems.

Dr. Lovelace devoted attention to the electrolytic production of sodium permanganate as a cheaper way of making this material for use in gas masks than the one first adopted.

OFFENSE RESEARCH

The offense research work developed rapidly principally along organic lines. Therefore, the services of a good organic research man were needed, and Dr. James F. Norris, of the chemistry department at the Massachusetts Institute of Technology, was called to take charge of the offense chemical research problems.

Norris, like many others, jumped suddenly from an academic position, teaching chemistry, carrying on research with a few students, writing text-books, in fact, a typical academic atmosphere, into the hubbub of a fast-growing, tremendous research organization. His work was principally executive, organizing the organic resources of the country, jumping from train to train and from city to city, and enlisting cooperation in getting laboratories started at different universities. Norris thrived on hard work. He brought into the organization a cheerful, sunny disposition, a capacity for lots of work, and an acquaintance with the organic chemists of the country. In addition, he started to organize the defense research, that part which had to do with the laboratory study of charcoals, soda-lime problems, etc.

Norris' work assumed such extremely large proportions in a few months that Dr. A. B. Lamb, director of the chemical laboratory at Harvard, was called in to relieve him of some of his arduous duties. Dr. Lamb took over the defense research. At the time the armistice was signed, he was handling a research organization of 150 men, principally concentrated at Washington, but with branch laboratories at universities and industrial plants throughout the country. Lamb is a rare combination of good executive and high-class research man: a man with an ever-ready smile, who, through cares and worries of personnel problems, and War Department red-tape covering purchases, accounts, etc., has always kept a firm grip on his problems. One cannot speak too highly of the wonderful service he rendered.

Dr. G. A. Hulett, head of the physical chemistry department at Princeton, had been sent abroad early in 1917 by the National Research Council, as part of a scientific mission to gather data on technical war problems. Hulett paid particular attention in Europe to the war gas situation. He came back with a great deal of information which has been an immense help. He preferred to organize a research group at Princeton, intimately directing scientific work. Hulett worked on the gas content of charcoals, on methods for determining moisture content, true density, and the volume of the capillary spaces, etc. These studies threw an entirely new light on the absorption of gas by charcoal. His work on the removal of iron oxide from glass sand was valuable and extraordinarily interesting. He found that the iron oxide in sand at the proper temperature was reduced by carbon monoxide set free from decomposed phosgene. The iron was then chlorinated by the chlorine of the phosgene and volatilized out of the sand. This reaction has other important industrial uses.

PHARMACOLOGICAL WORK

The pharmacological and physiological work at the beginning of the Research Division was carried on under the direction of Dr. Yandell Henderson at New Haven, Conn. The pharmacologists of the country responded to his call, and he organized a staff at New Haven, with laboratories in the Yale buildings, and a large, temporary one on the Yale baseball field. Here the early gassing experiments were made, and the foundation of future research work along this line laid. Able assistants who responded to his call were F. P. Underhill, E. K. Marshall, Harold Bradley, M. C. Winternitz, and others. The present medical research work has grown from the firm foundation laid by Henderson. His work in chemical warfare, since the United States declared war, has shown that his whole heart and soul have been with the Allies.

He gradually released the pharmacological part of his work

until the burden of it fell upon Dr. E. K. Marshall, formerly associate professor of pharmacology at Johns Hopkins University. Marshall's research has always been characterized by the most painstaking care, and early results of his efforts withstood the test of time until the finish of the work. Marshall later joined the Medical Division under Colonel Lyster, devoting most of his time to the defense side of chemical warfare. Dr. A. S. Loevenhart, professor of pharmacology at the University of Wisconsin, took over the offense side, principally the testing of new offense compounds; their lethal, vesicatory, sternutatory, and lachrymatory properties; care and breeding of animals; the supervision of the toxicological side of large-scale field tests, etc. Experiments at this station have been on dogs, rabbits, guinea pigs, mice, rats, monkeys, and man. Practically the entire personnel of the station volunteered their services for skin tests, eye tests, coughing and sneezing tests, etc. An ingenious apparatus was devised for determining the lachrymatory properties of gases. The gas mixture was prepared in a wooden chamber fitted with hose, to which gas masks were fastened. Men on the outside of the chamber put on the masks and breathed the air of the chamber. The air of course had to enter the facepieces and come in contact with the eyes. A sufficient concentration caused lachrymation. The operator could switch either chamber air or pure air into the mask without the knowledge of the subject. A tremendous amount depended upon the decision of the pharmacologists. They had to give the answer concerning the efficacy of a new substance. They dared not make mistakes because huge sums, time, and labor finally went into the construction of plants and devices to use materials which were passed by them.

Another Princeton man anxious to be of service was Dr. Frederick Neher, head of the organic chemical department at Princeton. Neher's work has had to do with the preparation of organic chemical compounds, and the preparation of chemical materials in large quantities for experimentation elsewhere. He has expressed his opinion more than once in no uncertain terms of government methods of doing things. It was his first experience along this line, and the hubbub and hurry of getting a war-machine going was difficult for him to understand from his academic chair at Princeton. Things could not run so smoothly in the new work as in the Princeton work. In spite of the difficulties he met, Neher kept plugging along, doing his bit admirably well.

Early in the work the writer found Dr. William McPherson, formerly dean of the chemical department at the Ohio State University, and then a Captain in the Ordnance Corps, wandering disconsolately around Washington. He had been doing useful war work at Columbus, Ohio, but thought by coming to Washington and joining the Service he could be of even more help. He arrived at the seething Ordnance Department, a huge machine, grinding and creaking in its endeavor to get going, and a machine in which chemical work had not yet found its place. He wandered over to the offices of the Research Division, took a look around, and said he thought that this was the place where most of the chemical work was going on. He was promptly seized and placed in charge of small-scale development work, principally organic work, in which he was at home, to be later applied, however, on a much larger scale than he or anybody else anticipated.

The Berlin Mills Company of Berlin Mills, New Hampshire, is a much larger concern than most chemists appreciate. Paper pulp is their specialty, but they also make sulfur chloride, carbon tetrachloride, chloroform, hydrogenated peanut oil, etc. It was in this atmosphere that Mr. George A. Richter received his chemical engineering experience on a large scale. He was ferreted out and brought to Washington among the first dozen attachés of the research staff. His first work had to do with the development of smoke screens, and smoke screens have been one

of his specialties ever since, but only one. At the windup of the work he had charge of 150 men, working on gas shell, on smokes for screening ships and troops from the enemy, on incendiary shell, incendiary drop bombs for airplanes, flaming guns, cements for shell, Navy signal lights, toxic gas cylinders, and all the numerous ways and devices for using research work developed in the laboratory. George Richter saw the objective as well as any man in the Research Division. "When can I get it finished and put it into production?" was his motto.

During this time, the summer of 1917, work was being done on fitting up one of the buildings of the American University, a group of two buildings located on the outskirts of Washington. Trustees of the University generously placed the buildings and grounds at the disposal of the War Department. Bishop J. W. Hamilton, President of the University, has been our host, and an admirable one. He gave space and more space, finally sacrificing his work and confining his activities to two small rooms in order to accommodate the Research Division. Two huge stone buildings were available. One was merely a shell. The latter was rapidly fitted up to provide a laboratory, and the other building was used for offices. On September 15, 1917, much of the research work carried on at different parts of the country moved into the American University, and this place became the headquarters of the Research Division. When the armistice was signed, there had been erected at this location about 70 buildings in addition to the two huge buildings already on the premises. The organization on September 15, 1917, consisted of the following:

Van H. Manning, Director, Bureau of Mines
G. A. Burrell, Assistant to the Director, In charge, Gas Investigations
W. K. Lewis, In charge, Defense Problems
Yandell Henderson, In charge, Medical Science Problems
J. F. Norris, In charge, Chemical Research
A. C. Fieldner, In charge, Gas Mask Research
G. A. Richter, In charge, Pyrotechnic Research
Wm. McPherson, In charge, Small-Scale Manufacturing
H. H. Clark, In charge, Mechanical Research
E. K. Marshall, In charge, Pharmacological Research
Lauson Stone, In charge, Administrative Section

BRANCH LABORATORIES

Johns Hopkins University—J. C. W. Frazer and E. E. Reid
Princeton University—G. A. Hulett and F. Neher
Nela Park, Cleveland, Ohio—F. M. Dorsey
National Carbon Co., Cleveland, Ohio—H. D. Batchelor and N. K. Chaney
Harvard University—E. P. Kohler and G. P. Baxter
Yale University—F. P. Underwood
Wesleyan University—C. R. Hoover
Ohio State University—C. E. Boord
Bryn Mawr College—R. F. Brunel
Massachusetts Institute of Technology—S. P. Mulliken

Many technical men in the country, not yet in war work, were waiting for a chance to be placed where their services could be utilized to the best advantage. Among this number was John Johnston, erstwhile research chemist at the Geophysical Laboratory, and, at the time he entered the government service, research chemist for a large zinc company. Johnston was asked to take charge of all the offense research problems in the organization, a co-worker of W. K. Lewis, who had charge of all the defense problems. Johnston stayed long enough to leave his imprint upon the work. He later accepted a larger sphere of usefulness with the National Research Council, as chairman of the Chemistry Committee. A valuable counselor was John Johnston, a canny Scotchman, able to brush everything aside when a problem was under consideration, except the essential parts of that problem.

By this time most of the large chemical staff of the Massachusetts Institute of Technology had joined the Research Division. Professor William H. Walker was one of those who remained behind to carry the increasingly heavy teaching load. He finally could stand the strain no longer, so packed

his suitcase and arrived in Washington. His first job was an important one. It is still a military secret.

The formation of a Chemical Service Corps was in the minds of many chemists. It was felt that chemistry should be recognized in the same way that other sciences had been recognized, by the creation of a staff corps in the Army, especially since chemistry was playing such an important part in the war. Therefore, the Chemical Service Corps was recognized, with Prof. Walker as its Chief, with the rank of Lieutenant Colonel. At this time the research work was still under the Bureau of Mines; gas manufacturing under the Ordnance Department of the Army, Capt. E. J. W. Ragsdale in charge; gas mask manufacturing under the direction of the Surgeon General's Office, Major Bradley Dewey in charge; and the large-scale proving grounds, Capt. Wm. Bacon in charge, getting under way, not knowing what its status was—whether Ordnance or Army Medical. Neither were the different branches of the Army quite ready for a consolidation. Therefore, we had a Chemical Service Corps without direct charge of the chemical warfare activities. Walker's thoughts and activities turned toward the manufacture of chemicals in the Ordnance Department. He became identified with this work to such an extent that finally he was placed in charge of the huge gas manufacturing project which the Ordnance Department had built at Edgewood Arsenal, about thirty miles from Baltimore. At this place, plants for the manufacture of phosgene, chlorpicrin, chlorine, titanium tetrachloride, and other offense chemicals were under way. Walker speeded up the manufacture of these substances, put in operation a tremendous "mustard" program, and developed an organization of about 10,000 people for the work.

When John Johnston resigned, early in 1918, from the Research Division to take up work with the National Research Council, his position in charge of offense problems was vacant. Somebody suggested Dr. E. P. Kohler, professor of organic chemistry at Harvard, as a suitable man to fill this vacancy. Somebody had a happy inspiration. Kohler had already been working at Harvard for the Research Division with a group of ten or twelve people on organic problems. The problem he had been paying particular attention to was the preparation of kaolin as a catalyst to speed up the reaction between sulfur monochloride and ethylene in the manufacture of mustard gas. Kohler was called, came, and conquered. He captivated everybody because of his sound judgment, chemical knowledge, tact, and personality. Kohler is another executive chemist, exceptionally good in both lines. Kohler on offense problems and Lewis on defense problems—men of opposite types, one cool and deliberate, the other, dashing and impetuous, both sound—handled matters admirably. One of Kohler's many duties was to link the chemical research work in the laboratory with the outdoor chemical manufacturing. He browsed through the "hill plants" with his pipe, greasing the machinery with his sound advice and good judgment.

METHODS OF RESEARCH

The course of research on a new gas was somewhat as follows: Methods of preparing it were thoroughly investigated in the Offense Research laboratories. Its physical and chemical properties were exhaustively studied. Next a sufficiently large quantity of it was turned over to the Pharmacological Section to examine its lethal, lachrymatory, vesicatory, or sternutatory properties. Then a plant process for making it was worked out in the Small-Scale Manufacturing Section. Chemists from the research laboratories joined hands with the chemical engineers at this stage. A certain amount of it was examined by the Gas Mask Research Section to determine its ease or difficulty of penetrating through American, French, and British masks. A large quantity of it was used by the Pyrotechnic and Dispersoid Sections to determine the best way of serving

it to the enemy, whether in artillery shell, Stokes shell, Livens shell, candles, or from cylinders as cloud gas attacks, etc. In the meantime, raw materials for its manufacture were thoroughly looked up. Finally, if all investigations had been satisfactory up to this point, it was either turned over to the Development Division of the Chemical Warfare Service, F. M. Dorsey in charge, to build the first large unit, or direct to the Gas Manufacturing Division W. H. Walker in charge. Chemists from the Research Division, familiar with the process of manufacture, were transferred along with the process when the latter left the Research Division. Troubles were by no means over at this point. Frequently unforeseen difficulties arose in the manufacturing stage, or better modifications of the process were discovered as the manufacturers wrestled with the problem.

As soon as the research on some of the more important substances had been completed by the Research Division, designs of larger plants were laid down for manufacturing the materials in large quantities at Edgewood Arsenal. Capt. McPherson, who had been working on the small-scale manufacture of offense substances for the Research Division, was transferred early in 1918 to Edgewood Arsenal, taking with him practically his whole force. His successor was William S. Rowland, chemical engineer with the Stanley Works of New Britain, Conn. Rowland's first job was working out plant processes for the manufacture of mustard gas. Things he discovered and recommended in that respect—the thorough scrubbing of ethylene, the subsequent thorough drying of the latter by sulfuric acid, and its introduction into the reaction kettle containing the sulfur monochloride by means of filtros blocks—were finally adopted at Edgewood Arsenal.

The method of development of the process for making mustard gas was typical of the methods employed by the Research Division in working on important projects. Groups worked in the research laboratories at Washington on laboratory methods; a group worked at the same place on the development of a small plant; a group worked at Hastings-on-the-Hudson, Mr. Zinsser in charge; a group worked at the Dow Chemical Company, under the direction of Dr. A. W. Smith; and another group at Cleveland, under F. M. Dorsey. Later, the best of the processes so discovered was installed at Edgewood, along with a method used by the French and a method used by the English.

Other projects developed on a plant scale by Rowland in coöperation with Dr. Lauder Jones' organic section, were bromobenzyl cyanide, diphenylchlorarsine, a reaction product of diphenylamine and arsenic trichloride, butyl mercaptan, nitrogen peroxide, cyanogen chloride, prussic acid, etc. The "hill" was an attractive place to the chemists of the Research Division. They all wanted to work for Rowland, at least until he started working three shifts, when the work outdoors through the winter nights became less attractive.

Dr. A. W. Smith did a great deal of good work—first on cements for gas shell, then on mustard gas, and finally on the manufacture of ethylene from mineral oil. The Dow Chemical Company built a mustard gas plant at Midland, Mich., under his direction. Smith worked so hard and continually on this problem that he suffered a temporary collapse. Small amounts of mustard gas, to which he was at times exposed, affected him.

The casualty list in the Research Division was always high. It could scarcely be otherwise with hundreds of men working on new and dangerous compounds. The percentage of gas casualties was undoubtedly greater than in any other group in the army, with the exception of the Manufacturing Division at Edgewood Arsenal, under Colonel Walker. The latter struggled through this condition, finally topped by serious inroads caused by the "Flu."

LIAISON WORK WITH ENGLAND

Efforts were being made all the time to tie closer the work going on in England and France with the work in this country.

One of the efforts in this direction was the installation of an American Gas Mission in England. The logical man to head this staff was James F. Norris, and in June 1918, Norris left these shores and installed himself at London in order to keep English investigators informed of American methods and results, and to transmit results of English practice to this country. Norris received the rank of Lieutenant Colonel for this work.

Norris' counterpart in this country was Major S. M. J. Auld, later Lieutenant Colonel Auld. England showed rare judgment in her selection of chemical representatives to this country. Major Auld on Offense problems, and Major H. W. Dudley on Defense problems, are two of the "finest" Auld, at the outbreak of the war, entered the English Army and saw action at the front. He later was made Divisional Gas Officer with the Third English Army. He was next sent to this country, and became head of the British Gas Mission in the United States. He had the satisfaction of seeing the gas service in the United States develop into a real service, probably the best coordinated, smoothest working service of any of the belligerents. He did much to bring this about. Every time Major Auld met a man, the latter became his friend. His winning disposition and pleasant smile were irresistible. In addition, "he had the goods."

The English and French were, however, slow in appreciating the value of mustard gas. For some time after its use on the battlefield, accounts of its effectiveness were apparently contradictory, and reports of its efficacy did not reach this country until about December 1917. I remember asking Major Auld in October 1917 what he thought of the value of mustard gas in warfare. He replied that he felt that phosgene was much more valuable. Neither he nor we had been informed up to that time of its efficacy, and it was not until December 1917 that reports of the service the Germans were getting out of it reached us. Our first work on it was done under the direction of Dr. Norris in the fall of 1917 in cooperation with the Commercial Research Company. The process first tried was the chlorhydrin method. The next reaction tried was that between ethylene and sulfur dichloride in the presence of carbon tetrachloride. Next the ethylene-sulfur monochloride scheme was tried and adopted. The problem was solved in this country practically coincident with its solution in England.

When Norris went to England in June 1918, the position of Chief of the Offense Chemical Research Section in the Research Division was left vacant. Dr. Lauder Jones, head of the department of chemistry at the University of Cincinnati, was asked to fill the vacancy. Jones, too, is an executive and a chemist, far above the average in this respect. He always had his work well organized, always worked on the important problems, and the Chemical Offense Research Section has remained one of our most important sections. Sterling assistants in organic research have been Major Roger Adams, Major J. B. Conant, Captain W. Lee Lewis, and Captain F. H. Smyth. To Captain Lewis is due a large amount of credit for developing the new American gas, the premier of them all. Production had reached the stage where a ten-ton a day plant for its manufacture was complete when the armistice was signed. Capt. W. Lee Lewis had charge of a group on organic problems at the Catholic University, Washington, D. C. Major Tolman carried on his early work at that place, and Lieut. Colonel Bancroft maintained a research staff there continually. Too much appreciation cannot be given the Catholic University for placing its facilities at the disposal of the Research Division. Very early in the progress of the work, the facilities at the American University became inadequate. The Catholic University promptly and generously placed its facilities at our disposal, and became the largest of the branch laboratories. Too much credit cannot be given Dr. J. J. Griffin head of the chemical department at that place, for his work, interest, and cooperation.

The Offense Research Section prepared over 1600 organic compounds for examination. To succeed, that is, to be put in production, a new gas had a difficult path to traverse. It had to possess some preëminent quality for tactical military use better than its forerunners. It had to have high lethal value, be a powerful lachrymator, a good sternutator or vesicant, or perhaps pass through the German mask more easily than its predecessors. The materials for its manufacture had to be plentiful. The process of manufacture could not be too difficult, especially when the end of the war appeared in sight. Great preparations were made for the spring offensive of 1919. The list of gases finally adopted (lethal, vesicatory, sternutatory, lachrymatory, mask piercing, etc.) and under manufacture or in process of manufacture was a formidable one. It represented the research of many of the best men in the country.

TYPES OF WAR GASES

Materials can be divided into two general classes (a) time lethal substances, generally respiratory asphyxiants, and (b) neutralizing substances.

The neutralizing materials are less poisonous, but are capable of putting men out of action for shorter or longer periods of time. To this class belong lachrymators, so-called tear shell, which make the eyes water; sternutators, which cause sneezing; and eye, lung, and skin irritants, which cause more lasting effects on the eyes, produce severe respiratory distress, and blister the skin.

Chemical or absorbent fillings, like charcoal, soda-lime, sodium phenate, hexamethylamine, tetramine, caustic soda, potassium carbonate, zinc oxide, etc., absorb or neutralize such gases as chlorine, phosgene, prussic acid, chlorpicrin, mustard gas, xylol bromide, bromacetone, etc., and protect the lungs against them. Special filters had to be incorporated in the gas masks, however, to protect against finely divided toxic solids, such as diphenylchlorarsine, and protective clothing made up for protection against skin irritants like mustard gas.

GAS MASK FILTERS

It is no small task to change gas mask design on a factory scale, especially when the factory is turning out thirty or forty thousand masks per day. This was necessary, however, when the Germans first introduced toxic solids, dispersed in high explosive shell. Although their use of substances of this character produced no heavy casualties, it did mean a tremendous amount of work by the Research and Manufacturing Divisions in the United States, devising proper filter protection. These solid particles simply had to be filtered out of the air as it was breathed through the mask. We made frantic haste to get something adequate. It was easy enough to filter out the particles, but not so easy to do it with a minimum resistance through the mask. Also, with every improvement made in the mask it had to be kept in mind that not one extra ounce of weight was desirable. Rather was it the aim all through the work to reduce the size of the mask.

PROTECTIVE CLOTHING

Probably 90 per cent of the mustard gas casualties were due to skin burns; burns on the feet and legs when standing in or walking through areas shelled with the liquid, on the hands from picking up guns or other equipment, or from sitting or lying down on the ground. Therefore, complete clothing protection was desirable. Again it was easy to provide heavy, gummed or treated suits that mustard gas would not eat through or the vapors pass through, but not so easy to provide a light, comfortable suit for wear by soldiers on hot days—and mustard did its worst damage on hot days. Frequently it was thrown over on cool or cold nights. The next day when the sun came out it was vaporized and got in its work. It would follow the sun, producing high or low concentrations as the sun rose and set. Two types of suits were finally built, one a porous fighting suit, which allowed air and moisture ingress and egress, but

which absorbed mustard vapor; and another, a heavier suit, for work around mustard factories where heavy concentrations of vapor or even splashings of the liquid were to be feared.

EDITORIAL STAFF

In October 1917, Dr. Wilder D. Bancroft of Cornell University joined the staff. At first he helped keep the various branch laboratories in touch with the Washington laboratory by visits to and correspondence with those places. By this time the work of the research staff was beginning to bear fruit, and numerous reports were being issued. Bancroft, therefore, organized an editorial section, which at the present time consists of twenty assistants. This staff, under the direction of Bancroft, edited and scrutinized all reports leaving the station. A progress report was written every two weeks by the section chiefs of all their investigations. A monthly report of achievements was also prepared by them. The editorial staff prepared an answer to all reports received from England and France, showing the work done by the Research Division on problems under investigation in English, A. E. F., and French laboratories. All of these reports left the Research Division after careful scrutiny by Bancroft and his assistants. They were sent to English, A. E. F., and French laboratories, to the different divisions of the Chemical Warfare Service, and to other bureaus of the Army and Navy cooperating with us in the work. Able assistants of Bancroft in the Editorial Section were, Major Clarence J. West, formerly Associate Editor of the *Journal of Biological Chemistry* and Dr. A. M. Patterson, the first Editor of *Chemical Abstracts*.

Bancroft also organized a research group for special studies on catalysis problems, and these miscellaneous research problems included oxidation of aldehyde to acetic acid; electrolytic production of fluorine; production of tetrachlorodinitroethane, synthetic charcoal, thermal smoke precipitation, etc.

Bancroft is much at home when surrounded by a mass of data, whedding it into shape. He is, of course, well known to the chemical fraternity of this country as an investigator, editor, teacher, and lecturer. No man on the staff of the Research Division has shown a keener interest in his work, and no man has handled his end of the problems better. He divided his time between his editorial duties, his laboratory work, his committee meetings, his family, his friends, and golf. He says the golf course is the only place where people cannot find him. Wilder Bancroft served his Government well in its time of need.

DISPERSOID SECTION

After Dr. Kohler had been with the staff for some time and surveyed the situation, he created a new section called the Dispersoid Section. He wanted to find the best way of dispersing toxic solids or liquids producing a fine powder or mist to go through masks. Dr. Tolman was placed in charge of this section. The choice has been well justified. Tolman provided himself with what can be called an ideal laboratory, at least for his character of work. He had laboratory facilities, drafting facilities, an instrument shop, and stenographic facilities, all in his one building, at his own command. His particular problems were the development of so-called toxic candles, which gave off a smoke containing microscopic toxic particles for penetrating enemy masks. He also worked out the best dispersion of mustard gas in shell, made tests on the penetrability of masks by dispersoid solid substances, and in general, tried to determine the best way of serving toxic solid to the enemy. He did a first-class job. An order of four million was placed for one of the devices he worked out.

Branch laboratories by this time had been installed at Harvard, Johns Hopkins, Princeton, Ohio State, Rice Institute, University of Wisconsin, Bryn Mawr, Worcester Polytechnic, Clark University, Columbia, University of California, Cornell

University, the Catholic University, Washington, D. C., and the Pittsburgh laboratory of the Bureau of Mines.

At Clark University, Dr. C. A. Kraus worked on a new type of mask to prevent dimming of the eyepieces; on metal Dewar flasks for providing liquid oxygen to aviators, aviation engines, and submarines; on the stability of gases; on a heat interchanger for use on submarines; on boosters for gas shell, etc. This brief paragraph is small printed appreciation for his efforts. Almost all of his waking hours and that of his staff were spent on the work. An extraordinary investigator and a pleasant, charming man is C. A. Kraus.

Dr. Treat B. Johnson directed the activities of a staff of organic chemists at Yale University. He worked principally on the halogen ethers, isothiocyan ethers, on hydrogen selenide, and on certain selenocyanides. Chemists at large know how capable he is on organic problems. His laboratory was a little later getting started than some of the others, but was extraordinarily fruitful. He and his staff put their efforts into the work.

Dr. R. F. Brunel at Bryn Mawr worked principally on the preparation of diazomethane and chlor- and brom-ketones. He was assisted by three women volunteer chemists. Dr. Brunel worked at his problems during practically the whole course of the investigations. We are indebted to him for some exceedingly important results.

Dr. C. A. Boord at Ohio State University worked on mustard gas, phenylchlorarsine, diphenylchlorarsine, and on selenium and tellurium derivatives of mustard gas. The latter threatened to displace mustard for a time, so it will be appreciated how important his laboratory was and how interested we were in his work.

Dr. C. P. Baxter did a great deal of work at Harvard on physical constants of war gases, especially vapor pressure. It was absolutely necessary to know these constants for the proper use of the materials. Here again a research man, famous for his physico-chemical investigations, did the things in the chemical warfare work which he was exceedingly well equipped to undertake.

The Pittsburgh laboratory of the Bureau of Mines, under Lieut. Katz, worked on diverse problems. Among them, the effect of temperature on the absorption of gas by charcoal. For instance, charcoal absorbs cyanogen chloride only one-half as well at 40° C. as it does at 0° C. The Pittsburgh laboratory also worked on hydrogen, oxygen, and carbon dioxide detectors for submarines, on analysis of gases, etc.

Dr. Reid Hunt at Harvard University, with a staff of pharmacologists, did excellent work along toxicological lines. We were fearful that the Hun might use poisonous bullets against the American soldier and it was due to Dr. Hunt's efforts that we were ready to retaliate in kind if this became necessary.

All of these University groups worked enthusiastically and gave their best efforts. Although they suffered from some handicap because of their isolation from headquarters, they maintained a steady interest and loyalty in the work. I find myself confronted with a task, in expressing appreciation for the work of these branch laboratories, that I cannot rise to. The full story must come out in the scientific records of their work to be published later.

EXPLOSIVES RESEARCH

A section consisting of about 35 men has been devoted to explosives research, Captain G. A. Rankin in charge. Captain Rankin built up this work entirely through his own efforts. The work was done for the Ordnance Departments of the Army and Navy on combination explosive and gas shells, originating in the Research Division, on surveillance tests of explosive materials, etc. An interesting development had to do with

new work on the French explosive, anilite. As used by the French, this explosive consists of benzene and nitrogen peroxide kept in separate compartments in a two-compartment bomb. At the instant of fire, the two materials mix and explode. Rankin's work consisted of making the mixture stable enough so that the two materials could be kept in a one-compartment bomb. A small nitrating plant was also built to study nitration conditions. Work was done on rifle grenades, chlorate and perchlorate explosives, on the stability of nitro explosives, flares, starters, incendiary mixtures, etc.

MECHANICAL RESEARCH

The first work along mechanical research lines on gas masks was done by W. E. Gibbs of the Bureau of Mines. Later this work was taken up by H. H. Clark, who carried it on for several months. Gibbs and Clark devoted themselves unsparingly to their tasks. Both men brought into the new work experience gained in the Bureau of Mines on mine rescue apparatus. Clark early turned to the development of a more comfortable gas mask—a device with neither mouthpiece nor noseclip, and with non-dimming eyepieces. A modification of his early design was later adopted. Clark then went to the Ordnance Department for work on mechanical appliances in that department, and his work in the Research Division was taken over by B. B. Fogler. This work principally consisted of the designing of the various parts of the gas mask, facepieces, eyepieces, canisters, etc.

Numerous designs of gas masks were turned out. The first, of course, followed the design of the English box respirator. Next the French Tissot type was studied and for a short time thought of, and then the Akron Tissot type appeared. It was stronger in every way than the fragile French type. This type of mask has practically non-dimming eyepieces, the inhaled air entering the mask behind the eyepieces, impinging on the eyepieces, and thereby clearing them of moisture from the breath. This type of mask contains no mouthpiece or noseclip. The final design was wonderfully comfortable—a real achievement, a beautiful example of the art—a mask in which a man could fight, work, and, if necessary, sleep. The resistance to breathing through the canister was reduced from about four inches of water to less than two inches. This mask resulted from work by the Research Division and the Gas Mask Manufacturing Division under Colonel Dewey. The latter organization maintained a Development Section. This was necessary in order to modify designs, if necessary, to suit factory conditions. This Development Section worked hand in glove with the Research Division, and practically all of the developments were joint products of the two organizations. Colonel Dewey's organization invariably put the finishing touches on gas mask ideas from the Research Division, and frequently put things in production which were products of its own creation solely. Dr. R. G. Pearce of the Medical Division did wonderfully exact fundamental work on mask design from the physiological and comfort standpoint.

MANUFACTURE OF WAR GASES

In the first program the offense gases decided upon were chlorpicrin, phosgene, xylol bromide, and prussic acid. This was in July 1917. The first large-scale work on a chlorpicrin plant was done at the plant of the American Synthetic Color Company at Stamford, Conn. The first phosgene plant was started at the Oldbury Electrochemical Company's works at Niagara Falls, N. Y. The xylol bromide process was worked out with the Dow Chemical Company and the supply of prussic acid was to be furnished from sodium cyanide made by the Bücher process. Prussic acid was finally discarded from the list because of its lightness. It is difficult to build up a sufficiently high concentration of it on the ground from bursting shell. The French Government used large quantities of it in admixture with chloroform, arsenic trichloride, and stannic

chloride. They called the mixture "vincennite." The diluents were added to prevent decomposition and to make the prussic acid hug the ground. The Research Division took definite sides with the English on the subject of prussic acid. It was felt that it was of too low density for battlefield use. The French insisted that in addition to its high lethal value, it had the additional moral effect on the battlefield of killing instantly. This is so. Prussic acid either kills immediately or does no harm. Victims do not linger and die later as in the case of phosgene.

The above offense manufacturing program was started by the Research Division, under the direction of Captain (now Lieutenant Colonel) McPherson. Later it was transferred to the Ordnance Department when that department commenced a definite gas-manufacturing program. Captain (now Lieutenant Colonel) Ragsdale had charge of the work. Later it was taken over by Colonel Walker.

Huge plants for the manufacture of phosgene and chlorpicrin were built at Edgewood. The Oldbury Electrochemical Company built a phosgene plant at Niagara Falls. This was under the direction of F. A. Lidbury. It is several months now since Lidbury has appeared in Washington. He was a frequent visitor during the summer and fall of 1917. He made frantic endeavors to get from Washington to Niagara Falls or back before the Ordnance Department cancelled or modified his phosphorus or phosgene contracts. Lidbury undoubtedly has made enough phosphorus by this time to light the world. This substance remained, throughout the war, preëminently the banner smoke producer. Gas warfare may be abolished or not, but smoke screens have found a definite place in warfare. They are used in small candles to create a barrage over no man's land preceding the advance of troops or tanks, in shell to block off a portion of the enemy, and in general to keep the other fellow from knowing what you are up to. Phosphorus has 40 per cent more smoke-screening power by weight than the best substance the Research Division could find. It was confined to shell use, however. A mixture consisting essentially of zinc dust and carbon tetrachloride was used in candles for infantry use and in smoke boxes for dropping overboard from ships to screen the latter from enemy submarines. Lidbury's phosphorus plant provided tons of phosphorus for America and her allies.

A project carried on independent of the War Department by Dr. C. L. Parsons, Chief Chemist of the Bureau of Mines, was the manufacture of sodium cyanide for the war gases with a cyanogen base

SHELL LININGS

Certain lachrymators could not be stored in steel shell because of chemical action on the steel. The Research Division worked out two different types of linings. One, a lead lining, worked out with the E. B. Badger Company of Boston, Mass.; and the other, an enamel lining, developed by the Pfaucler Company of Rochester, N. Y.

INCENDIARY BOMBS

A great deal of work was done on the subject of incendiary drop bombs, shell, and darts. Of the drop bombs, a final successful type was a 100-lb. bomb, containing thermit and solid oil. Two types of darts were made. One was a non-penetrating type, weighing 5.6 oz. The other weighed 3 lbs. and had a penetrating head. Large numbers of each type were intended to be dropped from an aeroplane at once. The incendiary shell contained about 3 ft. of strands of chlorated jute rope.

NON-INFLAMMABLE SUBSTANCE FOR BALLOON GAS

It was the writer's privilege to interest Mr. Manning in the development of a non-inflammable substitute for hydrogen in balloons. This is helium and is obtained from natural gas. Thus we see a substance of academic importance only before the

war, a laboratory curiosity, finally put to an exceedingly practical use. This is often the case and is another witness of the great value of pure or academic research. Mr. Manning in turn got the support of the Army and Navy on the work. The latter was carried on by the Research Division during the summer of 1917, when it passed to the general direction of Dr. F. G. Cottrell, Bureau of Mines, and Mr. Carter, Bureau of Steam Engineering, U. S. N. Dr. W. H. Walker had charge of the work in the Research Division for a short time before becoming chief of the Chemical Service Section. The Army and Navy both became extremely interested in the work and appropriated substantial sums for its prosecution. The Navy has already announced, in Washington newspapers, the progress made on the problem. An able representative of the British admiralty informed the writer that if the Germans had had a supply of helium, England could not have coped with the Zeppelins.

NAVY PROBLEMS

Navy problems were many and diverse. They included combination gas and explosive shell, smoke boxes for dropping overboard from ships, smoke devices for generating smoke on shipboard, submarine signals to be fired from a submerged submarine to let friendly surface craft know that an allied submarine was about to emerge, submarine rifle grenades for firing signals from submarines on the surface, signal rockets of various types, toxic smoke screens, and a host of gas mask problems, including a mask that would absorb carbon monoxide. At the present writing the Research Division is supervising a plant manufacturing a carbon monoxide absorbent to fill 50,000 Navy gas masks. Another Navy problem was an aeroplane landing marker for use at night to show a descending seaplane on the surface of the water.

The Research Division handled the whole Navy signal rocket program. An interesting problem along the latter line was the development of colored dye signals for daylight use. They contained essentially a small pocket of the dye above a heating element. The latter vaporized the dye in the air, leaving a trail of blue, red, yellow, or purple smoke, or any color desired.

CHEMICAL WARFARE SERVICE

On July 1, 1918, the War Department combined the research work (carried on up to that time by the Bureau of Mines); the gas manufacturing of the Ordnance Department, Col. W. H. Walker in charge; the gas mask manufacturing of the Medical Department, Colonel Bradley Dewey in charge; the proving ground at Lakehurst, N. J., Lt. Col. Wm. Bacon in charge; the Development Division, Colonel F. M. Dorsey in charge; the Overseas Division, Brig. Gen. Amos A. Fries in charge; and created the Chemical Warfare Service, under the direction of Major General W. L. Sibert.

Letters of appreciation were received by Mr. Manning from the Secretary of War and President Wilson for his work in creating the Research Division and starting chemical warfare work in this country.¹

With this reorganization there was created a well-knit, well-functioning, well-coordinated Chemical Warfare Service. General Sibert brought with him the experience in organizing and conducting big business, gained through years of service in the War Department, and culminating in his mastery work on the Panama Canal. His motto has been production, and especially production of "mustard gas." He quickly recognized in that fearful weapon something the American troops needed, and needed badly, if we were to fight on equal terms with the Hun. The stupendous mustard project he launched proved his faith in the material. His new position gave him his first insight into chemical research. He sympathized with the work, and furthered it wholeheartedly. When the research was

finished and the demonstration made, he got busy. He brought into the work experience in army tactics gained in France, and quickly saw the merits or demerits of a proposed idea. Things he was tremendously interested in, and got, were a fighting gas mask, a mobile noiseless cylinder for wave attacks, successful candles for dispersing toxic solids, a combination explosive and lachrymatory shrapnel, a fighting mustard gas suit, an American gas preëminent over all others, etc. Things he wanted and did not get to his satisfaction were—well, I was going to mention boosters, but happened to remember that that was outside our bailiwick. I have seen him pick up a 75-mm. booster, about as large as a man's thumb, after a two hours' discussion of the problem, and practically admit that he was baffled. He wasn't, however. Finally he nailed that problem.

CHANGES IN PERSONNEL

Up to July 1, 1918, there had been a large turnover of the personnel of the Research Division. Lieut. Col. Norris had gone to England, Lieut. Col. McPherson and his staff had migrated to the Gas Manufacturing Division at Edgewood, Colonel Dewey had been placed in charge of the huge gas mask manufacturing plants, Lieut. Col. Wm. Bacon had been placed in charge of the Proving Division at Lakehurst, Col. Dorsey had been placed in charge of the Development Division at Cleveland, Col. Wm. Walker had been placed first in charge of the Chemical Service Corps, and then in charge of the Gas Manufacturing Division. Colonel Raymond Bacon had organized a staff, taken chiefly from the Research Division, and gone overseas with them for chemical work in France. A large number of men had gone to more responsible positions in France, England, and in other divisions of the Chemical Warfare Service in this country. The Research Division provided a training ground for other branches of the Service. Some of the sections in the Research Division lost as many men as they retained.

At the signing of the armistice, the Research Division at its headquarters in Washington, consisted of the following staff:

Colonel G. A. Burrell, Chief, Research Division
Dr. W. K. Lewis, In charge, Defense Problems
Dr. E. P. Kohler, In charge, Offense Problems
Dr. Lauder Jones, In charge, Offense Research
Lieut. Col. A. B. Lamb, In charge, Defense Research
Lieut. Col. W. D. Bancroft, In charge, Editorial Work and Miscellaneous Research
Major R. C. Tolman, In charge, Dispersoid Research
Major A. C. Fieldner, In charge, Gas Mask Research
Dr. A. S. Loevenhart, In charge, Pharmacological Research
Major W. S. Rowland, In charge, Small-Scale Manufacturing
Major G. A. Richter, In charge, Pyrotechnic Research
Major B. B. Fogler, In charge, Mechanical Research and Development
Captain G. A. Rankin, In charge, Explosives Research
Major Richmond Levering, In charge, Administrative Section

The branch laboratories have already been mentioned.

ADMINISTRATIVE SECTION

An important part has always been the Administrative Section. The latter included the clerks, stenographers, mechanics, accountants, purchasing agents, etc., a total of 700 people. Important because research men demand and need their service in the highest degree, and must have it quickly in war time. Mr. Manning broke every rule in the Department of the Interior when a question of speed in turning out results was involved. A heavy load was thrown on the Bureau of Mines when a personnel larger than its own staff was organized. Later we had to learn our lessons in red tape all over again, when the transfer to the War Department was made. Mr. Lauson Stone handled the administrative end of the work from August 1917 to July 1918. His work was made particularly difficult because at first it was usually a case of securing materials, chemicals, equipment, etc., by mail, express, special messenger, etc.—any way to get them—and let the Administra-

¹ THIS JOURNAL, 10 (1918), 654.

tive Section worry about the payment and other details. Stone brought with him to the work tireless energy and knowledge of government methods. He was later succeeded by Mr. (now Major) Richmond Levering. Levering is a mechanical engineer by training, and developed a device which the Ordnance Department of the Navy got extraordinarily interested in. That it was important is shown by the fact that in due time three hundred seaplanes were to be placed at his disposal.

THE ASSISTANT CHIEFS

I wish that it were possible to tell more in this article, already too long, of the sterling assistance rendered by the assistant chiefs of the various sections of the work. I have reference to such men as Major L. T. Sutherland, Captain M. C. Teague, Major Roger Adams, Major C. J. West, Capt. F. H. Smyth, Capt. J. M. Braham, Capt. A. C. Kolls, Captain R. H. Uhlinger, Mr. W. G. Abbott, Lieut. Allen Abrams, Captain R. G. Knowland, Major R. E. Wilson, Capt. P. W. Carlton, Lieut. James F. Adams, and others. These men were the right-hand assistants in sections embracing from 40 to 200 technical men. On them fell the brunt of much of the detailed work. To them is credited a great deal of originality in solving problems for straightening out harassing personnel questions, attending to the question of supplies, keeping within the bounds of departmental methods, etc.

ENLISTED PERSONNEL

I want to mention specifically the enlisted staff of the Research Division, about 900 of them—privates to first class sergeants. They were transferred from their mobilization camps to Washington to do work they were especially fitted for. Some were mustered in in Washington. Many were promoted to the commissioned grades. Many more would have been if the war had lasted longer. Every one of them wanted to go to France. Many did. Every one of them wanted a commission. Their privilege, their remuneration, their recognition were not as great as that of the commissioned personnel; but they worked hard and faithfully. Their reward lies in the fact that they served their country in its crisis and in the line in which they had been trained.

WELFARE WORK

Welfare and social work were by no means neglected. There were football, baseball, and basketball teams, a glee club, musical organizations, educational classes, etc. A weekly paper, *The Retort*, was published. This work fell under the general supervision of Mr. W. L. Dubois, who handled it remarkably well.

DEMobilIZATION OF RESEARCH STAFF

When this article goes to press, the Research Division of the Chemical Warfare Service will have been largely mustered out. The war is over. Men of the highest ability, who gave their all, often at great sacrifice, want to get back to their customary tasks. Only enough of a force will be maintained to write up and leave a clear record of the experimentation. Chemists in this war turned their talents to a task, and put their best energies into it, only because the Hun forced it on them. Germany paid dearly for her attempt at world domination through her bag of "dirty tricks." One of the latest gas attacks her soldiery suffered from was a wave cloud of 75 tons of gas. She was feeling more heavily each day this country's efforts in chemical warfare. This country was making more toxic gas per day, when the armistice was signed, than both England and France put together. This was accomplished in spite of the late start. Plants for other more fearful ones were being built. Every American soldier was supplied with an American mask. It is true that much of the effort did not bear direct fruit as far as battlefield use of the materials was concerned. The same can be said of aeroplanes, shell, tanks, "eagle boats," etc. The war did not

last long enough. But materials in large quantities were moving toward the battlefield, and Germany knew this. Hence the final hopelessness of her position—and the chemists did their share in creating this feeling of hopelessness.

PERMANENT RESULTS OF THE WORK

Out of the war, with its tremendous waste and suffering, have come many important and permanent things for humanity at large. This is especially true in this country, where the resources of the nation were not taxed to exhaustion or anywhere near it. Lessons have been taught in the aeroplane, transportation, food, and other services that will produce lasting and revolutionizing effects. The same is true of the Chemical Warfare Service. It is inconceivable, for instance, that a chemical research division with a personnel of 2000 people, and comprising much of the best talent in the country, should not leave its imprint on chemistry in this country. Organic, physical, biological, analytical chemists, etc., joined forces in one huge coöperative scheme. As a result, the organic chemist appreciated more fully the things in physical chemistry, and *vice versa*, and discovered how well the two branches working closely together could solve problems which might baffle one branch alone. Chemists learned more fully the great importance of certain branches of biological chemistry, and biologists got much from the other branches of chemistry. All learned the difficulties in the way of large-scale manufacturing, and thought about all of their results in terms of production. They appreciated more fully than ever before that usually there exists a long and tedious path between laboratory test tube experiments and a successful manufacturing process developed from those test tube results. More research has been crowded into a short space of time by one single group than ever before. Chemists from all parts of the country met for a single purpose. High-class men who had scarcely a speaking acquaintance with each other before the war became lasting friends, exchanging ideas on research, education, factory management, etc. Many young men of extraordinary latent ability have been developed, and some of the older men have shown their many colleagues that they were better adapted for and could do a first-class job along lines somewhat different from their accustomed duties. All of these things will have an important bearing on chemistry in this country. It may, indeed, constitute an epoch in the science.

The direct fruits of the work are of course adapted for chemical warfare. It is possible that gas warfare may be outlawed because of its tremendous and fearful possibilities, so that many of the devices developed for chemical warfare will never be used in the future. On the other hand, the thought that went into the development of these devices cannot be destroyed. Men received an intensive training during the development by which they will profit. It is also true that some of the results have direct and important applications to the industries. This is certainly true of gas masks, and the absorbents in gas masks can be used for a diversity of purposes. The charcoal especially is an extraordinary absorbent or catalyst for a variety of purposes. Analytical chemistry received an impetus. It is undoubtedly true that never before was so much work done in so short a space of time on the refinement of analytical methods, necessary in order to measure gases in so great dilution as one part in ten million or twenty million. The Friedel and Crafts reaction was successfully put in operation on a larger scale than ever before in this country. For every offense problem there was a defense one, and the defense problems worked out for protection of American soldiers will bear fruit in protecting American workers in the industries.

MANUFACTURE OF METHYLDICHLORARSINE¹

By R. H. UHLINGER AND R. V. COOK

Received January 4, 1919

INTRODUCTION

Methyldichlorarsine promised to be a very valuable "gas" for warfare purposes. The manufacture of 1000 to 2000 lbs. was attempted so that tests of its properties could be made. During this experimental manufacture, data were gathered looking toward the erection and operation of a large-scale plant, should the nature of the material warrant such an expenditure. This report is a detailed description of the manufacturing process used.

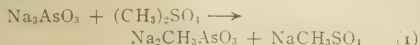
CHEMICAL DISCUSSION

Sodium arsenite is prepared by dissolving arsenic trioxide in caustic soda solution as indicated in the following reaction:

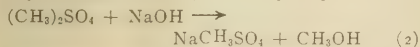


The reaction proceeds readily, considerable heat being evolved.

The solution of sodium arsenite is methylated by adding dimethyl sulfate at a temperature of 85° C.:

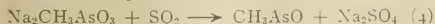


In the above reaction a considerable portion of the dimethyl sulfate is wasted, due to hydrolysis:



The products formed by hydrolysis, as indicated in the preceding reactions, are of no value as methylating agents for sodium arsenite. Some dimethyl sulfate is also lost by the formation of methyl ether. In the preliminary runs, dimethyl sulfate was added at various rates, taking from 1 to 5 hrs., but no difference was noticed in the yield of disodium methyl arsenite as shown by analysis.

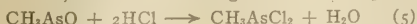
The disodium methyl arsenite is converted to methyl arsenine oxide by sulfur dioxide as indicated:



Sodium bisulfite is also formed with excess of sulfur dioxide acting on the excess of sodium hydroxide present; this is decomposed after the reduction, by adding sulfuric acid.



Methyl arsine oxide is finally converted to methyldichlorarsine by passing hydrogen chloride gas through the mixture, when the following reaction takes place:



The bisulfite is decomposed before conducting the final step in the process, as otherwise the sulfur dioxide liberated would carry off a large part of the final product. The methyldichlorarsine is obtained by distilling from the mixture and condensing. Hydrogen chloride is added until a concentration of about 20 per cent hydrochloric acid in excess is obtained; this gives a constant boiling mixture that distills without change

in composition, and tends to prevent reversal of Reaction (5). In adding hydrogen chloride it is important to keep the temperature above 85° C. at the end, in order to prevent formation of arsenic trichloride.

A two-layer mixture is obtained in distillation consisting of a lower layer of methyldichlorarsine and an upper layer of constant boiling hydrochloric acid. This is separated, and any product dissolved in the acid layer is salted out by the addition of a saturated solution of calcium chloride.

The methyldichlorarsine is finally freed from any water, methyl alcohol, and hydrogen chloride dissolved in it by distillation.

APPARATUS

The reaction vessel consisted of a 100-gal. jacketed Pfauder kettle with enamelled agitator. The cover was fitted with a hand-hole closed by a flange in which a thermometer well was inserted. There was also a sampling device in this opening which permitted sampling while the process was going on. The inlet for sulfur dioxide and hydrogen chloride was an open lead pipe reaching almost to the bottom of the kettle and connected to a Duriron T, the openings of which were closed by Duriron cocks; the side inlet of the T was used for introducing sulfur dioxide and hydrogen chloride, and the top inlet for the addition of sodium arsenite solution, dimethyl sulfate, and sulfuric acid. The vapor outlet was similarly fitted with a Duriron T and cocks; the upper opening led to a reflux condenser, the side opening to the distillate condenser. The kettle was discharged through a bottom outlet, closed by a Duriron cock. During the last month of manufacture, the Duriron cocks of this whole system were done away with and acid-proof valves used. They were made of antimony lead by the Chemical Equipment Co., of Chicago Heights, Ill. This substitution was necessary because the Duriron cocks stuck so badly they were not serviceable.

The sodium arsenite container was a 100-gal. iron drum with bottom outlet, mounted above the level of the kettle.

Sulfur dioxide cylinders were mounted on a platform scale, and connected by a manifold to the inlet tube.

Dimethyl sulfate was received in carboys, from which it was siphoned into the kettle. The carboy was mounted on a platform scale, placed above the level of the kettle.

Sulfuric acid was received in iron drums containing some 1500 lbs. The acid was pumped, by means of air pressure, into an iron tank mounted on a platform above the level of the kettle. From this storage tank it was run by gravity into the kettle.

The reflux condenser consisted of a coiled lead pipe, set in a galvanized iron can, and cooled by water or ice.

Vapors entered the bottom coil of the reflux, a sight glass being inserted in the line between kettle and condenser. The top coil of the condenser was connected to two sight bottles to observe any escape of gas from the apparatus.

The distillate condenser was a coiled 1½-in. lead pipe set in a galvanized iron can, and cooled by ice.

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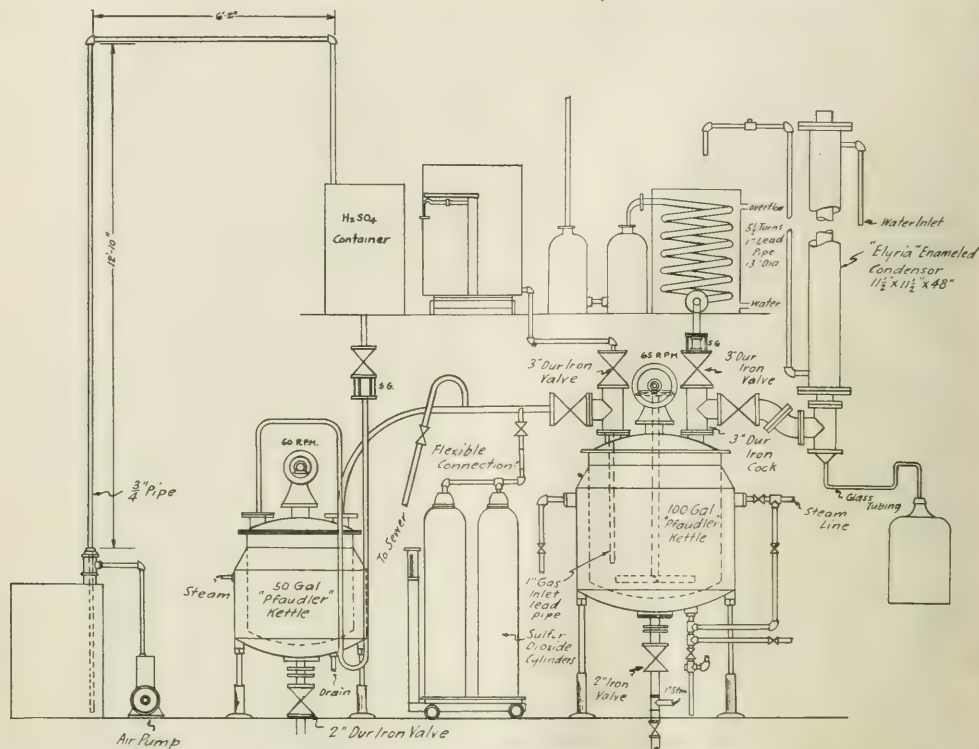


FIG. 1 - APPARATUS FOR MANUFACTURE OF METHYLDICHLORARSINE

A glass was placed between condenser and carboy, by means of which the lower layer of product was separated continuously from the acid layer.

The hydrogen chloride generator was a 50-gal. Pfaudler enamelled kettle with stirrer. The acids were added from receivers, connected to openings in the kettle through lead pipes, containing traps and sight glasses. An iron drum was used for the sulfuric acid container and a stoneware crock for hydrochloric acid; Duriron valves were used on each container. The containers were charged from carboys, from which the acid was discharged by air pressure. Spent acid was removed from the kettle through a bottom outlet, closed by a Duriron cock. This process worked splendidly until the wet gas ate holes around the top of the 50-gal. Pfaudler kettle. We then connected on an additional generating system composed of a 70-gal. fusion kettle made from 1½-in. cast iron and arranged to be heated with an oil burner. These two generation systems were so arranged that either could be used while the other was being repaired. The fusion kettle was charged with 100 lbs. of fine rock salt, closed, and heated to about 350° C. Sulfuric acid was then dripped in on the hot salt until all available hydrogen chloride had been obtained. Because of our lack of control of

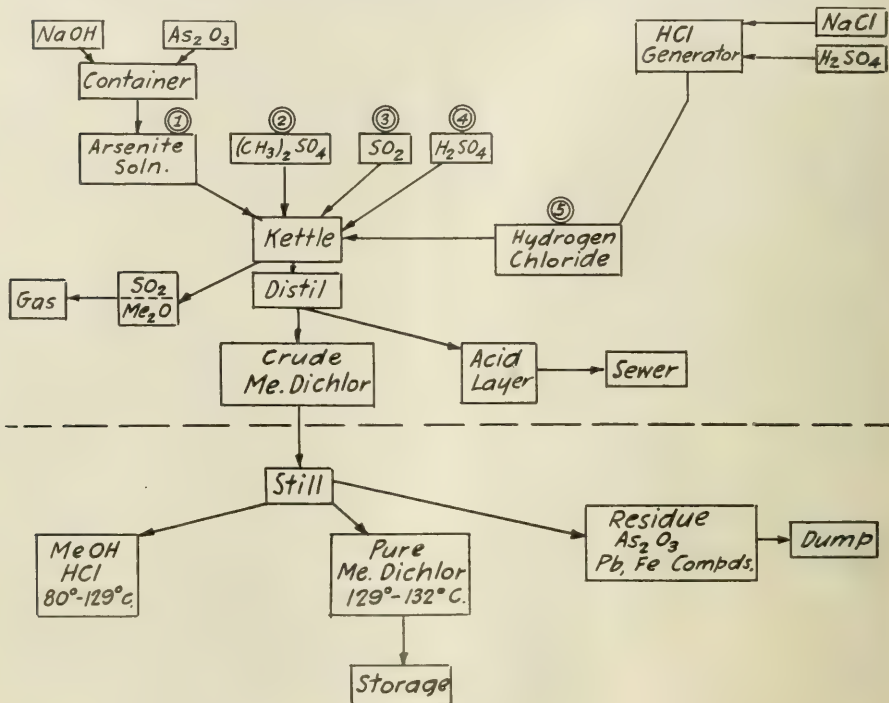
temperature, a good deal of foaming took place. This blocked the lead pipe line leading to the reaction kettle until a lead trap made very similar to a 60-gal. drum was inserted in the line. The gas entered the top of the drum on one side and went out at the top on the other. Thus any solids carried over by foaming were left in the trap. This second system of hydrogen chloride generation worked very nicely until the outlet of the kettle sprung a leak. The trouble encountered was due not to the difficulty of the problem but to the inadequacy of the apparatus provided.

The still used for redistillation of methyldichlorarsine was a 50-gal. jacketed Pfaudler kettle. Heating was effected by circulating oil through the jacket; the oil was heated in an open iron drum by means of a gas burner, and was handled by a small belt-driven gear pump. The still cover was provided with a charging inlet and thermometer well; the vapor outlet was provided with a thermometer and was piped to the condenser.

The condenser consisted of two coiled lead pipes, connected in series, and mounted in galvanized iron cans.

The condensate drained from the condenser into a receiver, consisting of a carboy.

MANUFACTURE OF METHYL DICHLORARSINE¹



	Temp. Deg. C.	Sp. Gr.	Yield Lbs.
First Fraction.....	60-127	0.82-1.71	56
Second Fraction.....	127-135	1.71-1.84	329
Residue (difference)....			50
TOTAL			435

Since 329 lbs. methylchlorarsine were obtained, the product of the last five runs was $329/435 \times 100 = 75.6$ per cent pure. This means that $87 \times 0.756 = 65.8$ lbs. of pure methylchlorarsine were obtained per run. Now the theoretical yield is 134 lbs. when calculated on the As_2O_3 as 98 per cent pure. This gives a yield of $65.8/134 \times 100 = 48.8$ per cent of the theoretical for the last 5 runs.

PRODUCTION CAPACITY

Sixty-five to 70 lbs. of product per 24 hrs. are obtained in the apparatus described. This is limited principally by the rate of production of hydrogen chloride and with a more satisfactory apparatus for the latter could be increased considerably.

METHODS OF ANALYSIS

TITRATION FOR ARSENIC—Mix a 5 cc. sample with 200 cc. water, and neutralize with hydrochloric acid, using litmus as an indicator. Add excess of sodium bicarbonate, and starch. Titrate in the cold, with $N/10$ solution of iodine in potassium iodide.

¹ Numbers refer to order in which chemicals are mixed.

COSTS

The cost of chemicals per pound of crude methylchlorarsine is calculated below:

128 lbs. caustic soda at 6.5 cts.....	\$ 8.31
84 lbs. arsenic trioxide at 10 cts.....	8.40
128 lbs. dimethyl sulfate at 75 cts.....	96.00
85 lbs. sulfur dioxide at 10 cts.....	8.50
677 lbs. sulfuric acid, 66° Be., at \$28 per ton.....	9.50
220 lbs. hydrochloric acid, 20° Be., at 3 cts.....	6.60
150 lbs. salt at \$3.75 per ton.....	0.28
10 lbs. calcium chloride at 2 1/4 cts.....	0.23
TOTAL	\$137.82

65-70 lbs. cost \$137.82
 Minimum cost = \$1.97 per lb. crude
 Maximum cost = 2.12 per lb. crude
 The cost of pure product (yield 55-59 lbs.) is:
 Minimum = \$2.33 per lb.
 Maximum = 2.50 per lb.

DETAILS OF DESIGN

REACTION KETTLE

100-gal. jacketed Pfaudler
 Agitator—Speed 65 R. P. M.
 Gas inlet—1 in.

REFLUX CONDENSER

Diameter—13 in.
 5 1/2 turns of 1 in. lead pipe

DISTILLATE CONDENSER

Elyria enamelled—3 in. diam. \times 10 ft.Later used $1\frac{1}{2}$ in. lead-coil condenser

HYDROCHLORIC ACID CONTAINER

25-gal. stoneware crock

HYDROGEN CHLORIDE GENERATOR

50-gal. jacketed Pfaudler kettle

Agitator—Speed 60 R. P. M.

STILL

50-gal. jacketed Pfaudler kettle

Oil container—50 gal. drum

Burner—1 in. gas line

Condenser—2 in series—13 in. diam.— $5\frac{1}{2}$ turns
of 1-in. lead pipe

This investigation was started at the American University Experiment Station of the Bureau of Mines and was continued under the Research Division of the Chemical Warfare Service.

SMALL SCALE MANUFACTURING SECTION
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MANUFACTURE OF ARSENIC TRICHLORIDE¹

By R. C. SMITH

Received January 4, 1919

Arsenic trichloride has occupied an important place as an intermediate in the manufacture of several toxic gases in connection with the Research Division, Chemical Warfare Service, at the American University Experiment Station, Washington, D. C. At first three general methods were considered for the preparation of this compound:

- 1—The action of dry chlorine gas on arsenic metal
- 2—The action of hydrochloric acid on arsenic trioxide
- 3—The action of sulfur monochloride on arsenic trioxide

This latter method was selected as the most practical because of the simplicity of the process, the small amount of apparatus required, the short time necessary to complete the operation, and the high yields of almost pure product.

The reaction employed in the manufacture is indicated below:



With the proper temperature control the reaction proceeds with no difficulty. It is necessary that the arsenic trioxide be as dry as possible. The commercial supplies of raw materials proved satisfactory.

The reaction was carried out in a 75-gal. unjacketed cast-iron kettle heated directly by a gas burner. Agitation was effected by means of a stirrer operated at 60 R. P. M. The bottom of the kettle was provided with a 2-in. outlet closed by a cap. The top was provided with a hand-hole for charging the solid material. A thermometer well was inserted for obtaining the temperature of the mixture. The vapor during the reaction and the distillation passed through a 2-in. opening in the cover connected to a T, the outlets of which led to the condensers. A sight glass and iron stop-cock were inserted between the reflux condenser and the kettle. A 2-in. iron gate-valve was inserted be-

tween the distillate condenser and the kettle. The upper end of the reflux was connected to the bottom of a 4-in. lead tower filled with stones, over which water was allowed to run; this served to absorb the sulfur dioxide formed in the reaction.

Forty-six pounds of arsenic trioxide were charged through the hand-hole, which was then closed. The kettle was heated until the temperature inside reached 95° to 100° C., at which temperature the sulfur monochloride starts to reflux. This usually took about 45 min. At intervals of 5 to 10 min. during this heating 200 to 300 cc. sulfur monochloride were added. The heat of reaction is very great and the addition of the sulfur monochloride greatly assisted in bringing up the temperature. The sulfur monochloride was run in by gravity from a 30-gal. iron drum mounted on a platform balance above the reaction kettle. This container held enough for one complete run and was filled from the supply drums by means of a small Roco pump. The sulfur monochloride could thus be weighed as it was added. A sight glass inserted in the line just before it entered the reaction kettle enabled us to estimate the rate of adding the sulfur chloride. Agitation was started as soon as the mixture was sufficiently fluid.

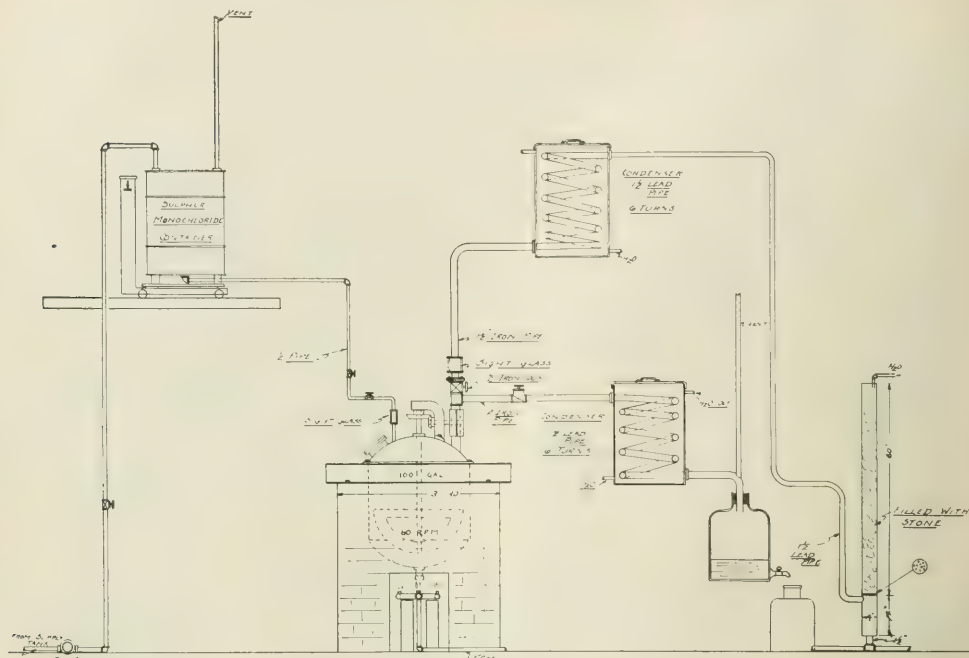
When the temperature of the mixture reached 95° to 100° C., the gas was turned off and the sulfur chloride allowed to run in at such rate as to produce a moderate refluxing. The temperature of the mixture rose to 120° to 125° C. The sulfur dioxide formed in the reaction passed up through the reflux condenser and was absorbed in the scrubber and carried away with the wash water.

The sulfur chloride was stopped when 89.5 lbs. had been added, and as soon as refluxing stopped the hand-hole was opened and 138 lbs. more arsenic trioxide added and the pot closed again. Heat was then applied to bring the temperature up to 95° to 100° C. and the sulfur chloride started again; 158.5 lbs. more sulfur chloride were added to complete the reaction. Care was taken to keep the arsenic trioxide in excess in order to prevent the product from being contaminated with sulfur chloride.

When the reaction was complete, heat was applied to the kettle, the reflux condenser cut off, the distillate condenser opened, and the distillation begun. The distillate was collected in a 10-liter aspirator bottle and drawn off into bottles or other containers. The first 25 to 50 lbs. arsenic trichloride was usually slightly colored and was saved to be redistilled. The remainder of the product was water white and averaged 99 per cent pure. The temperature of the mixture was 140° C. when the distillation began and did not rise until the product was nearly all distilled. Then the temperature gradually rose to 200° C., at which temperature the distillation was stopped. Above this temperature very little distillate comes over and it is yellow in color. The distillation required about 3 hrs. The average yield was 300 lbs. arsenic trichloride.

The residue in the kettle was discharged after cooling slightly, by unscrewing the cap on the bottom outlet. This residue consisted of molten sulfur containing a

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APPARATUS FOR MANUFACTURE OF ARSENIC TRICHLORIDE

trace of arsenic trioxide. If opened when too hot, the sulfur residue is liable to take fire.

The charge of arsenic trioxide was divided into two parts in order to use agitation during as much of the process as possible. The first charge required about $1\frac{1}{2}$ hrs. to complete and the second charge about 3 hrs. The total time of operation was between $7\frac{1}{2}$ and 8 hrs.

Based on the amount of sulfur chloride used the yield was 93 per cent of product averaging 99 per cent pure.

The first distillate which was always colored was decolorized by redistilling with a small amount of arsenic trioxide.

This investigation was started under the Bureau of Mines at the American University Experiment Station and was continued under the Research Division of the Chemical Warfare Service.

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ORIGINAL PAPERS

THE DETERMINATION OF CADMIUM BY THE HYDROGEN SULFIDE METHOD

By EDWARD SCHRAMM

Received August 12, 1918

I—INTRODUCTION

In the course of some cooperative work on the determination of small quantities of cadmium in brass it was found that varying results were obtained by several laboratories. A diversity of methods is in current use, most of which do not appear to have been tried out on materials of known composition.¹ The present work was accordingly undertaken with a view to developing a convenient and reliable procedure for this determination, and to ascertaining what degree of

accuracy is to be expected. To accomplish these aims, analyses were made of brasses with cadmium additions and of salt mixtures of known composition. The hydrogen sulfide precipitation was chiefly employed for the necessary separations, and accordingly the work became primarily a study of the most suitable conditions for separating a small amount of cadmium from other metals by this method.

Structural brasses may contain, besides the principal constituents, copper and zinc, one per cent or more of tin, and varying quantities of lead, iron, manganese, arsenic, and other metals, which may have been added intentionally or introduced accidentally as impurities in the copper or zinc. Very little has been published on the determination of cadmium in brass, but its determination in spelter has been the subject of a

¹ Two methods have been described in considerable detail in the second edition of Price and Meade, "Technical Analysis of Brass," pp. 229-233.

considerable amount of work, part of which will be briefly reviewed.

II—REVIEW OF LITERATURE

H. J. S. Sand¹ studied the electro-analytical separation of the metals by the graded potential method. The separation of cadmium from zinc was performed in acetate solutions containing free acetic acid.

J. J. Fox² separated cadmium from zinc as sulfide in the presence of trichloroacetic acid. This method is said to obviate the difficulty experienced in determining the proper concentration of mineral acid necessary for the complete precipitation of cadmium sulfide, uncontaminated with zinc sulfide, and to abolish the many solutions and reprecipitations necessary to purify the cadmium sulfide.

W. D. Treadwell and H. S. Guiterman³ found that the hydrogen sulfide separation gave better results in sulfuric than in hydrochloric acid solutions, less zinc being carried down. They recommended that the solution should be 4–5 *N* in sulfuric acid, and that hydrogen sulfide should be passed into the hot solution until it is cold. Treadwell and Guiterman also carried out the separation electrolytically, using oxalate or sulfate solutions; with the latter they found that 0.04 to 0.2 g. of cadmium could be separated from fifty times the amount of zinc.

E. J. Ericson⁴ separated cadmium from zinc by successive hydrogen sulfide precipitations in sulfuric and trichloroacetic acid solutions. The same author has described a separation of zinc from cadmium depending on the crystallization of zinc sulfate.⁵

W. Cooper⁶ dissolved 5 g. of zinc in dilute sulfuric acid and passed hydrogen sulfide into the cold solution. The precipitate was filtered off and dissolved in hydrochloric acid and bromine water, sulfuric acid was added, and the solution evaporated to the appearance of fumes. After filtering out any lead sulfate the process was repeated twice, and the cadmium was finally weighed as sulfide after drying at 100°.

A procedure commonly used in this country is the standard method of the American Society for Testing Materials.⁷ This consists briefly in dissolving 25 g. of drillings in dilute hydrochloric acid until nearly all the zinc has been dissolved. The residue, presumed to contain all the cadmium, is dissolved in nitric acid and evaporated with sulfuric acid to the appearance of fumes to remove the lead. The filtrate is diluted to 400 cc., 10 g. of ammonium chloride added, and hydrogen sulfide is passed in. It is occasionally necessary to start the precipitation of the cadmium sulfide by the addition of a drop or two of ammonia. The impure cadmium sulfide is filtered out by means of a Gooch crucible and is dissolved by boiling for 1/2 hr. with 1 : 5 sulfuric acid. The solution is filtered, diluted to 300 cc., and the cadmium sulfide reprecipitated. This may be repeated a third time. The cad-

mium sulfide is dissolved in hot dilute hydrochloric acid (1 : 3), and finally converted to sulfate and weighed as such.

III—GENERAL CONSIDERATIONS

Obviously none of the methods above outlined can be adopted as such for the determination of cadmium in brass because of the tin and the large amount of copper present. After the removal of these elements, any of the methods and especially the last, with certain modifications, may be taken as a guide to the further separation. The precipitation of the copper and cadmium together as sulfides followed by extraction with boiling dilute sulfuric acid has been employed by some analysts, but seemed a clumsy operation because of the great quantity of copper present. The best procedure therefore appeared to be the electrolytic separation of the copper from nitric acid solution, preceded by removal of the tin as metastannic acid. It is better to remove tin than lead at the start since the former is much more likely to contaminate the cadmium in subsequent operations. After the removal of the copper, the standard method of the American Society for Testing Materials was applied with certain changes in detail, and with the additional precaution of treating the cadmium sulfide with ammonium polysulfide before the final conversion to sulfate.

A brief consideration of the vital steps in the process outlined will assist in determining whether it will accomplish the desired separations, and in fixing suitable details.

We should not expect any deposition of cadmium during the electrolytic separation of the copper. With the very small concentrations of cadmium in question, a high potential would be required for its deposition under the most favorable conditions. It is well known that the concentration of nitric acid here employed (about 3 per cent) will prevent the separation of cadmium even from strong solutions. As an added precaution, the electrolysis should never be carried on long enough to cause much reduction of nitric acid, and should be stopped before all the copper is deposited.

The second vital step in the method is the precipitation of cadmium with hydrogen sulfide and its separation from zinc. In a solution of hydrogen sulfide¹ we have the following relation between the ions:

$$[H^+]^2 \times [S^{2-}] = K_2 = 1.1 \times 10^{-23}$$

The concentration of the sulfide ion is inversely proportional to the square of the concentration of the hydrogen ion. Now for the precipitation of cadmium sulfide to occur we must have

$$[Cd^{++}] \times [S^{2-}] > K_{Cas},$$

where K_{Cas} represents the solubility product constant of cadmium sulfide. Obviously, the larger the value of S^{2-} (hence the smaller the value of H^+), the smaller will be the concentration of Cd^{++} remaining in solution in equilibrium with the precipitated sulfide. If, however, the value of S^{2-} is made too large, the solubility product of zinc sulfide will be exceeded and we

¹ *J. Chem. Soc.*, **91-2**, 373-410; **93-4**, 1572-92.

² *Ibid.*, **91** (1907), 964-7.

³ *Z. anal. Chem.*, **52**, 459-70.

⁴ *Eng. Min. J.*, **87**, 1036.

⁵ *This Journal*, **9** (1917), 670.

⁶ *Chem. News*, **110** (1914), 280-1.

⁷ *This Journal*, **7** (1915), 547.

¹ Stieglitz, "Qualitative Analysis," **1**, 199, *et seq.*

shall fail to effect a separation. We therefore seek to regulate the acidity so as to permit cadmium but not zinc to come down. In the standard method for spelter (starting with a 25 g. sample) this is done by dilution to 300 or 400 cc. Now in diluting in this way, while we increase $S =$ we at the same time decrease Cd^{++} . It would therefore appear better to keep the solution as concentrated as possible in cadmium and regulate the acidity by other means than dilution. Moreover, since for a given hydrogen-ion concentration the concentration of cadmium in solution is fixed, the more dilute the solution the more cadmium will escape precipitation. To put the same proposition in another way—if we start with a 10 g. sample and precipitate in a volume of 100 cc., the percentage loss will be no greater than starting with 40 g. and precipitating in a volume of 400 cc., provided the acidity is the same in both cases. By using a smaller sample, therefore, we should lose nothing in the ability to separate cadmium, avoid the trouble of removing the large amount of copper, and greatly simplify manipulations. With a 10 g. sample 0.01 per cent cadmium will give 0.0019 g. of cadmium sulfate which can be weighed with sufficient accuracy.

The third important question concerns the freedom from contamination of the cadmium sulfide, and the means taken to purify it. The repeated precipitations in regulated acid solution insure complete separation from zinc, iron, and manganese, while the boiling with dilute sulfuric acid accomplishes separation from small amounts of copper and lead not removed during electrolysis. Finally, the treatment with ammonium polysulfide removes any sulfides of tin, arsenic, or antimony which would not have much effect on the color of the precipitate. (This precaution appears in most cases unnecessary, since these elements can be separated in previous operations. If, however, a great amount of tin were originally present it is safer to adopt it.) It is considered by some that the alkaline sulfide treatment results in loss of cadmium, but Noyes¹ has shown in his "System of Qualitative Analysis" that it is possible to treat 500 mg. of cadmium sulfide with ammonium polysulfide and not find any cadmium in the filtrate. However, it must be recognized that cadmium sulfide has a tendency to go through the filter in the colloidal condition, but this can be avoided by adding ammonium chloride, as recommended by Noyes, and in carrying out the final precipitation in small volume. Under these conditions the cadmium sulfide does not go into the colloidal condition and can safely be treated with ammonium polysulfide.

IV—EXPERIMENTAL RESULTS

The first method used, based on the principles discussed above, was as follows:

Dissolve 10 g. of brass in 75 cc. of nitric acid (1:1) and boil for 30 min. Filter off the metastannic acid, dilute to 350 cc., add 10 cc. of sulfuric acid (1:1), and electrolyze till nearly all the copper is removed and the lead deposited on the anode as peroxide. The solution is then treated as in the standard method for spelter, except that precipitations are made in smaller volume, and that a final treatment with ammonium polysulfide is employed.

To test the method, analyses were made of several brasses with and without additions of cadmium. The results are given in Table I.

SAMPLE NO.	Cadmium Added Per cent	Cadmium Found Per cent	Added Cadmium Recovered Per cent
1.....	0.0	0.007	
	0.016	0.025	0.018
2.....	0.0	0.034	
	0.020	0.049	0.015

Determinations of cadmium on 10 samples of manganese bronze were carried out, the results ranging from 0 to 0.034 per cent. On several of these, duplicates were run and good checks obtained.

Some time after the experiments just described had been completed, the matter of cadmium determinations again came up, and the work was resumed in an effort, if possible, to simplify the manipulations. My attention was called to the complication caused by the presence of arsenic. In working on a sample containing 0.15 per cent arsenic and low in cadmium the original method was modified in several respects. In the first precipitation with hydrogen sulfide, ammonia was added till zinc began to come down. Only one treatment with 1:5 sulfuric acid was employed. The second precipitation of sulfides (containing much of the arsenic) was extracted with cold dilute hydrochloric acid (1:1), the arsenic sulfides remaining unattacked. After a third precipitation with hydrogen sulfide, the solution was evaporated to dryness with sulfuric acid and the first weighing of cadmium sulfate made directly. As a check in some cases the cadmium was again taken into solution, reprecipitated as sulfide, and the latter purified as before.

To test this modified procedure a mixture of salts was made up containing 6 g. of copper, 3.5 g. of zinc, and 0.1 g. each of tin, manganese, iron, lead, and arsenic. This mixture was run as a blank and with graded additions of cadmium. The results of these experiments are given in Table II and some analyses of brasses in Table III.

TABLE II—ANALYSES OF SALT MIXTURES CONTAINING Cu, Zn, Pb, Fe, Mn, As, AND Sn

Cadmium Added Per cent	Cadmium Found Per cent	Difference Per cent	
		Actual	Mean
0.00	—	—	0.000
0.01	0.008	—0.002	
0.01	0.013	—0.003	0.000
0.02	0.015	—0.005	
0.02	0.019	—0.001	—0.003
0.03	0.024	—0.006	
0.03	0.030	0.000	—0.003
0.04	0.035	—0.005	—0.005

TABLE III—ANALYSES OF BRASSES

MATERIAL	Cadmium Found Per cent
Arsenical Brass.....	0.013
	0.013
	0.014
Brass A.....	0.054
	0.057
Brass B.....	0.020
	0.019
Brass C.....	0.027
	0.022
Brass D.....	0.021
	0.022

The results in Table II on salt mixtures show that the values obtained are within 0.005 per cent of the true cadmium content and that they tend to be slightly

¹ Technology Quarterly, 19, 274.

low rather than too high. This is what one would naturally expect, since there are a number of precipitations and filtrations, with opportunity in each operation for a slight loss of cadmium, by solution as well as by mechanical loss. Brasses can be run with at least the same degree of accuracy, since the salt mixtures used contained a greater proportion of possible interfering substances that is likely to be met with in an ordinary brass. Table III shows that excellent agreement can be obtained. As a final check, and to guard against the possibility of the results obtained being due to a balancing of errors, the cadmium sulfate residues from the salt mixtures, as well as from the brasses, were carefully examined. They were pure white and completely soluble in water. The combined solutions failed to give any test for interfering substances which could conceivably have been present.

The procedure for determination of cadmium in brass as finally adopted is as follows:

Dissolve 10 g. in 75 cc. of nitric acid (1:1). Boil the solution $\frac{1}{2}$ hr. and filter off metastannic acid. Dilute to 350 cc. which should bring the concentration of nitric acid to about 3 per cent. Add 10 cc. of sulfuric acid (1:1) and electrolyze with a current of 4 amp., using rotating anode, until the copper is nearly all removed, which should take about $2\frac{1}{2}$ hrs. Siphon off the electrolyte, add another 10 cc. of sulfuric acid, and evaporate over night nearly to dryness. Dissolve in 100 cc. of water, neutralize with ammonia, add 5 cc. of 1:1 sulfuric acid, pass hydrogen sulfide into the cold solution 30 min. until the sulfides settle. Add ammonia until zinc begins to come down and pass in hydrogen sulfide 30 min. more. Filter, using water containing ammonium chloride and hydrogen sulfide to wash the precipitate out of the beaker. Boil the precipitate 15 min. with 20 cc. of 1:5 sulfuric acid, maintaining the volume by adding water occasionally. Filter and wash, keeping the volume down to 50 cc. Add 5 cc. of strong ammonium hydroxide, pass in hydrogen sulfide $\frac{1}{2}$ hr., adding ammonia until the cadmium begins to come down. Filter and treat the precipitate with a little cold hydrochloric acid (1:1). Neutralize the solution with ammonia and add 5 cc. of 1:5 sulfuric acid, keeping the volume down to about 30 cc. Pass in hydrogen sulfide as before and add ammonia to start the precipitation of the cadmium. Filter, dissolve the cadmium sulfide on the filter in a little 1:1 hydrochloric acid. Collect the solution in a weighed platinum or porcelain dish, add 1 cc. of sulfuric acid, evaporate to fumes, and add a little concentrated nitric acid. Evaporate carefully to dryness and finally weigh as sulfate. If there is any possibility of the presence of tin, dissolve the cadmium sulfate in 25 cc. of water and 5 cc. of 1:5 sulfuric acid and reprecipitate with hydrogen sulfide, adding a little ammonium chloride to the solution. Let the sulfide settle, decant through a filter, add a little ammonium polysulfide and ammonium chloride to the precipitate in the beaker, warm for several minutes, and pour through the filter. If there is any turbidity, refilter until the solution comes through clear. Finally dissolve the cadmium sulfide in hydrochloric acid and proceed as before with the evaporation and weighing.

In conclusion, it will be well to call attention to certain possible sources of error and important precautions to be observed. Because of the mass of salts present, the first precipitation with hydrogen sulfide must be made in a somewhat larger volume than the later precipitations, *i. e.*, under less favorable conditions. Two means are taken to counteract this. A small part of the copper is allowed to remain in solu-

tion after electrolyzing and the copper sulfide precipitated tends to act as a carrier and bring down the cadmium. In addition the acidity is reduced so as to permit the precipitation of part of the zinc, under which condition the solubility of cadmium sulfide is greatly lowered. In later precipitations the volume of solution is so small that the cadmium sulfide forms readily, and the acidity can be so regulated as to effect a separation from zinc without any great proportion of the cadmium remaining in solution. It may sometimes happen, however, if the concentration of hydrogen ion is too small, that some zinc will come down with the third precipitate of cadmium sulfide. This can usually be detected by the color of the precipitate or by the appearance of the cadmium sulfate residue, and when it occurs a fourth precipitation must be made.

Finally, it must be remembered that cadmium sulfide is insoluble in a solution containing 2 or 3 per cent sulfuric acid only when the solution is saturated with hydrogen sulfide. Such solutions, however, are unstable and if allowed to stand in an open beaker, gradually lose their hydrogen sulfide. As a result of the removal of the sulfide ion the solubility product of cadmium sulfide is no longer exceeded, the reaction is reversed, and finally all of the cadmium goes back into solution. On the other hand, if insufficient time is allowed, the cadmium sulfide remains in a colloidal condition and runs through the filter. As pointed out above, the presence of ammonium salts tends to coagulate the sulfide, which can be successfully filtered under the conditions described. If any runs through, a second filtration will suffice to retain it. In case it is desired to allow the precipitate to stand, the solution must be placed in a tightly stoppered vessel or in communication with a hydrogen sulfide reservoir so that equilibrium may be established between the solution and a definite pressure of the gas.

It is doubtless through neglect to consider one or several of the conditions dwelt on in this paper that low results for cadmium have been sometimes reported.

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THE DETERMINATION OF PHOSPHORUS IN VANADIUM STEELS, FERROVANADIUM, NON-VANADIUM STEELS, AND PIG IRON

By CHAS. MORRIS JOHNSON

Received July 12, 1918

I—METHOD FOR STEEL CONTAINING VANADIUM UP TO 2.6 PER CENT

Ibbotson and Brearley, in 1902,¹ recommended that phosphorus be precipitated from the *reduced* solution of vanadium, using ferrous sulfate as a reducing agent, claiming thereby to aid in the precipitation of phosphorus when vanadium is present.

Cain and Tucker, in 1913,² recommended that the vanadium present be reduced with ferrous sulfate and sulfurous acid for the same purpose.

¹ "Analysis of Steel Works Materials."

² THIS JOURNAL, 5 (1913), 647.

The method here described gives a successful and convenient method for complete precipitation of phosphorus in the presence of highly oxidized vanadium:

Place 1.63 g. sample in 150 cc. beaker. Dissolve in 45 cc. HNO_3 (1.13 sp. gr.) over a low flame. When solution is clear and brown fumes have been driven off, add 3 cc. KMnO_4 solution; boil 3 min.; then add 3 cc. FeSO_4 solution to dissolve precipitate due to the excess permanganate; boil until brown fumes are gone. Avoid large excess of ferrous sulfate.

Add 40 to 50 cc. conc. HNO_3 (1.42 sp. gr.); bring to a boil; rinse cover and sides of beaker with least amount of distilled water; then add 50 cc. of the water solution of ammonium molybdate. Stir vigorously for a minute or two and let stand over night.

Decant through a 7 cm. paper, placing a little paper pulp in apex of filter, keeping the main precipitate in the beaker. Wash iron out of filter by washing 15 times with the nitric wash, then proceed to pour the main precipitate onto filter.

Transfer all of precipitate as far as possible, with the aid of the nitric wash. Add about 2 cc. of wash to the beaker and remove adhering particles with a rubber-tipped glass rod. Use separate beaker for catching washings. Wash 15 times with the dilute nitric wash; then 25 times with KNO_3 wash, or until the outside of the filter has no sour taste, especially along the double thickness.

Place filter containing washed precipitate in 150 cc. beaker; add enough standard NaOH solution to cause the yellow color of the precipitate to disappear on macerating the paper to a pulp with a rubber-tipped stirring rod. Dilute to about 30 cc. with distilled water; add a drop of phenolphthalein solution, which should cause a deep red coloration, otherwise more standard NaOH solution is needed; then titrate back carefully with standard HNO_3 solution until the pink just disappears. Subtract total cc. of acid used from total cc. of alkali used. The difference in cc. $\times 0.01$ = percentage P.

TABLE I—SHOWING EFFECT OF INCREASING AMOUNTS OF NITRIC ACID (1.42 Sp. Gr.) ON PHOSPHORUS RECOVERY¹

Vanadium Added Per cent	15 cc. HNO_3 Added P found	30 cc. HNO_3 Added P found	40 cc. HNO_3 Added P found	50 cc. HNO_3 Added P found
None	0.121	0.121	0.121	0.121
0.20	0.119	0.121	0.120	...
0.40	0.114	0.118	0.121	...
0.60	0.111	0.117	0.120	...
0.80	0.110	0.116	0.121	...
1.00	0.110	0.115	0.120	0.119
1.40	0.110	0.112	0.121	0.122
1.80	0.105	0.112	0.119	0.121
2.20	0.099	0.111	0.119	0.120
2.60	0.093	0.108	0.117	0.117

¹ This work was done with 1.63 g. samples of U. S. Bureau of Standards, 0.120 P standard, 106.

REMARKS—The tests with the higher vanadium content were more tardy in precipitating than the lower ones, though all settled well after 40 min. standing. Those to which 15 cc. conc. HNO_3 were added gave deep orange precipitates, darkening in color about in proportion to the vanadium content, clinging tightly to the stirring rods and beakers. The three highest vanadiums are lower in yield of phosphorus than the preceding ones because of the impossibility of detaching the adhering precipitate from the stirring rods.

Those with 30 cc. conc. HNO_3 were an improvement in speed of precipitation, color of precipitate, and cleaning from beakers and rods. Those with 40 cc. and 50 cc. showed the best colored precipitates, i. e., nearest the normal yellow phosphomolybdate color and gave water-white washings, from which no recoveries of phosphorus were made. The 50 cc. ones were a little prompter than the 40 cc. though both sets were

a vast improvement over the 15 cc. and 30 cc., and both cleaned very easily from beakers and rods and gave good results.

The precipitate from the 15 cc. conc. HNO_3 in particular seemed to be too finely divided and passed through the pores of the filter, necessitating reprecipitation of the washings in all those of higher vanadium content.

The vanadium was added as nitrate from an acid solution made as follows: Fuse 4.5 g. V_2O_5 (56.14 per cent V) with 10 g. Na_2CO_3 in a platinum crucible for 10 to 15 min. Let cool; place in a 400 cc. beaker; add 10 cc. water; then HNO_3 (1.20 sp. gr.) until effervescence ceases and 25 cc. in excess. Rinse off crucible thoroughly with distilled water; cool solution to room temperature; transfer to 500 cc. flask; dilute to the mark with water; stopper, and shake to mix thoroughly. 1 cc. = 0.00505 g. V. 1 per cent V in 1.63 g. sample = 3.25 cc. solution.

The vanadium was added after the tests were weighed and before the 45 cc. HNO_3 (1.13 sp. gr.) were added. The vanadium was, in each instance, reduced from yellow to green due to the action of the reducing gases liberated by the reaction between the acid and the steel. The 40 to 50 cc. conc. nitric added just before removing from the fire caused the yellow vanadic color to return.

SOLUTIONS REQUIRED—*Nitric Acid for Titrating*—Dilute 35.4 cc. HNO_3 (1.42 sp. gr.) to 4000 cc. with distilled water.

Stock Solution of Sodium Hydroxide—Dissolve 150 g. NaOH (c. p. sticks) and 1 g. $\text{Ba}(\text{OH})_2$ in 1000 cc. water. Stir well and allow to stand 24 hrs. Filter off the clear solution (or decant if preferable) and dilute with an equal volume of distilled water. Put into a 2-liter bottle and close with a rubber stopper.

Sodium Hydroxide Solution for Titrating—Dilute 566 cc. stock solution to 8000 cc. with distilled water.

Ferrous Sulfate Solution—Dissolve 55 g. steel (low in phosphorus and sulfur) in 1000 cc. beaker in 720 cc. H_2SO_4 (1 : 3). Add a little water occasionally to prevent salting out, and heat gently, but do not boil. Filter, cool, and dilute to 1000 cc.

Concentrated Potassium Permanganate Solution—Dissolve 50 g. KMnO_4 in 1000 cc. water.

Nitrate Wash—Dissolve 8 g. KNO_3 in 8000 cc. water.

Acid Wash—Dilute 102.4 cc. HNO_3 (1.42 sp. gr.) to 8000 cc. with water.

Faintly Ammoniacal Water Solution of Ammonium Molybdate—Into each of four 800 cc. beakers weigh 55 g. ammonium molybdate and 50 g. ammonium nitrate, and add 40 cc. ammonium hydroxide (0.95 sp. gr.). Dilute each to 700 cc. with water. Heat for about 30 min., stirring once in a while until all salts are in solution. Combine contents of the four beakers by pouring into a large bottle; then dilute to 4000 cc. with water. Let stand over night. Filter the insoluble material through double 15 cm. papers. *Do not wash.* The clear solution thus obtained should remain clear indefinitely. Do not filter out the in-

soluble material until the total mixture from the four beakers has stood over night.

II—METHOD FOR PHOSPHORUS IN U. S. STANDARD STEELS AND PIG IRONS TO WHICH HAVE BEEN

ADDED 28 PER CENT VANADIUM AND IN FERRO-VANADIUM CONTAINING 56.7 PER CENT VANADIUM

PROCEDURE—Weigh out 0.5 g. steel and 0.5 g. V_2O_5 (56.14 per cent V). Transfer to 250 cc. porcelain dish. Digest with a mixture of 30 cc. HCl (1.20 sp. gr.) and 30 cc. HNO_3 (1.42 sp. gr.) for about 1 hr.; then rinse off cover, add 100 cc. HNO_3 (1.42 sp. gr.), and take to dryness. Bake 5 min. at $750^\circ C$. in an electric muffle furnace.

Dissolve the oxides in 35 cc. conc. HCl, evaporate to 10 cc.; add 50 cc. HNO_3 (1.42 sp. gr.), take to 10 cc. volume, then add 10 cc. more strong nitric and heat awhile with cover glass on. Filter through a platinum Gooch crucible with a thin pad of acid-washed asbestos, using suction. Wash 15 times, using the following wash: 200 cc. HNO_3 (1.42 sp. gr.), 100 cc. water, and 20 g. $Fe(NO_3)_3$. Ferric nitrate made by dissolving 5 g. low phosphorus, melting bar steel in 50 cc. HCl (1:1) and taking to syrupiness twice with 50 cc. HNO_3 (1.42 sp. gr.) each time).

Concentrate the filtrate from the separated V_2O_5 to 10 cc. in 150 cc. beaker and filter out the second crop of vanadium "rust" as before. A third concentration to 10 cc. should show no "rust" (V_2O_5).

To the third concentration add 40 cc. HNO_3 (1.42 sp. gr.), and bring to a boil; rinse cover and sides with water and precipitate with 50 cc. of the faintly ammoniacal ammonium molybdate solution. Stir vigorously for about 2 min. Let stand one hour; filter and wash as described for steels containing up to 2.6 per cent V. Titrate with alkali and acid in the usual manner.

TABLE II—RESULTS OBTAINED USING THIS METHOD ON U. S. STANDARDS

No.	Standard	V_2O_5 Added Mg.	P Found Per cent	Per cent 2 Given by U. S. Govt.
1	Iron D, 6a V_2O_5	500	0.522	0.526
2	Iron D, 6b V_2O_5	500	0.531	0.531
3	10b V_2O_5	500	0.124	0.120
4	10b V_2O_5	600	0.115	0.120
5	No. 20 Std. V_2O_5	500	0.033	0.031
6	No. 20 Std. V_2O_5	600	0.033	0.031

In the above procedure an average of 0.007 per cent P was found in the V_2O_5 added.

TABLE III—PHOSPHORUS IN FERROVANADIUM, 56.7 PER CENT VANADIUM

Author's Method by Removal of about 7/10 of V with Faintly Ammo- niacal Ammonium Molybdate Solution	V_2O_5 reduced with $FeSO_4$ and H_2SO_4 Prtn. with Acid Molybdate Solu- tion. No V re- moved	Per cent P	Per cent P	Faintly Ammoniacal Molybdate Prtn. (1.42 sp. gr.) No V removed
Per cent P	Per cent P	Per cent P	Per cent P	
0.414	0.240	0.053	0.185	
0.418	0.232	0.108	0.183	
0.397	0.235	...	...
0.401	0.228	...	...
...	0.234	...	...
...	0.260	...	...
...	0.220	...	...

III—METHOD FOR DETERMINING PHOSPHORUS IN NON-VANADIUM STEELS AND PIG IRON USING A FAINTLY AMMONIACAL WATER SOLUTION OF AMMONIUM MOLYBDATE

PROCEDURE—Weigh 1.63 g. sample into 150 cc. beaker. Dissolve in 45 cc. HNO_3 (1.13 sp. gr.) over low flame. (In case of pig iron and certain chrome steels, when all metal is in solution filter off carbon residue through 7 cm. paper; wash 15 times with dilute HNO_3 , wash, catching filtrate in 150 cc. beaker. Concentrate filtrate to original volume.)

Add about 3 cc. of the $KMnO_4$ solution, boiling for 3 min., then just enough $FeSO_4$ solution (about 3 cc.) to dissolve the oxides of manganese. Boil off brown fumes. Add 15 cc. HNO_3 (1.42 sp. gr.). Rinse cover and sides of beaker with least amount of water, add 50 cc. ammonium molybdate solution, and stir briskly until phosphorus precipitate is completely formed (about 2 min. stirring). Let stand $\frac{1}{2}$ hr. or less. Filter through 7 cm. paper; wash 15 times with dilute HNO_3 ; wash; then with nitrate wash until the outside fold of the filter has no sour taste. In case of high phosphorus samples this may mean as much as 35 or 40 times.

(The washings in such a case were kept separate from the main filtrate, concentrated to 10 cc., acidified with 15 cc. conc. HNO_3 , and 50 cc. of the ammonium molybdate solution added. It was then allowed to stand over night. There were no recoveries, showing the insolubility of the precipitate in the wash.)

TABLE IV—COMPARING RESULTS OBTAINED WHEN USING FAINTLY AMMONIACAL WATER SOLUTION WITH THOSE OBTAINED BY USE OF A NITRIC ACID SOLUTION OF AMMONIUM MOLYBDATE¹

SAMPLE No.	Slightly Ammoniacal Water Solution of Molybdate Per cent P found	Nitric Acid Solution of Ammonium Molybdate Per cent P found
9.....	0.054	0.056
34.....	0.023	0.023
7132.....	0.019	0.018
3622.....	0.056	0.054
1.....	0.013	0.014
2.....	0.058	0.058
4.....	0.042	0.044
5.....	0.052	0.052
70.055.....	0.055	0.052
80.042.....	0.042	0.044
x, pig.....	0.736	0.730
r, steel.....	0.006	0.004
3641.....	0.050	0.049
34.....	0.025	0.025
39.....	0.058	0.056
Pig Iron Std. A.....	0.097	0.096

TABLE V—SHOWING RESULTS OF TESTS ON U. S. GOVT. STANDARDS

SAMPLE	P Found Per cent	U. S. Bureau P Value Per cent
Pig Iron, D, third set.....	0.610	0.602
Pig Iron, B 6a.....	0.104	0.105
Pig Iron, D 6a.....	0.540	0.545
Steel, 10b.....	0.119	0.120

This method is the same as the one published by the author in *Iron Age*, April 5, 1917, except that it was afterwards found that more rapid precipitation of the yellow precipitate was secured by the addition of 15 cc. of concentrated nitric acid (or 30 cc. 1:1 acid is safer to handle) to the boiling solution of the sample just before removing from the fire to add the molybdate solution; and 1.13 sp. gr. HNO_3 is used instead of 1.20 as the steels in general dissolve more rapidly in the 1.13 acid.

ADVANTAGES OF THE FOREGOING METHODS FOR ORDINARY ROUTINE WORK ON PLAIN AND OTHER STEELS

1—The simplicity of the preparation of the faintly ammoniacal water solution of ammonium molybdate as compared with the elaborate method of preparing the old acid molybdate solution in nitric acid.

2—The handling of the acid molybdate is disagreeable, hard on the clothing and fingers of the operator and on table tops. The slightly ammoniacal water solution is harmless in these particulars.

3—As stated, the slightly ammoniacal water solution keeps as clear as distilled water after it has been properly filtered; and its precipitating power is constant, whereas the old acid solution soon becomes turbid and therefore its precipitating power is continuously lessened.

¹ See *Iron Age*, April 5, 1917.

4—The interference of vanadium up to at least 2.6 per cent V in the determination of phosphorus is prevented in a simple way and the true phosphorus is obtained from ferrovanadium containing the very high vanadium content of 56.7 per cent.

ACKNOWLEDGMENT

Credit is due Mr. F. D. Hawkins for his careful analytical work when making the trial analyses required by the author to prove the foregoing.

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SOME MIX-CRYSTALS OF CALCIUM FERRITE AND ALUMINATE

By EDWARD D. CAMPBELL
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About five years ago in an article on "The Constitution of Portland Cement Clinker,"¹ some experimental evidence was given to show that the formation of Portland cement clinker comprises essentially a series of solutions of certain silicates and lime in a magma which is fluid at the clinkering temperature and serves as a solution in which the recrystallization of the basic silicates characteristic of Portland cement takes place. As early as 1897 Törnebohm had applied the term celite to the magma in which the crystalline portions of the clinker were imbedded, and states that this fusible magma promoted the crystallization of the alite, as the basic silicates were termed. Prior to 1913 no satisfactory method for separating celite from alite had been described, but in the article above referred to a method was given for separating the celite present in clinker at different temperatures, and it was further shown that the celite of ordinary Portland cement clinker consists essentially of a mixture of calcium aluminate and ferrite in which both ortho-calcium silicate and lime are soluble, the solubility of these being a function of the temperature of the fluid solution.

In an article on "Synthetic Celite and Large Crystals of Tricalcic Silicate,"² it was shown that if pure silica, alumina, and calcium oxide were mixed in the same molecular proportions as those in which they had been shown to exist in the celite previously obtained from Portland cement clinker and the liquid mixture was very slowly cooled, the tricalcic silicate crystallized out in large thin plates, thus demonstrating that it was the aluminate which constitutes the solvent in which the crystals had formed.

In a third paper on "The Function of Ferric Oxide in the Formation of Portland Cement Clinker,"³ it was shown that if a mixture of pure silica, ferric oxide, and calcium oxide of the same molecular proportions as those found in the celite drawn off from the Portland cement clinker is melted and slowly cooled, large crystals of tricalcic silicate will separate, thus demonstrating that calcium ferrite may act as a solvent for both calcium silicate and lime in a manner almost exactly similar to that of the calcium aluminate.

As early as 1909, Shepherd, Rankin, and Wright⁴

showed the existence of a definite calcium aluminate of the empirical formula $5\text{CaO} \cdot 3\text{Al}_2\text{O}_3$, and gave the melting point in a pure state as 1386°C ., which was lowered by the addition of a small amount of CaO to 1382° . In a later publication by Rankin and Wright¹ the melting point of pure $5\text{CaO} \cdot 3\text{Al}_2\text{O}_3$ is given as 1455°C ., which is first lowered by the addition of lime to 1395° , and then gradually raised as the concentration of the solution increases until, when the concentration reaches that of the empirical formula $3\text{CaO} \cdot \text{Al}_2\text{O}_3$, it has reached 1535° . In formulating a hypothesis of the formation of clinker by recrystallization of the basic silicate, assumption was made that the aluminate which acted as a solvent was the one having the empirical formula $5\text{CaO} \cdot 3\text{Al}_2\text{O}_3$ and also, although there was no experimental evidence to support it, that since it had been shown that tricalcic silicate could be crystallized from calcium ferrite as easily as it could from calcium aluminate, probably a calcium ferrite of the empirical formula $5\text{CaO} \cdot 3\text{Fe}_2\text{O}_3$ might exist and function exactly like that of the $5\text{CaO} \cdot 3\text{Al}_2\text{O}_3$.

In a "Preliminary Report on the System Lime-Ferric Oxide,"² Sosman and Merwin seem to have demonstrated pretty clearly the probable existence of only two calcium ferrites having the formulas, the dicalcic ferrite, $2\text{CaO} \cdot \text{Fe}_2\text{O}_3$, and the monocalcic ferrite, $\text{CaO} \cdot \text{Fe}_2\text{O}_3$.

In the present investigation, the experimental work of which was carried out by W. C. Kwong, B.S.E., there were two points on which it was hoped to secure some additional information: the first was to re-determine the existence or non-existence of a calcium ferrite of the empirical formula $5\text{CaO} \cdot 3\text{Fe}_2\text{O}_3$; and the second, to obtain some experimental evidence as to what is formed when a mixture of calcium oxide, ferric oxide, and alumina is melted and then cooled at a rate slow enough to permit the material to be nearly in equilibrium during the entire cooling period.

MATERIALS USED

Kahlbaum's purest analyzed calcium carbonate and ferric oxide were used as the source of CaO and Fe_2O_3 , the Al_2O_3 being the purest available ignited oxide, giving by analysis 99.60 per cent Al_2O_3 . These materials were thoroughly dried at about 105° before being accurately weighed in molecular proportions prior to mixing and melting.

The mixture to be melted was placed in a flat-bottom cylindrical platinum crucible 48 mm. in diameter and 55 mm. deep, having a capacity of about 100 cc. Enough material was used for each experiment to give from 75 to 92 g. of the final melt. It was usually necessary to heat the mixture in two lots over night to a temperature of about 1100° in order to shrink it sufficiently to enable the entire charge to be put in the crucible before melting. During the melting and cooling the crucible was covered, first with the platinum cover on which was placed enough ignited magnesium oxide to fill the concavity of the cover, and then with a pure magnesium oxide crucible cover. This arrange-

¹ THIS JOURNAL, 6 (1913), 627.

² *Ibid.*, 6 (1914), 706.

³ *Ibid.*, 7 (1915), 835.

⁴ *Am. J. Sci.*, 28 (1909), 293.

¹ *Am. J. Sci.*, 39 (1915), 1.

² *J. Wash. Acad. Sci.*, 6 (1916), No. 15.

ment was made in order to prevent a too rapid loss of heat during cooling by upper radiation from the surface of the liquid melt.

The meltings, slow cooling for crystallization, and subsequent treatment for absorption of liquid constituents were all carried out in a modified Meker furnace which has given very satisfactory results in this laboratory for similar work carried on for the past four years. During the time a sample was being melted and slowly cooled for crystallization, the temperature was measured by means of a platinum-rhodium thermocouple protected by means of a fine closed Marquart tube, the bead of the thermo-couple being placed within 2 mm. of that portion of the crucible containing the fused material. The thermocouple was standardized, before using, at the melting point of pure silver taken as 961°C .

In making slow coolings for crystallization, the sample was first allowed to heat over night, this usually bringing the temperature to 1100° . In the morning, blast was put on and the temperature raised until it had reached the point from which it was desired to begin slow cooling. When the thermocouple indicated the maximum temperature, this was held for $1\frac{1}{4}$ to $1\frac{1}{2}$ hrs., after which the gas supplying the burner was very gradually reduced so that the temperature would fall at the rate of 25° per hr. Although the temperature recorded could not of course be claimed to represent the absolute temperature to within less than 5° , a variation of about 1° could be observed, and when readings were recorded every 15 min. it was possible to hold to a time-temperature schedule so that at any time during the 6 to 8 hrs. of slow cooling the temperature indicated was within 2° to 3° of that desired. After crystallization had been completed, the gas was turned off and the furnace allowed to cool over night before removing the crucible. When the melt in the crucible was cold, it was removed by means of a hardened steel drill in the form of pieces which could be used for subsequent work.

The absorption of pure magnesia discs of those components which were liquid at a given temperature was carried out in a manner somewhat similar to that used heretofore for the same purpose. Two discs, each about 4 cm. in diameter and 15 mm. thick, made of pure magnesium oxide burned at 1550° , were first accurately weighed and then stacked in a pure magnesium crucible, 5 cm. inside diameter and 55 mm. deep. The bare wires of a standardized platinum-rhodium thermocouple were then led through fine slits sawed in the upper edge of the crucible and the wire bent in such a way that the bead of the thermocouple rested on the surface of the upper disc. Accurately weighed pieces of the material to be treated, in most cases from 9 to 14 g., were placed on the upper magnesia disc, and a third somewhat smaller disc was placed on top of the pieces to weight them down in order to insure good contact and absorption by capillary action. The cover was then placed on the magnesia crucible and the whole allowed to heat over night, the temperature in the morning usually being 1100° . Experience showed that when the fur-

nace had come to equilibrium the inner couple, which was in direct contact with the absorbing disc, usually indicated a temperature about 25° lower than that of the couple in the annular space just outside the magnesia crucible. The temperatures of absorption recorded in this work are those shown by the inner couple which was in direct contact with the absorbing disc and material under treatment. In making absorptions of the pure ferrite, E_5 and E_6 , the temperature was raised gradually over a period of 3 hrs. from 1100° to 1300° and was then held constant for 5 hrs. longer. In all the other absorptions the temperature was raised within less than an hour from about 1100° to that at which it was desired to carry on the absorption, and then held constant for 8 hrs., after which the furnace was allowed to cool over night. During the period the temperature was supposed to be held constant, it did not vary more than 5° in any case. When the material was cold, the pieces were removed from the disc and the amount which had been absorbed was determined from the loss of weight.

Analyses of the absorbed material were made by dissolving nearly the entire upper absorption disc and taking aliquot portions such that each would contain about 0.4 g. of the absorbed material. The results reported were all obtained by means of at least two closely agreeing determinations. Blank analyses were made on the absorption disc to correct for the small amount of ferric oxide and alumina contained in the magnesium oxide which was free from calcium oxide. The correction required did not exceed 0.005 g. for 6 g. of the magnesia.

The temperature ranges through which the different samples were cooled at the rate of 25° per hr. in order to facilitate crystallization are shown in Table I:

TABLE I		Range of Slow Cooling
MATERIAL		
E_1		1525° down to 1375°
E_2		1525° down to 1375°
E_3		1575° down to 1375°
E_4		1575° down to 1400°
E_5		1475° down to 1275°

By heating accurately weighed portions of the original crystallized materials on the magnesia discs, they could be quantitatively separated into crystals remaining unabsorbed on the discs and the portion absorbed by the discs at the given temperature. Analyses could then be made of the two portions and the effect of absorption studied.

The first three samples prepared consisted of calcium ferrite alone. The first, E_5 , had the empirical formula $5\text{CaO} \cdot 3\text{Fe}_2\text{O}_3$, or equally well, $2(2\text{CaO} \cdot \text{Fe}_2\text{O}_3) + \text{CaO} \cdot \text{Fe}_2\text{O}_3$. A section of this material showed it to be made up of large, very dark brown, tabular crystals embedded in a nearly opaque magma from which they had evidently crystallized. E_6 had the empirical formula $6\text{CaO} \cdot 3\text{Fe}_2\text{O}_3$ or $3(2\text{CaO} \cdot \text{Fe}_2\text{O}_3)$. A section of this material showed it to consist apparently entirely of the large, dark brown crystals which constituted a portion only of E_5 . E_3 had the empirical formula $8\text{CaO} \cdot 3\text{Fe}_2\text{O}_3$ or $3(2\text{CaO} \cdot \text{Fe}_2\text{O}_3) + 2\text{CaO}$. Samples of E_5 , E_6 , and E_3 were finely ground and pats made, as in testing Portland cement, to determine

whether the ferrites were hydraulic and for indications of the presence of free lime. All three set on mixing with enough water for normal consistency, E_3 and E_6 taking initial set in from 14 to 22 min. and final set in about three-fourths of an hour. On subjecting the pats, after standing in moist air for 24 hrs., to the action of boiling water, E_3 and E_6 remained sound and free from cracks, E_8 being somewhat harder than E_3 ; but E_8 soon completely disintegrated in boiling water, indicating the presence of a considerable amount of free lime.

On heating a sample of E_8 for 5 hrs. at 1300° there was a loss of weight of 20.5 per cent, the unabsorbed crystals remaining on the magnesia discs constituting 79.5 per cent of the original weight. On submitting a sample of E_8 to the same conditions, the loss of weight by absorption was only 0.80 per cent. Analysis of the material absorbed in the case of E_8 showed it to contain 26.94 per cent CaO and 73.06 per cent Fe_2O_3 . If this is assumed to be a mixture of monocalcic ferrite, $CaO \cdot Fe_2O_3$, and dicalcic ferrite, $2CaO \cdot Fe_2O_3$, the absorbed material would be made up of 93.78 per cent monocalcic ferrite and 6.22 per cent dicalcic ferrite. The crystals remaining on the absorption disc gave, by analysis, 38.87 per cent CaO and 61.07 per cent Fe_2O_3 . Assuming these crystals also to be made up of monocalcic and dicalcic ferrites, they would be composed of 15.26 per cent monocalcic with 84.74 per cent dicalcic ferrite. Since one would expect a certain proportion of the liquid solvent to adhere to the surface of the crystals, it is only reasonable to assume that the crystals themselves are probably pure dicalcic ferrite. The very small amount, 0.80 per cent, absorbed in the case of E_6 would go to indicate that this latter consisted wholly of dicalcic ferrite. The results obtained on E_3 , E_6 , and E_8 may thus be taken to confirm the work of Sosman and Merwin, and their statement that the monocalcic ferrite and dicalcic ferrite are the only two definite compounds of lime and ferric oxide.

In a previous paper on "The Formation of Tricalcic Aluminate,"¹ it was shown that if a mixture having the empirical formula $4CaO \cdot Al_2O_3$ is very slowly cooled from $1600^\circ C.$, at which temperature probably nearly all the lime would be in solution, calcium oxide crystallizes out as the temperature is lowered, the concentration of the solution thus becoming decreased with falling temperature, but no large crystals of tricalcic aluminate could be observed in a section of the final material. The hypothesis was advanced that tricalcic aluminate was not, strictly speaking, a stable phase, but was probably either a saturated solid solution of CaO in $5CaO \cdot 3Al_2O_3$, or this latter aluminate with four molecules of lime of crystallization. In order to see whether tricalcic aluminate could be obtained in large crystals, provided there was no excess of lime to form crystals of calcium oxide, thus impoverishing the liquid solution and preventing the formation of large crystals, a mixture, G_8 , having the empirical formula $8CaO \cdot 3Al_2O_3$ was made. This mixture was melted and cooled at the rate of 25° an hour from 1575°

to 1400° . That the absence of any crystals of calcium oxide will permit the solution to be supersaturated, thus inducing the crystallization of tricalcic aluminate, is strikingly shown in Fig. 1, which is a photograph, just slightly less than the natural size, of the crucible containing the melt as it was taken from the furnace.

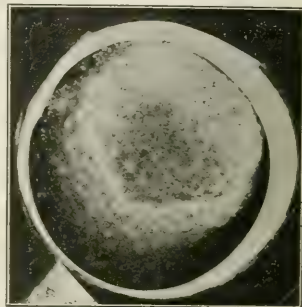


FIG. 1

A sample of G_8 , consisting of three pieces weighing 10.3026 g., was held for 8 hrs. at 1450° . The crystals from which the fluid magma had been drawn off by the capillary action of the magnesia disc, weighed 7.1132 g., thus constituting 69.0 per cent of the original material. The fluid magma absorbed by the magnesia disc thus constituted 31.0 per cent of the whole. Fig. 2 shows, in natural size, the crystals from which the fluid magma had been drawn out by the action of the magnesia disc on which they rested during the absorption.

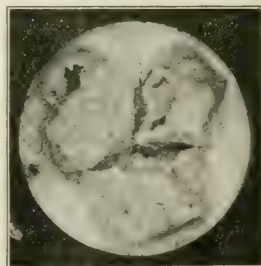


FIG. 2

Analysis of the crystals showed them to contain CaO, 61.86 per cent, and Al_2O_3 , 37.93 per cent. This would give an empirical formula $2.98 CaO \cdot Al_2O_3$, or corresponding almost exactly with that of the tricalcic aluminate. The material absorbed by the magnesia disc gave, by analysis, CaO, 53.64 per cent, and Al_2O_3 , 46.36 per cent. This would give a molecular ratio of 2.11 CaO to one Al_2O_3 . The percentage composition of the material absorbed at 1450° is in very close agreement with that shown in the lime-alumina diagram of Rankin and Wright¹ for the composition of material having the melting point of

¹ THIS JOURNAL, 9 (1917), 943¹ Am. J. Sci., 39 (1915), 1.

1450°. Fig. 3 is a section of G_3 magnified 100 diameters and shows very clearly the general structure of the large crystals of tricalcic aluminate and the embedding magma in which they formed.

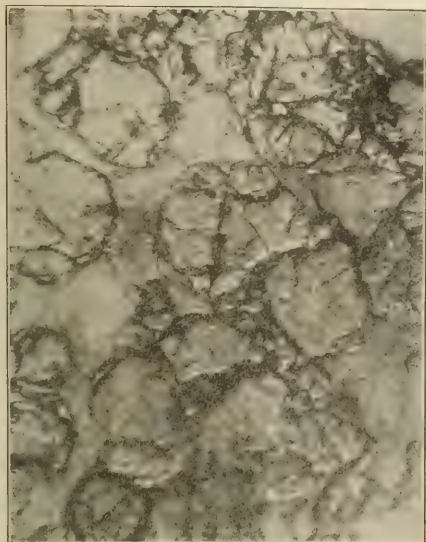


FIG. 3—SECTION OF G_3 MAGNIFIED 100 DIAMETERS

An EG_3 sample was prepared from a mixture of G_3 and E_3 taken in such proportion that one-fourth of the R_2O_3 was Fe_2O_3 and three-fourths was Al_2O_3 . While the general formula of EG_3 would be $8CaO \cdot 3R_2O_3$, it might be expressed as $9(3CaO \cdot Al_2O_3) + 2(2CaO \cdot Fe_2O_3) + CaO \cdot Fe_2O_3$. This mixture was melted and finally cooled at the rate of 25° an hour from 1475° down to 1275°. A previous melting and slow cooling, which was stopped at 1375°, showed that at this latter temperature too large a portion of the material was still liquid so that a second crystallization was made at lower temperature.

A pat made from EG_3 showed that it, like the other samples, was hydraulic, but the pat on being submitted to the usual boiling test completely disintegrated, thus showing the presence of free lime.

A section of EG_3 showed it to consist apparently of large, light brown crystals embedded in a very dark brown, almost black, magma from which they had apparently crystallized. The appearance of this section of EG_3 magnified 100 diameters is shown in Fig. 4. A comparison of the sections illustrated in Figs. 3 and 4 shows that while the size and general form of the large crystals are much alike, the appearance of the EG_3 crystals is very suggestive of that of certain pearlitic or sorbitic steel in which certain solid solutions on slow cooling have separated into two components.

Four absorption tests were made on samples of EG_3 . In the first test the sample was held for 8 hrs.

at 1300°, but on examining the material after the furnace was cold, no sign of any melting or absorption could be observed. In the second test, the same sam-

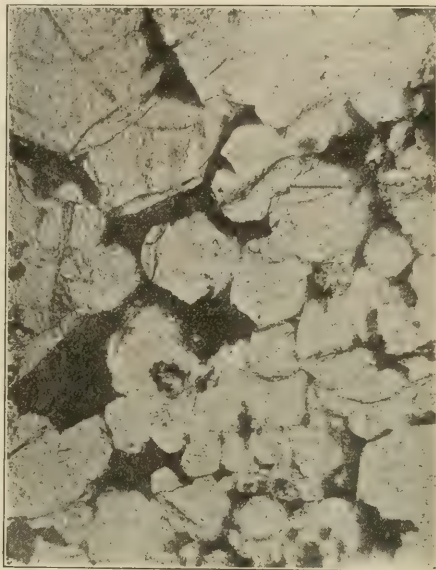


FIG. 4—SECTION OF EG_3 MAGNIFIED 100 DIAMETERS

ple was used and the temperature was increased to 1400° and held again for 8 hrs. The crystals remaining on the absorption disc at 1400° were a uniform light brown in color and constituted 40.9 per cent of the original weight. The portion which was liquid at 1400° and absorbed by the disc was therefore 59.1 per cent of the original. In the third absorption test the temperature was held for 8 hrs. at 1350°, but the amount of material absorbed was so small that it produced only a slight stain on the upper surface of the absorption disc. The fourth absorption was made by raising the temperature to 1370°, at which it was again held for 8 hrs., the same sample as that previously heated to 1350° being used in this test. The crystals remaining on the absorption disc after heating for 8 hrs. at 1370° constituted 72.3 per cent of the original material, while the magma, liquid at 1370° and absorbed by the disc, made up 27.7 per cent of the whole. An examination of the crystals showed that they were made up of two distinct kinds, one portion light brown in color like those remaining on the disc after the absorption at 1400°, the other portion made up of crystals which were very dark brown in color, almost indistinguishable from the magma in which they had formed. In order to get a separation of the light brown from the dark brown crystals, the mixture was carefully crushed and, after removing the very fine powder, was poured into methylene iodide and stirred. The pure, dark brown crystals, having a specific gravity greater than that of

TABLE II

	Per cent Original Material	Weight Per cent—			Molecular Per cent—			CaO R ₂ O ₃	R ₂ O ₃		8R ₂ O ₃	
		CaO	Fe ₂ O ₃	Al ₂ O ₃	CaO	Fe ₂ O ₃	Al ₂ O ₃		Fe ₂ O ₃	Al ₂ O ₃	Fe ₂ O ₃	Al ₂ O ₃
E ₈ Original.....	100.0	36.91	63.09	...	62.50	37.50	...	1.67	1.00	...	8.0	...
E ₈ (a) Absorbed at 1300° C.....	20.5	26.94	73.06	...	51.26	48.74	...	1.08	1.00	...	8.0	...
E ₈ Crystal at 1300° C.....	79.5	38.37	61.07	...	64.48	35.52	...	1.82	1.00	...	8.0	...
E ₈ Original.....	100.0	41.26	58.74	...	66.67	33.33	...	2.00	1.00	...	8.0	...
E ₈ Original.....	100.0	48.36	51.64	...	72.73	27.27	...	2.67	1.00	...	8.0	...
G ₈ Original.....	100.0	39.40	...	40.60	72.73	...	37.27	2.67	...	1.00	...	8.0
G ₈ Absorbed at 1450° C.....	31.0	53.64	...	46.36	67.84	...	32.16	2.11	...	1.00	...	8.0
G ₈ Crystal at 1450° C.....	69.0	61.86	...	37.93	74.83	...	25.17	2.98	...	1.00	...	8.0
E ₆ Original.....	100.0	56.19	15.00	28.81	72.73	6.81	20.46	2.67	0.25	0.75	2.0	6.0
E ₆ (a) Absorbed at 1370° C.....	27.7	46.95	32.51	20.54	67.39	16.43	16.18	2.07	0.50	0.50	4.0	4.0
E ₆ Dark cryst. at 1370° C.....	24.0	56.25	21.88	21.95	74.02	10.11	15.87	2.85	0.39	0.61	3.0	5.0
E ₆ Light cryst. at 1370° C.....	48.3	56.15	10.20	27.55	76.85	4.44	18.71	3.31	0.19	0.81	1.5	6.5
E ₆ (a) Absorbed at 1400° C.....	59.1	50.79	23.96	25.25	69.53	11.51	18.96	2.28	0.38	0.62	3.0	5.0
E ₆ Crystal at 1400° C.....	40.9	64.46	6.70	29.05	77.91	2.85	19.24	3.53	0.13	0.87	1.0	7.0

(a) Points on composition-temperature diagram, Fig. 5.

methylene iodide, settled to the bottom, while the pure, light brown crystals and those having a small amount of the dark crystals adhering to them would float. The mixture of crystals was thus separated into two portions which were washed with benzol and dried before making the analyses. The light brown crystals recovered by flotation with methylene iodide constituted 48.3 per cent of the original, while the dark brown crystals made up 24.0 per cent of the same. The small proportion of dark brown adhering to the light brown crystals recovered at 1370° would account for the increased proportion of these, 48.3 per cent as compared with 40.9 per cent of pure light brown crystals, recovered at 1400°, and also for the smaller ratio of Fe₂O₃ to Al₂O₃ in the latter crystals.

The results of all analyses are summarized in Table II, in which are also given the molecular per cents, the molecular ratio of CaO to one R₂O₃, the proportion of Fe₂O₃ and Al₂O₃ in one R₂O₃, and, finally, the proportion of Fe₂O₃ and Al₂O₃ in eight molecules of R₂O₃.

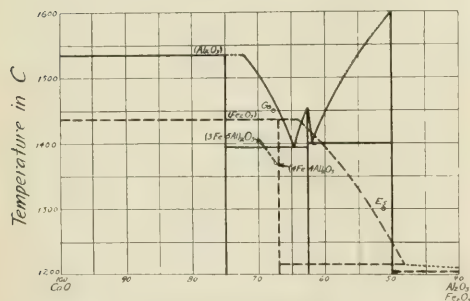
Composition-Temperature Diagram of
the Systems CaO-Fe₂O₃ and CaO-Al₂O₃

FIG. 5

In the article by Sosman and Merwin,¹ previously referred to, they give a composition-temperature diagram for the system CaO-Fe₂O₃ in which the ordinates represent the melting points and the abscissas the molecular per cents of CaO and Fe₂O₃. In the paper on "The Ternary System CaO-Al₂O₃-SiO₂,"² Rankin and Wright give a concentration-temperature diagram for the system CaO-Al₂O₃, in which the ordi-

nates show the melting points, but in which the abscissas represent the composition in weight per cent rather than in molecular per cent, as shown in Sosman and Merwin's diagram. Fig. 5 is a composition-temperature diagram in which the ordinates represent the melting points and the abscissas the molecular per cents of CaO and R₂O₃, in which diagram the curve for the pure ferrites is taken from Sosman and Merwin's diagram, while that of the pure aluminates is computed from the data given by Rankin and Wright.

A study of the data given in Table II and of the diagram shown in Fig. 5 would seem to lead to the following conclusions:

I—That the statement that the dicalcic ferrite and the monocalcic ferrite are the only definite compounds of CaO and Fe₂O₃ is correct.

II—That pure tricalcic aluminate may be recovered by crystallization from a solution of CaO in 5CaO·3Al₂O₃ as a solvent, provided the concentration of CaO at the beginning of the crystallization is less than that which would be required to form tricalcic aluminate with all the Al₂O₃ present.

III—That if a solution with the empirical formula 8CaO·3R₂O₃, containing both Fe₂O₃ and Al₂O₃ in the molecular proportion of 2 to 6, be slowly cooled, mix-crystals with Fe₂O₃ and Al₂O₃ in the ratio 1 to 7 crystallize out until the Fe₂O₃-Al₂O₃ ratio in the solution has been increased to 3 to 5.

IV—That when the Fe₂O₃·Al₂O₃ ratio has been increased until it has become 3 to 5, mix-crystals of this latter ratio crystallize out, producing a further increase in the Fe₂O₃·Al₂O₃ ratio until at about 1370° it has become 4 to 4.

V—That the aluminates in which part of the Al₂O₃ is replaced by Fe₂O₃ are capable of holding in solid solution less calcium oxide than the pure aluminates, as indicated from the boiling test on E₆s and the abnormally high ratio of 3.53 CaO to 1 R₂O₃ in the crystals recovered at 1400°, since the crystals of free lime present would remain mixed with the crystals of aluminate recovered at 1400°.

The experiments described herein suggest a possible explanation of the general formation of many minerals which apparently consist of mix-crystals which are formed in a slowly cooling magma.

¹ J. Wash. Acad. Sci., 6 (1916), No. 15.² Am. J. Sci., 39 (1915), 1.

A STUDY OF THE FATTY ACIDS OBTAINED FROM VARNISH OILS AND FROM VARNISHES

[PAPER NO. I.]

By W. T. PEARCE

Received June 13, 1918

This work was undertaken with the object of finding methods for estimating China wood and other oils that are being substituted for linseed in oil varnishes. It was stated eight years ago that a part of the above problem would be taken up by the Bureau of Standards, but inasmuch as nothing had been reported and as it was of such importance to the development of a reliable system of varnish analysis, we decided it must be included in the program of varnish investigations begun in this laboratory in June 1917. We report here a part of the work we have in progress.

The linseed oil used was the raw oil boiled 2 hrs. at 200° C. with the oxides of lead and manganese. The China wood oil used was clear and possessed a golden yellow color. The soy bean oil was light and clear, and the menhaden and cottonseed were light clear oils.¹

The acid mixtures were in most cases obtained by making up mixtures of the desired oils, saponifying with alcoholic caustic potash, extracting the liberated acids with ether, and drying the solvent-free acids at 110° C. In other designated cases we used the fatty acids obtained from varnishes of known composition by Boughton's method.²

INDICES OF REFRACTION

The following readings were obtained:

Composition of Mixtures from which the Acids were made	Per cent	Readings Calc. to 20° C.	Difference
Linseed, 100.....	1.4666	....	....
Linseed, 95	1.4707	+0.0041	
China wood, 5	1.4775	+0.0109	
Linseed, 90	1.4824	+0.0158	
China wood, 10	1.4895	+0.0229	
Linseed, 80			
China wood, 20			
Linseed, 50			
China wood, 50			

These were repeated several times and fair checks were obtained in the cases where the acids came from the oils direct, but where they came from varnishes the values were not in good agreement. Readings were taken on mixtures of the other oils with linseed but the change in reading with the increase of the adulterating oil was too small to be of any value.

JELLY TEST

This was carried out as given by Boughton,³ except that the fatty acids were used instead of the oils and the time of heating was increased to 2 hrs. A 5 g. sample was used in each test. The results obtained by using acids from the oils direct are found in table near top of next column.

Mixtures of soy bean and China wood and cottonseed and China wood gave just as good results as linseed and China wood, while mixtures of linseed and soy bean and linseed and cottonseed gave no jelly.

Menhaden, 100 per cent, gave a small brown residue which in no way resembled the China wood jelly.

Composition of the Mixtures from which the Acids were made

Per cent	JELLY FORMED
Linseed, 100.....	Not any
Menhaden, 100.....	Not any
Soy bean, 100.....	Not any
Cottonseed, 100.....	Not any
China wood, 100.....	Large amount—1 in. in 6 × 3/8 test-tube
China wood, 50	{ Large amount—1/2 in. in 6 × 1/8 test-tube
Linseed, 50	{
China wood, 33 1/3	{ Fair amount—1/4 in. in 6 × 1/8 test-tube
Linseed, 66 2/3	{
China wood, 20	{ Small amount—1/8 in. in 6 × 1/8 test-tube
Linseed, 80	{
China wood, 10	{ Very small amount
Linseed, 90	{
China wood, 5	{ Not any
Linseed, 95	{
China wood, 50	{ Fair amount—1/4 in. in 6 × 3/8 test-tube
Menhaden, 50	{
China wood, 20	{ Very small amount
Menhaden, 20	{
China wood, 40	{
Menhaden, 30	{ Good amount—1/8 in. in 6 × 3/8 test-tube
Linseed, 30	{
China wood, 20	{ Small amount—1/8 in. in 6 × 3/8 test-tube
Soy bean, 40	{
Menhaden, 40	{

Fatty acids from a varnish containing East India copal, rosin, and an oil mixture made up of 25 per cent China wood, 25 per cent menhaden, and 50 per cent linseed gave a fair amount of jelly, about 1/8 in. in 6 × 3/4 test-tube. One containing rosin and China wood oil alone gave results previously found for 100 per cent China wood; and one containing Sierra Leone copal and linseed gave the negative test.

PHYSICAL CHARACTERISTICS

Composition of the Mixtures from which the Acids were made

Per cent	PHYSICAL CHARACTERISTICS
Linseed, 100.....	Liquid
Soy bean, 100.....	Liquid
Cottonseed, 100.....	Liquid
Menhaden, 100.....	Solid; fishy odor
China wood, 100.....	Solid; characteristic odor of oil
China wood, 50	{ A large part is solid; characteristic odor
Linseed, 50	{
China wood, 20	{ A small part is solid; no odor detected
Linseed, 80	{
China wood, 50	{ Solid; fishy odor
Menhaden, 50	{
China wood, 50	{ A large part is solid; odor of China wood
Soy bean, 50	{
China wood, 20	{ A small part is solid; no odor detected
Soy bean, 80	{
China wood, 20	{ A small part is solid; no odor detected
Cottonseed, 80	{

ACKNOWLEDGMENT

The writer wishes to express his thanks to Dr. E. F. Ladd who not only suggested the work, but gave advice and encouragement while it was in progress.

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THE FORMATION OF AMMONIA AND AMINES IN CANNED SARDINES DURING STORAGE

By F. C. WEBER AND J. B. WILSON
Received June 17, 1918

In the investigations conducted in the sardine industry of Maine by this laboratory during the seasons of 1913 to 1916, numerous determinations of ammonia were made in following the degree of spoilage of the fish. In this phase of the work, two methods of determining ammonia, namely, titrating and nesslerizing the volatile alkaline material, were employed.

¹ These oils were obtained from Toch Brothers.

² E. W. Boughton, Bureau of Standards, Technical Paper 65.

³ Proceedings of the Seventh International Congress of Applied Chemistry, Sec. 1, p. 96.

The methods used were as follows:

NESSLERIZING—Weigh out three 1-g. samples and transfer to large test-tubes, or small Kjeldahl flasks, with 20 to 25 cc. of water. Add 3 cc. of 10 per cent solution of potassium carbonate, 3 cc. of 15 per cent solution of potassium oxalate, and a little heavy cylinder oil. Pass a strong current of air through this mixture for 4 hrs. Collect the ammonia in 5 cc. of $N/20$ sulfuric acid contained in a 100 cc. volumetric flask. After aerating, dilute the contents of the flask to the 100 cc. mark. Transfer a 25 cc. aliquot portion to a 100 cc. volumetric flask and dilute nearly to the mark. After adding 2 cc. of Nessler solution and making to volume, compare the density of the color of the solution in a Duboscq colorimeter with that of a known standard.

TITRATION¹—The same procedure as above was followed to the point of dilution of the contents of the 100 cc. flask. After aeration, the excess of acid was titrated with $N/50$ alkali, using methyl red as the indicator. The results are calculated to milligrams of nitrogen per 100 grams of material.

In fish and fish products, the results by the titration method constitute the total volatile nitrogen (ammonia and amines) and are here considered as such. In order to obtain a sufficient quantity of total volatile nitrogen on which to make a separation of the ammonia and amines, thirty 3-g. samples were aspirated, using the procedure described for the titration method.

SEPARATION OF AMMONIA AND AMINES²—Unite the distillates obtained by the preceding method in a large dish, make distinctly acid, and evaporate until the volume is about 400 cc. Wash into a 500 cc. graduated flask and cool. If the total volatile nitrogen exceeds a strength equivalent to 30 cc. $N/10$ in amount, make up to 500 cc. and transfer a portion equivalent to 20–30 cc. of $N/10$ to another 500 cc. flask. If the amount of total volatile nitrogen is less than the equivalent of 20 cc. $N/10$ add enough of a standard solution of ammonia to raise the content to that point. Add to the liquid in the 500 cc. graduated flask 10 cc. of a solution made by mixing equal parts of 20 per cent sodium hydroxide and 30 per cent sodium carbonate. Fill to the mark with water. Now add 0.1 g. of yellow mercuric oxide for each cc. of $N/10$ acid to which the total volatile nitrogen present in the solution is equivalent. Stopper tightly, cover with a black cloth to exclude light, and shake 1 hr. Allow to stand 12 hrs., or over night, to permit the oxide of mercury to settle. Separate from the mercuric oxide by forcing the liquid through a tube containing a little absorbent cotton, using a moderate blast. Discard the first 20–30 cc. Distil 200 cc. of the filtrate in duplicate into standardized acid. The amount of acid required is equivalent to the nitrogen present as amines. The total volatile nitrogen minus the amine nitrogen equals ammonia nitrogen. Express the quantities as milligrams of nitrogen per 100 g. of sample.

The separation and estimation of the alkylamines composing the "amine" fraction of the total volatile nitrogen were made according to our own method.³

In the analysis of experimental packs of sardines made from fresh fish and from fish which had been allowed to stand for 24 hrs., it was found that the results by the titration method were enormously higher, amounting in some instances to nearly twice the amount obtained by the nesslerizing method. From the nature of the product and the well-known fact that amines are formed in the decomposition of fish, fish brine

being a source of trimethylamine, these substances were naturally regarded as being the cause of the discrepancy.

This difference in the values for ammonia, as determined by these two methods, was noted in other instances where analyses were made at the time of packing and after the same packs had stood. A change evidently takes place in the packed goods on standing, with the liberation of substances having an alkaline reaction (amines) and which are determined as ammonia by the titration method. Unfortunately the method of determining ammonia by nesslerizing is not reliable in the presence of amines. The difference in the values, determined by the methods employed for ammonia, while giving some indication of the amount of amines present, is not even sufficiently accurate to warrant regarding it as an approximate measure of the amine content.

In packs of fresh and 24-hr.-old fish (sampled a short time after packing) the average of two determinations calculated to a water- and fat-free basis, expressed as milligrams of ammoniacal nitrogen per 100 g., was:

	Nesslerizing	Titration
Fresh fish, not in pickle.....	107.8	147.6
24-hr.-old fish, not in pickle.....	121.7	189.6

After these packs had stood for 19 mos. the total volatile nitrogen, which was separated into ammonia and amine nitrogen, was again determined on samples of the pack made from the fresh fish. The following results, expressed as milligrams of nitrogen per 100 g. on a moisture- and fat-free basis, were obtained:

	Total Volatile Nitrogen by Titration	Ammonia Nitrogen by Difference	Amine Nitrogen by Separation
Fish, 1/2 hr. in pickle.....	271.8	49.5	222.3
Fish, 1 hr. in pickle.....	239.4	43.7	195.7
Fish, 1 1/2 hrs. in pickle.....	223.0	34.2	188.8

¹ The pickle employed was approximately a saturated solution of common salt.

The values for total volatile nitrogen in this tabulation correspond to the results shown by the titration method above. The total volatile nitrogen by the titration method, on samples of these particular packs when they were 7 mos. old, amounted to 203.1, 206.1, and 204.5 mg. of nitrogen per 100 g., respectively. These results indicate that upon standing the packed sardines show a marked increase in the quantity of total volatile nitrogen contained, the greater part of which is in the form of amines. On extracting a little more than a kilogram of the sardines from this pack with 1 1/2 liters of 50 per cent alcohol, 280 mg. of total volatile nitrogen were obtained by the titration method and 189 mg. by the nesslerization method. About 1.5 to 2.0 g. of a white crystalline material having a strong ammoniacal odor and very deliquescent was obtained when this alcoholic extract was evaporated after making acid with hydrochloric acid. There was a considerable loss of total volatile nitrogen during the evaporation; nevertheless determinations of total amines on the residue obtained showed that 62.46 per cent of the alkaline material present was in the form of amines.

The following results were obtained on samples of sardines from commercial packs which had been kept at a practically uniform temperature and which were 2, 4, and 6 yrs. old at the time the determinations were made.

¹ Adapted from methods of Polin, Macallum, and Farmer, *J. Biol. Chem.*, 11 (1912), 500, 523.

² Adopted from method of Erdmann, *J. Biol. Chem.*, 8 (1910), 41.

³ "A Method for the Separation and Quantitative Determination of the Lower Alkylamines in the Presence of Ammonia," *J. Biol. Chem.*, [2] 35 (1918), 383.

TABLE I.—DETERMINATION OF AMMONIA AND AMINES IN COMMERCIAL PACKS OF SARDINES AFTER LONG PERIODS OF STORAGE

SAMPLE No.	Description	No. Years Packed	Water Per cent	Fat Per cent	Total Alkaline Volatile Material ¹			Mg. Nitrogen (N) ² per 100 g.		Percentage of Total	
					Titration	Nessler	Difference	Total Ammonia	Amines	Ammonia	Amines
533A	Best grade. Packed in 1912. Good appearance on opening cans.	2	55.88	20.73	46.6	17.3	29.3	46.9	20.1	26.8	42.9
533A ₁		2	54.15	21.76	40.8	17.4	23.4	46.6	15.6	31.0	33.5
533B	Poorer grade. Packed in 1912. Very good appearance on opening cans.	2	57.08	18.73	39.6	14.7	24.9	44.7	17.8	26.9	39.8
533B ₁		2	55.40	20.95	43.1	18.9	24.2	37.7	5.0	32.7	13.3
533C	Packed in 1910. Poor appearance on opening cans.	4	50.01	33.60	33.8	14.0	19.8	37.2	5.9	31.2	15.9
533C ₁		4	...	...	...	...	...	45.9	6.4	39.5	13.9
533D	Packed in 1908. Poor appearance on opening cans.	6	57.75	21.94	60.6	14.9	45.7	51.1	8.6	42.5	16.8
533D ₁		6	...	...	...	...	...	69.3	...	Lost	...

¹ Determinations made on 3.0-g. samples.² Determinations and separations made on 50.0-g. samples.

Determinations of ammonia by the titration and nesslerizing methods were made on 3-g. samples. The volatile alkaline material for the separation of ammonia and amines was obtained in these determinations from 50-g. samples, in duplicate, using the same proportional amount of 10 per cent carbonate of soda and 15 per cent potassium oxalate as used in the ordinary determination of ammonia. In addition, about 1½ g. of potassium fluoride were added to the flasks containing the samples to prevent decomposition during the time of aspiration, which was carried on for 5 hrs. The volatile material, ammonia and amines, was carried into an excess of N/10 acid. At the end of the operation the excess of acid was titrated, and the total alkaline material determined. Duplicates agreed closely, the results being taken as the total number of milligrams of volatile alkaline nitrogen per 100 g. of material.

The separation of ammonia and amines was made on the total volatile alkaline material obtained by combining the portions from the two 50-g. samples. The results by the titration method on the 3-g. samples, which is the ordinary method of determination, agree but fairly well with the amounts obtained on the 50-g. samples as here used. It was found that the 50-g. samples continued to give off a small amount of ammonia, even after air had been passed through them for a period of 5 hrs. All the alkaline material was obtained from the 3-g. samples in 3 to 4 hrs. of aspiration. In later work a sufficient number of 3-g. samples were taken for the determination to obtain an amount of alkaline material on which this separation could be made.

The difference between the amounts of ammonia obtained by the titration and nesslerizing methods is again shown to be very great, although in some instances it agrees fairly well with the amount of amines actually determined. The determinations indicate that a change in the relative amount of ammonia and amines occurs, the degree depending on the time the fish remain in the cans. The total amount of alkaline material appears to be quite constant in the 2- and 4-yr.-old goods, but has noticeably increased in the 6-yr.-old pack. The quantity of ammonia, both in the actual amount obtained and in the percentage of the total volatile nitrogen, decreases, while the increase in the percentage amount of amines corresponds directly to the age of the goods. Eliminating one determination, which shows a very low ammonia content on the 2-yr.-old packs, the average percentage amount of ammonia of the total is 38.7, while the three determinations on the 4- and 6-yr.-old packs show only 15.5 per cent of

the total alkaline material as ammonia, with the corresponding increase of from 61.3 to 84.5 per cent, respectively, in nitrogen as amines.

An experiment was conducted to ascertain whether these changes in the canned fish could be followed during shorter periods of standing. A pack of a little more than half a case of quarter oil cans was made from fresh fish which had been only a short time in brine. After the fish were steam cooked and dried, under ordinary commercial conditions, the heads were removed, the portion used for packing ground in a meat chopper, and the whole thoroughly mixed in a large pan, a representative sample (534A, Table II) being taken for analysis. The ground meat was then packed in the cans which were sealed and processed for 1¾ hrs. at 212° F. Samples (534B) were taken from several cans directly after they had been processed. Other samples were taken from this pack after it had stood at room temperature for 1, 2, 3, 4, 6, 18, and 36 mos. Water, fat, and the total alkaline material were determined, and the separation of ammonia and amines was made. The results for the total alkaline volatile material, reported in Table II, were obtained by the titration method which was here employed for the determination of ammonia, using 3-g. samples. Also in this experiment for the separation of ammonia and amines, 50-g. samples were used, with the exception of the determinations after the 4-mo. period of standing, when thirty 3-g. samples were employed. The total volatile alkaline material obtained was combined to make an amount sufficient for the separation.

The ground fish meat, after steaming and drying, and before being packed, contained 13.3 mg. of total volatile alkaline material per 100 g. of meat, of which 7.4 mg., or 55.6 per cent, was present in the form of ammonia, and 5.9 mg., or 44.4 per cent, in the form of amines. After being processed in the cans for 1¾ hrs. at 212° F. the total volatile alkaline material per 100 g. of this meat had increased to 39.7 mg., of which 63.6 per cent was present as ammonia and 36.4 per cent in the form of amines. During the processing, therefore, an increase in the amount of ammonia, with a corresponding decrease in the amount of amines, occurs. There is an increase in the actual amounts of both the ammonia and amines. Standing produces a gradual increase in the amount of total alkaline material obtained from the meat, due to the formation of alkylamines, the ammonia content remaining fairly constant, with the exception of a decrease in the pack at the 6-mo. period of standing.

The results, expressed in percentage of the total

TABLE II—CHEMICAL CHANGES, ON STANDING, IN GROUND WHOLE FISH STORED AT ORDINARY ROOM TEMPERATURE
Packed in quarter oil cans, processed 13/4 hrs. at 212° F.

SAMPLE No.	Description	Time Packed Months	Water Per cent	Fat Per cent	Total Alkaline Volatile Nitrogen (N) per 100 g. Titration Method	Mg. Volatile Nitrogen N per 100 g.		Percentage of Total	
						Total	Ammonia	Amines	Ammonia Amines
534A	Ground fish meat before packing in cans	0	67.01	9.07	14.0	15.3	7.4	5.9	55.6 44.4
534B	Ground fish meat after packing and processing	0	65.72	9.13	30.3	38.3	18.4	18.6	63.6 36.4
534C	Ground fish meat after packing and standing	1	65.85	9.02	42.0	46.8	27.2	19.6	58.1 41.9
534D	Ground fish meat after packing and standing	2	67.00	8.72	47.8	47.3	22.6	24.7	47.8 52.2
534E	Ground fish meat after packing and standing	3	66.40	8.69	52.5	53.1	24.2	28.9	45.6 54.4
534F	Ground fish meat after packing and standing	4	66.64	8.18	55.0	54.3(a)	25.8	28.4	47.7 52.3
534G	Ground fish meat after packing and standing	6	66.5	9.23	55.0	55.0(a)	19.1	36.5	34.3 65.7
534H	Ground fish meat after packing and standing	18	64.79	9.93	69.0	69.0(a)	35.8	33.2	51.9 48.1
534K	Ground fish meat after packing and standing, normal cans	36	...	...	...	78.9(a)	41.3	37.6	52.4 47.6
534K	Ground fish meat after packing and standing, swell cans, "springers"	36	...	...	...	82.4(a)	44.0	38.4	53.4 46.4

(a) These determinations were made on the combined volatile alkaline nitrogen obtained from thirty 3-g. samples.

volatile alkaline material, point more clearly to a reduction in the quantity of ammonia, with a corresponding increase in the relative amount of amines, up to and including the 6-mo. period of standing. The figures show that this ammonia decreased from 63.6 per cent in the fresh processed meat to 34.3 per cent after standing 6 mos., while the amines increased from 36.4 per cent in the fresh processed goods to 65.7 per cent. The same determinations were made on samples of this pack after it had stood 18 and 36 mos.

At the end of the 36-mo. period of storage, analysis was also made of the contents of a few cans which were just beginning to swell ("springers"). The total volatile material continued to increase in the case of the cans stored for 18 and 36 mos. A more marked increase over the amount found at the end of 6 mos. occurred during the first 18 mos. than during the last year and a half. The incipient swell cans contained but a slightly greater quantity of volatile alkaline material than the normal cans. The separation of ammonia and amines in the volatile alkaline material gave, in all three cases, results quite different from those obtained at the earlier periods of examination, particularly those of the 6-mo. period. After standing 18 and 36 mos. the volatile alkaline material was composed of practically equal parts of ammonia and amines.

Table III gives the results of the analysis of different packs of sardines, showing the influence of time and temperature of storage on the formation of ammonia and amines. Part of these packs were stored for different lengths of time at ordinary room temperature and at a temperature of 33° F., just above freezing.

The fish used to prepare Packs 599, 600, and 601 were dry salted when taken from the water at the rate of 1/2 sack of salt per hoghead (1000 lbs. of fish). The fish had been in the salt for the periods of time indicated in the table. Pack 603 consisted of fish which were surrounded with an ice and salt mixture during transportation, and at no time in contact with salt or pickle. The fish composing Pack 604 were "feedy" fish from Grand Manan, N. B. They were gorged with feed which did not have the appearance of shrimp.

The fish were steam cooked, dried, packed, without being eviscerated, in one-quarter cans, and processed for 13/4 hrs. in a boiling water bath. The packs were prepared from fish which varied greatly in preliminary treatment, in regard to "feedy" condition and length of time in salt. As soon as the processed cans were

cool, samples were prepared and analyzed. The remainder of the packs was placed in shooks and stored for future examinations. At the time the analyses were made, the viscera of some of the fish were separated from the meat and determinations were made upon the whole fish, as taken from the can, upon the meat of the fish, and on the viscera and contents.

As seen by the results, these variations in the preliminary treatment of the fish and their condition had no connection with the formation of ammonia or amines during the time of storage. Except for slight variations in the results of the analyses of the whole fish as removed from the can, the fish meat alone, and the viscera and contents, there is no indication that greater changes took place in either of these portions of the fish. The quantity of total volatile alkaline material gradually increased in amount during storage at ordinary temperatures in all three of the divisions made for analysis, but when stored at a temperature of 33° F. the formation of total volatile alkaline substances was greatly retarded.

The relative quantities of ammonia and amines composing the total volatile alkaline material change during storage. After processing, the results indicate that practically two-thirds of the total alkaline nitrogen consists of ammonia and one-third of amines. After storage these proportions have changed, the volatile alkaline material consisting of about equal parts of ammonia and amine nitrogen. Storage at low temperature, while causing a decrease in the total quantity of ammonia and amines apparently does not affect the relative amounts. The quantity of ammonia and amines in the storage samples is also about equally divided.

In Table IV¹ are given the quantities of monamine, diamine, and triamine composing the fraction of the total volatile alkaline material designated as total amines in Table III. The method for this determination was not available at the time the first examination of these packs were made, consequently the data for the separation of the total amine fraction into its different constituents are given only for the longer periods of storage.

It is seen that by far the largest part of the volatile alkaline material, consisting of amines, exists in the form of triamine in canned sardines stored for the lengths of time indicated.

¹ For the method of determination see *J. Biol. Chem.*, [2] 35 (1918), 385.

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Lab. No.	Description	Time in fish store, hrs.	-Mg. of Nitrogen- (N) per 100 g.					-Mg. of Nitrogen- (N) per 100 g.					Percentage of Total					-Mg. of Nitrogen- (N) per 100 g.					Percentage of Total				
			Water cent	Fat cent	Total Mg. cent	Am. monia cent	Am. monia per cent	Water cent	Fat cent	Total Mg. cent	Am. monia cent	Am. monia per cent	Water cent	Fat cent	Total Mg. cent	Am. monia cent	Am. monia per cent	Water cent	Fat cent	Total Mg. cent	Am. monia cent	Am. monia per cent					
599	Packed and processed. Stored at room temperature. 12 mos. at room temperature. 13 mos. at 33° F.	0	53.07	20.19	73.26	24.8	13.4	64.9	35.1	58.33	17.12	75.45	24.8	13.4	67.2	32.8	58.81	17.03	75.84	24.8	13.4	67.2	32.8				
600	Packed and processed. Stored at room temperature. 12 mos. at room temperature. 13 mos. at 33° F.	4	52.18	22.85	75.03	26.1	23.9	50.5	48.7	57.53	16.95	74.48	23.5	22.2	42.0	58.0	54.15	19.20	73.35	22.4	22.3	30.1	42.6				
		32	47.87	26.76	74.63	24.0	10.0	70.6	29.4	54.78	18.97	73.75	26.2	11.3	69.9	30.1	55.61	21.70	77.31	25.9	15.3	62.9	37.1				
601	Packed and processed. Stored at room temperature. 12 mos. at room temperature. 13 mos. at 33° F.	3	48.67	27.00	75.67	23.9	11.4	67.5	32.5	56.84	16.95	73.80	27.1	10.6	71.8	28.2	55.30	20.65	75.95	27.4	13.8	70.8	29.2				
		15	48.58	26.93	75.51	23.7	3.9	53.7	46.3	52.87	21.85	73.72	27.1	10.6	71.8	28.2	55.30	20.65	75.95	27.4	13.8	70.8	29.2				
602	Packed and processed. Stored at room temperature. 12 mos. at room temperature. 13 mos. at 33° F.	25	47.05	28.70	75.75	24.5	3.2	56.7	43.6	52.87	21.85	73.72	27.1	10.6	71.8	28.2	55.30	20.65	75.95	27.4	13.8	70.8	29.2				
		32	47.05	28.70	75.75	24.5	3.2	56.7	43.6	52.87	21.85	73.72	27.1	10.6	71.8	28.2	55.30	20.65	75.95	27.4	13.8	70.8	29.2				
603	Packed and processed. Stored at room temperature. 12 mos. at room temperature. 13 mos. at 33° F.	4 (4)	59.83	18.64	78.47	33.5	22.7	9.8	61.0	39.0	53.23	20.79	74.9	23.1	11.8	66.2	33.9	61.47	18.54	79.01	34.9	23.1	11.7				
		1	60.06	18.64	78.70	33.5	22.7	9.8	61.0	39.0	53.23	20.79	74.9	23.1	11.8	66.2	33.9	61.47	18.54	79.01	34.9	23.1	11.7				
604	Packed and processed. Stored at room temperature. 12 mos. at room temperature. 13 mos. at 33° F.	15	64.49	14.78	79.27	26.0	22.4	48.7	51.3	61.49	16.80	77.3	32.5	31.6	49.7	55.9	53.78	21.40	74.9	32.5	31.6	49.7	55.9				
		32	80.0	72.8	152.8	72.8	39.3	55.4	46.9	58.94	18.97	77.91	26.6	12.1	66.1	33.9	54.68	20.66	78.66	26.6	12.1	66.1	33.9				
605	Packed and processed. Stored at room temperature. 12 mos. at room temperature. 13 mos. at 33° F.	0	58.83	23.75	82.58	15.0	10.4	39.1	40.9	58.43	17.92	76.35	24.9	31.4	31.5	50.0	50.0	53.02	28.45	59.3	30.9	28.4	52.1				
		6	50.21	26.77	76.98	30.0	3.5	48.0	52.0	53.88	22.37	76.25	34.9	23.1	11.8	66.2	33.9	49.39	31.98	44.8	21.9	22.9	48.9				
606	Packed and processed. Stored at room temperature. 12 mos. at room temperature. 13 mos. at 33° F.	15	49.90	27.80	77.7	19.2	2.1	57.2	52.8	53.88	22.37	76.25	34.9	23.1	11.8	66.2	33.9	49.39	31.98	44.8	21.9	22.9	48.9				
		32	76.4	42.4	118.8	42.4	21.5	55.5	44.5	76.4	42.4	118.8	42.4	21.5	55.5	44.5	76.4	42.4	118.8	42.4	21.5	55.5	44.5				
607	Packed and processed. Stored at room temperature. 12 mos. at room temperature. 13 mos. at 33° F.	6	49.8	22.4	72.2	22.4	3.0	45.0	55.0	49.8	22.4	72.2	22.4	3.0	45.0	55.0	49.8	22.4	72.2	22.4	3.0	45.0	55.0				
		32	49.8	22.4	72.2	22.4	3.0	45.0	55.0	49.8	22.4	72.2	22.4	3.0	45.0	55.0	49.8	22.4	72.2	22.4	3.0	45.0	55.0				
608	Fish composing this pack were held 4 hrs. at 33° F.	0	No pickle or salt.																								

—Viscera and Contents—

[illegible]

The results for triamine do not indicate a difference in amount for the separations of the canned fish as made for analysis.

In respect to the different portions of the fish analyzed, there does not appear to be any uniform increase or decrease in the amount of triamine in relation to the different periods or temperatures of storage.

Monamine and diamine are present in very small amounts and about equal quantities at the end of 15 and 18 mos. At the end of 32 mos. of storage no monamine was found, while the amount of diamine had increased, in some instances being double or more than double the quantities found at 15 mos. The temperature of storage apparently has no influence on the quantities of monamine and diamine found.

CONCLUSIONS

The data collected in the analyses of old packs of sardines and of the experimental packs under known conditions of storage show that marked changes in the quantities and relative amounts of ammonia and amines take place in the canned fish on standing. In the case of packs composed of ground meat, these changes could be detected at 1 mo. intervals, and amount, in the first few months, to an increase of approximately 5 mg. of alkylamines per 100 g. of material per month. Directly after processing, the volatile alkaline material obtained by the method of determination contains practically two-thirds ammonia and one-third alkylamines. During storage at room temperature the proportions appear to change slowly, until after a long period of standing the total alkaline material is about equally divided between the ammonia and amines. When stored at a temperature just above freezing the total quantity of volatile alkaline material produced is much less than that produced when stored at ordinary temperatures. Table III shows that the samples stored above a freezing temperature for 32 mo. contained in most cases less volatile alkaline material than was found in the sardines held at room temperature for a period of 15 mo. The relative amount of ammonia and amines formed at the lower temperature of storage remains the same as that composing the total volatile alkaline material formed while the sardines were standing at room temperature. The amines composing this volatile alkaline material consisted in most part of triamine which amounted to practically 80.0 per cent of the total. Monamine and diamine are also present during the earlier periods of storage (15 and 18 mo.) but in much smaller quantities. At the end of the 32-mo. storage period no monamine was found, but the diamine had increased 50.0 per cent and over in some instances. The difference in the rate of formation of ammonia and amines at a lower temperature of storage and at room temperature suggests that these changes may be caused in some instances by bacterial growth. Anaerobic, spore-bearing, gas-forming bacteria which have been found associated with these fish produce both ammonia and amines when grown on media containing fish protein.

It is doubtful whether the quantities of ammonia and amines in the canned product have any direct

relation to the keeping qualities of sardines in respect to the appearance, softness, or texture of the fish. It is noted, however, that when cans of the long standing commercial packs were opened, the fish constituting the 4- and 6-yr.-old goods were decidedly soft. These contained the largest amounts of amines. Other work has shown that the quantity of ammonia and amines in the canned sardines has a decided bearing upon the detinning of the interior of the cans.

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FUMIGATION WITH FORMALDEHYDE¹—A SUBSTITUTE FOR THE PERMANGANATE-HORMAL METHOD

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The object of this paper is to explain, defend, and justify the use of bleaching powder and formalin in the fumigation of rooms. The common method using permanganate has become prohibitively expensive since the war began. The dichromate method uses an unstable and corrosive acid mixture of formalin and is chemically of low efficiency. The bleaching powder method will be shown in this paper to be to-day the cheapest and best available method for the fumigation of rooms.

In the past the main difficulty in dealing with new methods proposed for fumigations has been to learn how much formaldehyde gas actually was evolved* and how the proposed methods compared with the well-tried permanganate method. In this paper the method using bleaching powder is compared quantitatively with the permanganate method and with the dichromate methods, and a simple apparatus and procedure are described whereby the yield of formaldehyde gas in any wet method may be determined.

The present state of knowledge with respect to just how much formaldehyde gas must be set free in a room to get satisfactory germicidal action may be fairly gathered from the very different quantities recommended by several authorities, and brought together in the following table:

TABLE I—YIELDS OF FORMALDEHYDE GAS BY SEVERAL FUMIGATION METHODS

A—Methods in Which Liquid Formalin Is Used					
CHAR- ACTERISTIC (CHEMICAL)	Formalin used for 1000 cu. ft. Cc.	Chemical efficiency of methods Per cent	Formal- dehyde gas given off Grams	Formal- dehyde gas at 68° F. Cu. ft.	Formal- dehyde in the air of the room Volume— Per cent
Permanganate ² ...	500	37.5	75.0	2.10	0.210
Permanganate ² ...	296	35.6	42.3	1.20	0.120
Dichromate ² ...	473	13.9	26.5	0.75	0.075
Alum and lime ¹ ...	177	14.0	10.0	0.28	0.028
B—Methods in Which Solid Paraform Is Used					
	Paraform used for 1000 cu. ft. Grams	Chemical efficiency of methods Per cent	Formal- dehyde gas given off Grams	Formal- dehyde gas at 68° F. Cu. ft.	Formaldehyde in the air of the room Volume— Per cent
	2834	45.0	122.2	3.49	0.350
	257	45.0	10.8	0.31	0.030
	308	45.0	12.9	0.37	0.037

The calculations for this table were made from the most reliable data available and upon the assumption

¹ Abstract of a paper presented before Section C, American Association for the Advancement of Science, Pittsburgh, December 29, 1917.

* Numbers refer to corresponding numbers in "References," p. 129.

that no gas is lost by leakage, by polymerization, by solution in condensed or absorbed water, or by any other way in which loss may occur in actual fumigations.

The effectiveness of a formalin fumigation as measured by bacteriological tests of record is an experimental value showing wide variations from a constant value. Experience with both chemical and bacteriological methods leads me to the belief that closer agreement and more reliable generalizations are to be expected from the chemical than from the bacteriological tests. I have therefore used chemical methods, taking the permanganate-formalin fumigation procedure as set forth by Rosenau² as beyond reasonable dispute and as the reliable standard procedure for fumigation when measured by bacteriological tests.

METHOD OF ASSAY OF FUMIGATIONS

The apparatus used was made from a round battery-jar and a tubulated bell-jar, serving together as a glass gasometer. A glass cylinder open at both ends supported a glass dish in which the reaction between the formalin and the oxidizing agent was made to occur. The oxidizing agent in weighed amount was placed in the dish and the measured volume of formalin delivered upon it from a suitable pipette through the tubulus of the bell-jar. A jet of water was used to moisten the ground glass surface of the tubulus before inserting the pipette. When empty, the pipette was rapidly withdrawn and the glass stopper immediately inserted into the tubulus. Although the expansion of the enclosed air along with the hot gases rapidly evolved causes the bell-jar to float up on the water, it is easy to adjust the charge and the volume of the absorption water so as to avoid all loss of gas. The slight pressure upon the enclosed reacting mixture due to the weight of the floating bell-jar may readily be overcome by the use of a string and pulley and a suitable weight. For experiments on a larger scale, one can readily obtain similar glass apparatus of such size as he may wish.

In analysis of the absorption water, the Volhard-Romijn method⁹ was adopted. It was tested out on dilute formalin solutions containing from 13 to 400 parts formaldehyde per 100,000. The solutions were standardized against known weights of Merck's "precipitated silver" dissolved in nitric acid. The results obtained in testing out this method are given in the following table. They fully confirm the applicability of the Volhard-Romijn method to the determination of small quantities of formaldehyde.

TABLE II—ANALYSES OF FORMALDEHYDE SOLUTIONS BY VOLHARD-ROMIJN METHOD

STOCK BOTTLE	Formalin taken Cc.	Formaldehyde taken Grams	Formaldehyde in 10 cc. of each stock solution tested Gram	Formaldehyde found in 10 cc. by Volhard-Romijn method Gram	Error by Vol.-Romijn. method Gram
6	5.0	2.004	0.02004	0.01921	-0.00083
10	2.5	1.002	0.01002	0.00973	-0.00029
15	1.0	0.401	0.00401	0.00387	-0.00014
33	0.666	0.267	0.00267	0.00274	+0.00007
62	0.333	0.134	0.00134	0.00131	-0.00003

The correction for the formaldehyde gas escaping from the formalin in the dish during the time occupied by an experiment, when no oxidizing agent is intro-

duced into the dish, was determined. The value of this error was found to be small enough to neglect. There are variations to be noted among the results, as must be expected in heterogeneous systems where stirring is impossible, where the oxidizing agent is attacked only superficially, and where contact between the formalin and the solid oxidizing agent is more or less accidental and incomplete.

QUANTITY OF FORMALDEHYDE GAS EVOLVED

Having an apparatus adapted to the purpose, and a method of volumetric analysis not to be questioned, the quantity of formaldehyde evolved as gas was determined in each of the three processes.

(1) THE PERMANGANATE-FORMALIN METHOD—Results obtained, which are set forth in the following table, show that the maximum yield is not obtained by the use of those proportions urged by the advocates of this method. Using the same relative amounts of permanganate and formalin, the same value as found by Base was obtained. Contrary to published statements, the maximum yield is not dependent upon the dryness of the residue.¹⁰ The yield increases with the weight of permanganate used, as must be expected if the area of surface of contact is the principal factor¹¹ as it usually is in heterogeneous systems.

TABLE III—WEIGHT-PER CENT CH_2O YIELDED BY THE PERMANGANATE-FORMALIN METHOD

Final volume to which absorption water and rinsings were diluted = 725 cc. Temperature of formalin = 22.5° to 23.5° C.

Ratio G. KMnO_4 : Cc. Formalin used	G. KMnO_4 : Cc. Formalin actually used in each set of experiments	NH_4SCN solution required in titrating 25 cc. of the combined absorption water and rinsings Cc.	Per cent by weight of the total CH_2O used that was yielded as gas
10,000 : 5	2,500 : 1,250	1.34	70.9
7,500 : 5	1,875 : 1,250	1.26	56.4
5,000 : 5	1,250 : 1,250	1.24	52.7
2,500 : 5(a)	2,500 : 5,000	1.77	37.4
2,370 : 5	2,370 : 5,000	1.73	35.6
1,875 : 5	1,875 : 5,000	1.61	30.1
1,500 : 5	1,500 : 5,000	1.44	22.4
1,000 : 5	1,000 : 5,000	1.18	10.5
Blank No. 1.....	1.25	1.50	..
Blank No. 2.....	5.00	3.14	..
Reagent blank.....	0.00	0.95	..

(a) This is the proportion recommended by Rosenau.

(2) THE DICHROMATE-FORMALIN METHOD—These determinations were made using a specimen of formalin recently acidified with the stated amount of sulfuric acid and also treated with the quantity of glycerin directed.¹² Unless the formalin had been recently acidified, I was unable to prevent the separation, as a solid polymer, of some of the formaldehyde. This separation occurred more rapidly the lower the temperature. A specimen of the acidified formalin kept one year at room temperature was found, after filtration, to contain only 84 per cent of the formaldehyde originally present.¹³ A specimen to which glycerin was also added¹⁴ was found after one month at room temperature to contain 91.7 per cent of the formaldehyde originally present.

In the experiments in the following table, the chemicals were used in the proportions recommended by the Pennsylvania Department of Health, and also in other

ratios between the weight of oxidizing agent and of formaldehyde.

TABLE IV—WEIGHT-PER CENT CH_2O YIELDED BY THE DICHROMATE-FORMALIN METHOD

Final volume to which absorption water and rinsings were diluted = 725 cc. Temperature of formalin = 22.5° to 23.5° C.

Ratio G. $\text{Na}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$: Cc. Formalin used, Also amounts used	NH_4SCN solution required in titrating 25 cc. of the combined absorption water and rinsings Cc.	Per cent by weight of the total CH_2O used that was yielded as gas
1.56 : 6	1.18	11.44
3.12 : 6(a)	1.23	13.93
6.24 : 6	1.56	30.35
12.48 : 6	1.54	29.36
Blank No. 6.....	2.96	...
Reagent blank.....	0.95	...

(a) This is the proportion recommended by the Pennsylvania Department of Health.

(3) THE BLEACH FORMALIN PROCESS—Although I had advised this method in 1915 only to clients of mine and had written of it only in correspondence, the process was brought to Hamilton's attention with a request for an opinion upon it. In 1917 he printed in a paper on "Facts and Fallacies in Disinfection"¹⁵ the following statements:

Various improper methods have been proposed and applied for generating the gas (formaldehyde) from its aqueous solutions. * * * When lime is used as a heating agent * * * the lime water slowly but almost completely destroys the aldehyde. * * * It is also essentially true if calcium hypochlorite is so employed. * * * A prompt and more or less violent reaction occurs when a 40 per cent aqueous solution of formaldehyde is mixed with any of the above-named reagents (lime, caustic soda, calcium hypochlorite), but careful experiments failed to find effective quantities of formaldehyde among the evolved gases. * * * The method employed to determine the amount (of formaldehyde) evolved was essentially that described by Frankforter. * * * By this method 30 per cent of the theoretical quantity of gas was found to be liberated from a solution by means of potassium permanganate. * * * Chlorinated lime under the same conditions appeared to evolve only chlorine compounds, no formaldehyde gas being detected in the aqueous solution collected.

In the following table are given the yields in the bleach-formalin process when assayed by the method described under the heading, "Method of Assay of Fumigation." The correction for chlorine compounds evolved from the bleach was determined by adding absorption water (from assays) to silver nitrate solution and, without adding any acid, filtering off the precipitate and titrating the filtrate with sulfocyanate. The precipitate was only sufficient to produce a turbidity and required double filtration to remove it. The correction was found to range from 0.01 to 0.02 cc. sulfocyanate solution, which is of the same order as the variation among the results of comparable fumigation assays by the method I have described. These chlorine compounds failed to bleach moist litmus paper in experiments conducted on the large scale, even when the litmus paper was so placed that the outrushing gases had to pass over it before mingling with the air of the room. Further, this method has already been used in fumigating upward of 3000 rooms, without a single objection or intimation of injury to fabrics, colors, metals, or anything else, by the gases. In the Frankforter and West apparatus used by Hamilton in testing the bleach method, the upper part of the flask and apparatus act as a return condenser. Frankforter and West did not recognize this and probably Hamilton also did not, for he used the apparatus notwithstanding the statements elsewhere

in the literature¹⁶ that call attention to this important factor. There is no room, of course, for difference of opinion on the fact that formaldehyde can be completely destroyed by oxidation if sealed up with an oxidizing agent, or if heated with one under an efficient return condenser or in a closed bottle. In fact, Blank and Finkenbeiner's method¹⁷ for determining methyl alcohol in commercial formalins rests upon the completeness of such an oxidation under such conditions.

TABLE V—WEIGHT-PER CENT CH_2O YIELDED BY THE BLEACH-FORMALIN METHOD

Final volume to which absorption water and rinsings were diluted = 1000 cc. or 725 cc. Temperature of formalin = 22.5° to 23.5° C.

Ratio G. Bleach : Cc. Formalin used	G. Bleach : Cc. Formalin actually used in each set of experiments	NH_4SCN solution required in titrating 25 cc. of the combined absorption water and rinsings Cc.	Volume to which dilutions were made Cc.	Per cent by weight of the total CH_2O used that was yielded as gas
10.0 : 5	2.50 : 1.25	1.12	1000	42.0
7.5 : 5	1.88 : 1.25	1.07	1000	29.6
5.0 : 5	2.50 : 2.50	1.17	1000	27.2
2.5 : 5	2.50 : 5.00	1.26	1000	19.1
2.0 : 5	2.00 : 5.00	1.28	725	15.1
1.0 : 5	1.00 : 5.00	1.18	725	10.5
Blank No. 1.....	5.00	2.57	1000	..
Blank No. 2.....	5.00	3.14	725	..
Reagent blank.....	..	0.95	..	..

RELATIVE EFFICIENCIES AND COSTS OF THE THREE METHODS IN PRACTICE

In the proportions originally directed for practical use in actual room fumigations, it appears from Tables II, III, and IV that the percentages of the total formaldehyde used evolved as gas are:

	Per cent
Permanganate-formalin.....	37.5
Bleach-formalin.....	23.3
Dichromate-formalin.....	13.9

By the permanganate-formalin method, using, as directed, 250 g. permanganate and 500 cc. formalin for 1000 cu. ft. of room space, the weight of formaldehyde gas evolved into the room is 75 g. In order to produce this same weight of formaldehyde gas using bleach, one should take to fumigate a room of 1000 cu. ft. the following:

Bleaching powder.....	620 g., or 1 1/2 lb.
Formalin.....	800 cc., or 1 1/2 pt.

In order to produce this same weight of formaldehyde gas using the dichromate mixture as recommended by the Pennsylvania Department of Health, one must take to fumigate a room of 1000 cu. ft. about three times as much of the chemicals as one would use if following the directions laid down by the Department.

Taking each method in the form and quantity in which it was recommended for use by its advocates, the relative cost per 1000 cu. ft. of room space are found to be:

Permanganate-formalin method.....	\$2.29
Dichromate-formalin method.....	0.40
Bleach-formalin method.....	0.29

Taking as the criterion for all reliable methods the permanganate method as recommended by Rosenau and set forth immediately above, and then making the dichromate and bleach methods equal to it in yield of grams of formaldehyde gas, the relative costs per 1000 cu. ft. of room-space are:¹⁸

Permanganate-formalin method.....	\$2.29
Dichromate-formalin method.....	1.14
Bleach-formalin method.....	0.39

A question that naturally arises upon consideration of the data given for the bleach-formalin method is, why not increase the proportion of bleach to formalin? There are two answers to this. First, the reaction becomes extremely violent by the time the ratio of 5 parts by weight of bleach to 5 parts by volume of formalin is reached; second, above this ratio notable quantities of chlorine compounds are set free along with the formaldehyde gas. It is better to adhere to the proportions recommended, which proportions both experiment and practical experience in fumigating rooms have demonstrated to be unobjectionable. It is not advisable to sacrifice satisfaction for the slight saving in cost that could thus be realized.

SUMMARY

The use of bleaching powder and formalin in fumigating rooms has been proposed in this paper. By the aid of a new and convenient apparatus, this new method has been compared quantitatively with the permanganate-formalin and with the dichromate-formalin methods. The comparison leads to the conclusion that by using 620 g. bleaching powder and 800 cc. formalin for each 1000 cu. ft. to be fumigated, as much formaldehyde gas will be thrown off into the room as by the use of 250 g. permanganate and 500 cc. formalin, and at only one-sixth the cost. The bleach-formalin method is shown to be only one-third as costly as the dichromate-formalin method. It has been shown that the printed objections to the bleach-formalin method are without foundation in fact and are contradicted both by experiment and in practice.

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- 2—Rosenau, "Preventive Medicine and Hygiene," 3rd Ed., p. 1134. Permanganate was proposed in 1902 by Johnson in a paper read before the Sioux Valley Medical Association; the files of this society have been destroyed by fire, and the original paper is not available. See articles by Evans and Russell and by Base, cited in Reference 1. For bacteriological tests, see Russell, and also McClinic, *Hygienic Laboratory Bulletin*, U. S. Pub. Health and Mar. Hos. Service, No. 27.
- 3—Hasseltine, *U. S. Public Health Reports*, **30**, 2058.
- 4—Dixon, *Loc. cit.*, Reference 1; cf. Rosenau, *Loc. cit.*, Reference 2.
- 5—Walker, *J. Am. Chem. Soc.*, **27**, 227; cf. MacNutt, *Manual for Health Officers*, p. 578, who directs the use of the same chemicals in other proportions.
- 6—Lockermann and Croner, *Desinfektion*, **2**, 724.
- 7—Parkes, "Practical Hygiene," 4th Ed., p. 580.
- 8—New York City Dept. of Health, quoted by MacNutt, *Loc. cit.*
- 9—Roniijn, *Z. anal. Chem.*, **36**, 18. Smith, *J. Am. Chem. Soc.*, **25**, 1028. Base, *Loc. cit.*, p. 968. See also Evans, *Loc. cit.*
- 10—McClinic, *Loc. cit.*, p. 20.
- 11—Evans and Russell, *Loc. cit.*, 14th Report, p. 233.
- 12—Glycerin is added to prevent polymerization. It had been used for this purpose in some of the early forms of autoclaves for fumigations. See, Newman, "Bacteriology and the Public Health," 3rd Ed., p. 444.
- 13—Cf. Dixon, *Loc. cit.*, "LaWall found the solution would be perfectly stable."
- 14—For proportion, see Rosenau, *Loc. cit.*, p. 1137.
- 15—*Am. J. Pub. Health*, **7**, 282.
- 16—Fendler and Stubler, *Z. angew. Chem.*, **21**, 2021. Evans, *Loc. cit.*, 14th Report, p. 227.
- 17—*Id.*, **39**, 1327.
- 18—These costs were calculated for the original paper, read December 29, 1917. The prices were from the *New York Journal of Commerce and Commercial Bulletin* and were the minimum prices listed for December 24, 1917. I have not recalculated at later prices as confusion might result, since these costs appeared in the *Am. J. Pub. Health*, **8**, 161.

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THE PRESENCE OF ACETYL METHYL CARBINOL IN SACCARINE SORGHUM SILAGE

By W. G. FRIEDEMANN AND C. T. DOWELL

Received May 28, 1918

In the course of the determination of the alcohols in some saccharine sorghum silage by the Duclaux method, that is, by the distillation of the alcohols from a neutral solution, oxidation of the distillate with potassium dichromate and sulfuric acid, redistilling, and determining the acids by the Duclaux method in the second distillate, it was observed by one of us (Friedemann) that an unusually large amount of acetic acid was present. This led us to make a further examination of this substance and it was found that the distillate had reducing properties and that it would form an osazone. No further work was done on this until recently when another sample of saccharine sorghum silage was being studied and it was decided to determine what this reducing substance might be.

The work of Balcom¹ on the volatile reducing substance in cider vinegar was recalled in this connection, and the conditions under which the silage was formed and the fact that it was formed from a cane having a very large amount of sugar led us to suspect that the reducing substance was acetylmethylcarbinol which was found by Balcom to be present in cider vinegar.

It was thought desirable to compare the reducing power of the distillate with the reducing power of the original extract from the silage. For this purpose 25 cc. of the juice were clarified by treating with lead subacetate and sodium carbonate and centrifuging. The reducing power of the clarified juice was then determined by Fehling's solution and subsequent oxidation and weighing of the copper as cupric oxide. It was found in this way that the reducing power of 100 cc. of the silage extract was represented by 1.26 g. of metallic copper. In order to get the reducing power of the distillate, 500 cc. of water were added to 100 cc. of the silage extract and 300 cc. were distilled off; then another 200 cc. of water were added and the distillation continued until the total distillate amounted to 500 cc. The purpose of adding the 200 cc. of water was to avoid the concentration of the acid becoming great enough to act on the pentosans to form furfural. The reducing power of the distillate was determined by taking 25 cc. and proceeding as in the case of the silage extract. It was found that the reducing power of the total distillate of 500 cc. was represented by 0.9660 g. of metallic copper. It was

thought possible that even with this large amount of distillate not all of the volatile substance had been carried over and in order to decide this point another 100 cc. of water were added to the distillation flask and 100 cc. distilled over. The reducing power of this 100 cc. distillate was found to be represented by 0.0796 g. of metallic copper. This shows that there was still considerable of the volatile reducing substance left in the distillation flask. It is interesting to note that the total reducing power of the 600 cc. of distillate was represented by 1.0456 g. of metallic copper and the total reducing power of the silage extract, as stated above, was represented by 1.26 g. of metallic copper. When it is remembered that probably part of the volatile reducing substance was still in the distillation flask, it is seen that very little of the reducing power of the extract was due to sugar and other reducing substances, and this in spite of the fact that the total sugars in the cane when it was made into silage ran 13.35 per cent and the reducing sugars (as dextrose) ran 7.62 per cent.

Part of the distillate was treated as directed by Balcom for the formation of the osazone and after heating on the water bath for 2 hrs., a considerable quantity of a lemon-colored precipitate was formed. It was found when we tried to filter off this precipitate that a considerable amount of it had stuck to the bottom of the flask. There was no apparent reason why it should adhere in this way since the precipitate up in the liquid seemed to be more or less pulverulent. When it was attempted to remove the precipitate from the flask with a stirring rod, it was found that it stuck to the rod, indicating that there was some glue- or oil-like substance holding the precipitate together. No attempt was made to determine what this oily substance was but the precipitate was recrystallized twice from 95 per cent alcohol, when a lemon-colored powder was obtained. The melting point of this precipitate was determined and found to be 243° to 244° C. This was the melting point found by Balcom for the osazone of the compound acetylmethylcarbinol so that there is no doubt that this is the volatile reducing substance that is present in the saccharine silage. A nitrogen determination was not made on the substance on account of the fact that the department has but a small supply of phenylhydrazine hydrochloride and has not been able to buy it on the market, and for this reason we did not care to use much of it. Furthermore, it was thought that sufficient work was done to prove that the substance was actually acetylmethylcarbinol without its being necessary to make the nitrogen determination.

Extracts from Sudan grass, corn, and feterita silage were distilled and tested for volatile reducing substances without finding them to be present. Neither was furfural found to be present in any of these distillates. One would expect, however, that since the composition of these substances is very similar to that of the saccharine sorghum, the greatest difference being in the per cent of sugars present, that acetylmethylcarbinol would be present in the fresh silage

formed from these substances. This point will be tested out this next Fall. It is very important to determine whether or not this substance is present in these silages since, if it is present, it will be necessary to modify the method for the determination of sugars and also the method for the determination of the alcohols in silage. It is quite probable, as pointed out by Balcom, that when acetylmethylcarbinol is oxidized, acetic acid is formed, and hence in the Duclaux method for the determination of the alcohols, as outlined above, if the ethyl alcohol is calculated on the basis of the amount of acetic acid found, it is seen that this method is totally unreliable for the determination of ethyl alcohol in saccharine sorghum silage. It should be added here that the saccharine sorghum silage is the only one in which we have found formic acid to be present and this is quite likely due to the fact that formic acid is one of the oxidation products of acetylmethylcarbinol.

As stated above, a further test will be made on the fresh silages this Fall to determine whether or not acetylmethylcarbinol is present in the fresh silage made from field crops that are usually used for this purpose.

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COURSE OF REACTION IN EXPLOSIONS OF DILUTE CS-AIR MIXTURES

By G. R. STEWART AND JOHN S. BURD

Received June 29, 1918

The enormous destructiveness of ground squirrels, and the great practical benefits resulting from any improvement in methods of coping with these pests, recently led us to undertake field and laboratory studies on the effects of various gases believed to be effective as killing agents. The results of this work are, for the most part, printed elsewhere,¹ the present paper being confined to that phase of our experiments which may be of technical interest to chemists.

Carbon disulfide, the compound which we have to consider, is extensively used in attempts to exterminate ground squirrels. Two general procedures are commonly followed in its application. One of these is to pump the vaporized carbon disulfide into the burrow; the other method consists in saturating an absorbent cloth with liquid carbon disulfide, placing the same within the mouth of the burrow and igniting.

Considerable difference of opinion exists among practical men as to the relative efficiencies of the two methods. This is doubtless due to the fact that conditions vary so much in the field that one method may be superior under a given set of conditions and quite inferior under other circumstances. It seems clear, however, that the effectiveness of both procedures depends upon two factors, toxicity of the disulfide or its combustion products, and the rate of dissemination of the toxic gases into the subterranean passages of the burrow. Any comprehensive study

¹ Stewart and Burd, "Control of Ground Squirrels by Fumigation Methods," *Bulletin, Cal. Agr. Expt. Station*, 1918. In preparation.

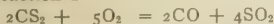
of the problem should have reference to both of these factors and be based upon definite data as to the probable amounts and concentrations of the disulfide and its combustion products.

In general, about $1\frac{1}{2}$ oz. of carbon disulfide are used for each burrow, but since the burrows vary in length and their volumes cannot be anticipated in practice, there is doubtless considerable variation in the concentration of the resulting gaseous mixture. As a result of numerous observations made by us and by Joseph Dixon¹ we have concluded that 2 to 6 per cent of disulfide represent the reasonable limits of the probable concentration obtaining in ordinary field practice. In our work we have used several concentrations as conventional approximations to average practice.

It is generally assumed that the combustion of carbon disulfide in dilute mixtures with air (excess oxygen) results in the formation of equivalent amounts of carbon dioxide and sulfur dioxide exclusively. The work reported hereafter shows that such is not the case with reference to explosion caused by an electric spark under the controlled conditions of the laboratory. Furthermore we have demonstrated, spectroscopically, the presence of carbon monoxide in the blood of squirrels killed in artificial burrows when the gas was ignited with a flame. We have also found this compound in the mixed gases to which the animals were subjected.

Two reactions suggest themselves as being the more probable result of carbon disulfide combustion.

Reaction I



1 Vol. + $2\frac{1}{2}$ Vol. = 1 Vol. + 2 Vol. + $\frac{1}{2}$ Vol. (contraction)

Reaction II



1 Vol. + 3 Vol. = 1 Vol. + 2 Vol. + 1 Vol. (contraction)

It is furthermore quite possible that both reactions take place and also that a small portion of the carbon disulfide remains as such. Another possibility is that elemental sulfur may separate and that some of the sulfur dioxide goes over to sulfur trioxide. We have demonstrated in the laboratory in CS_2 -air mixtures (excess of oxygen) detonated by means of an electric spark, the presence of carbon disulfide, carbon monoxide, carbon dioxide, and sulfur dioxide. It is evident that all of these substances in varying degree may be present and contribute to the death of the animals when carbon disulfide is ignited in the burrow.

It will be noted in both reactions as written that two volumes of sulfur dioxide result from the combustion of one volume of carbon disulfide. The sulfur dioxide determination thus becomes valueless as distinguishing between the two reactions and is only useful to show the completeness of decomposition of the disulfide or as a check on other determinations. If the decomposition is complete as shown by formula-

¹ Dixon, 1918. Manuscript, Museum of Vertebrate Zoology, University of California.

tion of the equivalent amount of sulfur dioxide and the absence of carbon disulfide in the residual gases, determinations of other constants should indicate the course of the reaction.

DISCUSSION OF EXPERIMENTS

(1) **HEMPEL PIPETTE (OVER WATER)**—The water of course immediately absorbed a portion of the sulfur dioxide formed, making it necessary to remove the water from the apparatus and titrate with iodine solution. The observed contraction therefore had to be corrected for the dissolved sulfur dioxide. Both the measurement of contraction and of sulfur dioxide are inconvenient in this apparatus. A number of determinations (4 per cent carbon disulfide in air) gave varying figures for sulfur dioxide + contraction and we were always in doubt as to whether this was due to incomplete recovery of sulfur dioxide or to a loss of gas from the apparatus at the time of detonation. Furthermore, the amounts of carbon dioxide and residual oxygen varied materially in each experiment. This method was therefore abandoned.

(2) **HEMPEL PIPETTE (OVER MERCURY)**—The mercury invariably filmed over with mercuric sulfide, thus vitiating both the sulfur dioxide and the contraction determination so that it was deemed preferable to try more promising methods than to attempt to determine the minute quantity of sulfur in the large mass of mercury.

(3) **CLOSED CONTAINERS WITHOUT HYDROSTATIC SEAL**—The preceding experiments and the further fact that the course of reaction over water and mercury might be very different from that in the field led us to conduct experiments in closed containers. Preliminary experiments in which the gas was caused to explode in heavy bottles (equipped with mercury manometer) under atmospheric temperature and pressure (initial) showed considerable variation in the contractions computed from the diminution of pressure after explosion and cooling to the initial temperature. In these experiments the bottles were equipped with rubber stoppers, and although these were tied in and great care was taken to avoid leakage we were never quite certain whether the aberrations in the contractions were due to leakage at the time of the very violent explosion or to variations in the course of the reaction. We therefore had recourse to an iron bomb especially constructed for the purpose.

(a) **IRON BOMB EXPERIMENTS**—This bomb had the advantage of giving large volume (1075 cc.) and a tight container. It was found necessary, however, to lute the electrodes and pet cocks with litharge to make the container tight. The presence of this substance as well as the nature of the material of the bomb (iron and possibly a little oxide of iron) doubtless vitiated the sulfur dioxide determination but the results on carbon dioxide and residual oxygen are indicative of the character of the reactions which are likely to take place in the ignition of carbon disulfide.

In two experiments we recovered an amount of carbon dioxide practically equivalent to the amount of carbon disulfide in the mixture, but the amount

TABLE I—PRODUCTS OF COMBUSTION OF CARBON DISULFIDE
(Ignited by electric spark)

(Ignited by electric spark)												
		DETERMINED				COMPUTED						
		<i>a</i>	<i>b</i>	<i>c</i>	<i>d</i>	<i>e</i>	<i>f</i>	<i>g</i>	<i>h</i>	<i>i</i>	<i>j</i>	<i>k</i>
		CS ₂	CO ₂	O ₂	SO ₂	CS ₂ after	O ₂	O ₂	CO after	CS ₂ after	CS ₂ Unde-	SO ₂ = C =
		Used	Recov- ered	Con- sumed	Recov- ered	Reaction II	Consumed	Consumed	Reaction I	Reaction I	composed	CO ₂ + CO
		(<i>a</i>)	(<i>b</i>)	(<i>c</i>)	(<i>d</i>)	(from <i>b</i>)	(3 × <i>e</i>)	(<i>g</i> - <i>f</i>)	(<i>g</i> + 2½ <i>f</i>)	(<i>i</i> = <i>h</i>)	(<i>a</i> - (<i>e</i> + <i>i</i>))	2(<i>b</i> + <i>h</i>)
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
EXPT. No.	CONTAINER											
2.....	Iron bomb	4.0	2.3	9.6	...	2.3	6.9	2.7	1.1	1.1	0.6	6.8
6.....	Iron bomb	4.0	2.7	9.2	...	2.7	8.1	1.1	0.4	0.4	0.9	6.2
8.....	Glass bomb	2.5	1.4	5.9	4.1	1.4	4.2	1.7	0.6	0.6	0.3	4.0
9.....	Glass bomb	2.5	1.1	5.5	4.0	1.1	3.3	2.2	0.9	0.9	0.5	4.0
10.....	Glass bomb	2.5	1.1	5.0	3.8	1.1	3.3	1.7	0.7	0.7	0.7	3.6

TABLE II—SUMMARY OF COURSE OF REACTION

EXPT. No.	CONTAINER	EFFECT ON CS ₂ ¹				PRODUCTS RESULTING ²			
		CS ₂ Used Per cent	CS ₂ after Reaction II Per cent	CS ₂ after Reaction I Per cent	CS ₂ Undecomposed Per cent	CO ₂ Per cent	CO Per cent	CS ₂ Per cent	SO ₂ Per cent
2.....	Iron bomb	4.0	57.5	27.5	15.0	2.3	1.1	0.6	10.4
6.....	Iron bomb	4.0	67.5	10.0	22.5	2.7	0.4	0.9	10.8
8.....	Glass bomb	2.5	56.0	24.0	20.0	1.4	0.6	0.5	14.1
9.....	Glass bomb	2.5	44.0	36.0	20.0	1.1	0.9	0.5	14.5
10.....	Glass bomb	2.5	44.0	28.0	28.0	1.1	0.7	0.7	13.0

¹ Expressed as percentages of the CS₂ used. ² Expressed as percentages of the original gas mixtures.

of oxygen consumed was materially less than three times that of the carbon dioxide (theory after Reaction II), pointing to the formation of elemental sulfur or to metallic sulfides by secondary reactions.

(b) GLASS BOMB EXPERIMENTS—The defects of the iron bomb due to the presence of oxides of lead and iron which might influence the course of the reaction as well as prevent determination of the end products due to secondary reactions, led us to return to the use of glass as being the more suitable material for a container. In the following experiments we used a large (2-liter) separatory funnel, equipped with electrodes and a tubulure for introducing the gas. The gaseous mixture in these and also in the iron bomb experiments was obtained by introducing the proper amount of liquid carbon disulfide into each of a train of 4- to 50-liter carboys. The bomb was connected at one end of the train and water pressure applied at the other. A stream of the gaseous mixture was thus forced through the bomb and a considerable amount wasted before the process was interrupted, thus insuring the complete displacement of air and its replacement by the proper concentration of the mixture for experiment.

As indicated in the table, we have computed all results from the amount of carbon disulfide used, the amount of carbon dioxide recovered, and the amount of oxygen consumed, finally deriving the amount of sulfur dioxide equivalent to the carbon dioxide found and carbon monoxide computed. A comparison of the sulfur dioxide computed (Column *h*) with the sulfur dioxide found (Column *d*) gives a measure of the degree of accuracy of the procedure. We regard the differences shown as within the limits of variation to be expected in gas explosions when working on dilute gas mixtures.

In Expt. 9 we determined total sulfur (gravimetrically) in the exploded gases from the bomb and found the equivalent of 190 mg. of sulfur dioxide as against 181 mg. computed from the gas analysis. This is probably within the limits of analytical error and in any event makes it highly improbable that sulfur trioxide is a normal product of the combustion.

As stated heretofore, qualitative tests of the residual gases always indicated the presence of carbon mon-

oxide and carbon disulfide. A logical step would be to make the examination of the residual gases quantitative and confirm beyond criticism the results given heretofore. We made numerous attempts to do so and all resulted in complete failure for various reasons, some of which may be indicated. We were unable to find any non-volatile reagent which would absorb carbon disulfide quantitatively when present in such small quantities (less than 1 per cent); trials of solutions of metallic sulfides, of miscible vegetable and mineral oils, all resulted in failure, giving figures greater or less than theory on dilute mixtures of carbon disulfide of known concentration. Attempts were made to utilize the very precise combustion apparatus designed for gas analysis by the United States Bureau of Mines in the hope of being able to obtain figures for sulfur dioxide and contraction for the computation of carbon disulfide and carbon monoxide. It was found, however, that mercuric sulfide was formed immediately on passing the spark, thus preventing measurement of sulfur dioxide and estimation of contraction.

It seems clear that the only satisfactory method of determining carbon disulfide in the presence of carbon monoxide in such low concentrations is to "freeze out" the carbon disulfide and burn the residual carbon monoxide to carbon dioxide. At this juncture we concluded that further expenditure of time on this determination was not justifiable inasmuch as all of our previous work showed that the principal reaction is variable even under the controlled conditions of the laboratory. These variations would seem to require explanation, but any one who has worked with gas combustions will appreciate the fact that such variations will appear even under careful control. Imperceptible variations in the conditions are bound to occur, such as variation in the tension, continuity, and shape of the electric spark and may have appreciable effects on the reaction.¹ Finally the great variations in the conditions prevailing in the field would seem to make unnecessary a very precise measurement of these end products or additional experiments on the principal reaction. It is hoped, however, that our ex-

¹ Burrell and Oberfell, "The Limits of Inflammability of Mixtures of Methane and Air," U. S. Bureau of Mines, Technical Paper 119, 1-29.

perience as here set forth may be of use to others working with sulfur gases.

CONCLUSIONS

QUALITATIVE RESULTS—Combustion of carbon disulfide in dilute mixtures with air always results in the formation of carbon dioxide, carbon monoxide, sulfur dioxide, and some residual carbon disulfide. The formation of sulfur trioxide does not appear to take place. The formation of elemental sulfur was not observed, but sulfides were indicated in several experiments when metals were present. We ascribe this sulfide formation to secondary reactions not likely to occur in the field.

VARIATIONS IN THE RESULTS—Some variation in the reaction appears to take place even under laboratory conditions. Inasmuch as the conditions must vary much more in the field than in the laboratory, multiplication of laboratory experiments to secure greater concordance seemed unnecessary.

CHARACTER OF THE REACTIONS—In the experiments in the glass container which are regarded as the more reliable, from 40 to 60 per cent (in round numbers) of the initial amount of carbon disulfide followed Reaction II, from 25 to 35 per cent followed Reaction I, and 15 to 30 per cent remained undecomposed.

RESULTING GAS MIXTURE—The character of the resulting gas mixture, quantitatively considered, depends more upon the initial carbon disulfide concentration than upon variation in the reaction. With $2\frac{1}{2}$ per cent carbon disulfide the oxygen content of the air is reduced from approximately 20 to about 15 per cent, and the carbon dioxide increased to about 1 per cent; carbon monoxide and carbon disulfide approach, but seldom exceed, 1 per cent, but sulfur dioxide appears to the amount of about 4 per cent.

TOXICITY OF RESULTING GAS MIXTURES—Carbon disulfide is quite toxic to squirrels. Two per cent gas kills normal animals in less than 15 min.¹ The residual carbon disulfide always found must be an important factor in the toxicity of the exploded gases. Sulfur dioxide is also quite toxic but not so virulent as carbon disulfide. Two per cent sulfur dioxide kills in about 45 min. Although we have conducted a great many experiments with animals we have observed no indication that the depletion of the oxygen or the presence of small quantities of carbon dioxide contributes materially to death. We ascribe some effect to the small amounts of carbon monoxide but death would probably ensue in approximately the same time in the absence of this gas.

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LABORATORY AND PLANT

THE WEBB PAPER TESTER—A NEW INSTRUMENT FOR TESTING CORRUGATED FIBER BOARDS

By J. D. MALCOLMSON
Received October 7, 1918

Corrugated fiber boxes, when used as containers for freight shipments, must meet certain railroad specifications. The most important of these specifications states that the fiber boards used in the construction of the box shall have a certain minimum thickness and must show a specified minimum "bursting test."

These tests of the bursting strength are at present made with a regular Mullen paper tester. While this machine was not originally intended for testing corrugated boards, it is used because, until very recently, there has been nothing else available. Owing to the unsatisfactory results which ensued from this use of the Mullen tester on corrugated boards, a machine known as the Webb Tester has recently been developed especially for testing this product.

It is the object of this paper to give a description and summary of the results obtained in an investigation of this tester carried out at the Mellon Institute.

Corrugated fiber boxes are made of what is known as double-faced corrugated board. These faces consist of tough fiber board ranging from 0.016 in. to 0.030 in. in thickness, and are made of a mixture of waste paper and new fiber. The percentage of the latter depends upon the resulting strength desired and may vary from 0.0 to 100.0 per cent. These faces are pasted to a corrugated "liner" of strawboard about 0.009 in. thick to make the finished board (Fig. 1).

During the past eighteen months, the Mellon Institute has been conducting an investigation of the Mullen and Webb testers and their application to this product. The results of this investigation have shown that the Mullen machine is not adapted to testing a corrugated fiber board, while the Webb machine gives a much more accurate value of the strength of such a board.

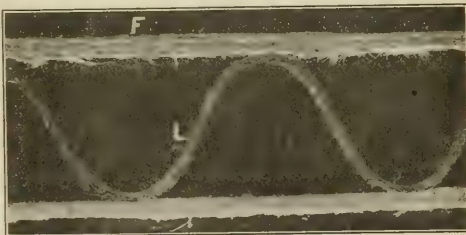


FIG. 1

The fundamental difference between the two testers is that in the case of the Mullen the board as a whole must first be firmly clamped in the machine, thus crushing the corrugations, and a puncture test of the board is then made. The puncturing medium is a rubber diaphragm actuated by hydrostatic pressure. In the case of the Webb machine, the component parts are tested separately by means of a metallic plunger actuated by a compressed helical steel spring.

¹ Loc. cit.

The initial crushing of the strawboard by the Mullen clamp causes the corrugations to flatten into irregular lumps as shown in Fig. 2. These alternate ridges and hollows weaken the faces of the board to such an extent that the Mullen values are often less than those shown upon testing the two facings with the strawboard entirely absent. Moreover, the facings often burst separately, which prevents a true test of the combined board and often gives a value only slightly higher than that of a single facing. Table I is a typical instance of the effect on Mullen values caused by tightening the clamp over a sample of corrugated board.

TABLE I

Typical Mullen results on corrugated board and on the components of the same board. Clamp brought down tight in each case. Board Sample No. 100.

SAMPLE	MULLEN RESULTS	AVERAGE Lbs.
Complete corrugated board (two facings and corrugated strawboard).....	175-169-160-176	170
Two facings and flat strawboard.....	235-211-237-210	228
Two facings only.....	180-187-204-192	191

From the standpoint of the Mullen test, therefore, the corrugated structure often appears to be a source of weakness, instead of additional strength. The new machine was developed in an attempt to remedy these irregularities, by testing a finished board in such a way that the trussed structure is not first destroyed.

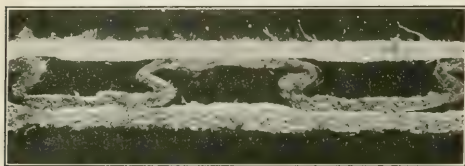


FIG. 2

In order to do this, the Webb machine was designed to test separately the component parts of a corrugated board. Since this is impossible with the Mullen tester, it was necessary to approach the problem from a new angle. This was accomplished by using a steel plunger, one-tenth of an inch in diameter, as a puncturing means, in place of the rubber Mullen diaphragm, which is slightly over one inch in diameter.

By using a plunger of this size, it is possible to attack the small portion of facing lying between the tips of the corrugations, thus avoiding the straw and the adhesive used in gluing these tips to the facing.

In order to prevent the facing from bending under the pressure of the plunger, it is necessary to have a firm bearing beneath the test area. It is also desirable to be able to test the components of a box, without first tearing up the box. These objects are accomplished by means of a finger-shaped attachment which fits snugly into the corrugation immediately under the spot to be tested. This steel finger is a fixed part of the machine and has a circular "well" drilled in it, slightly larger than the plunger. When the puncture occurs, the plunger, together with the paper torn loose by the puncture, is received by this well.

When testing flat sheets, such as ordinary paper, "solid fiber" board, etc., the upper part of the machine

can be slipped into a lower level in the bed plate, thus concealing the finger. Figs. 3 and 4 illustrate these two positions.

In appearance, the Webb tester is roughly the size and shape of an ordinary desk telephone. Pressure is applied to the plunger by means of a helical steel spring surrounding the upper part or "barrel" of the plunger. This spring is compressed by turning a small hand-wheel, the force being transmitted by suitable gearing. A dial, actuated by a rack and pinion, measures the deflection of the spring and is calibrated to read in pounds per square inch.

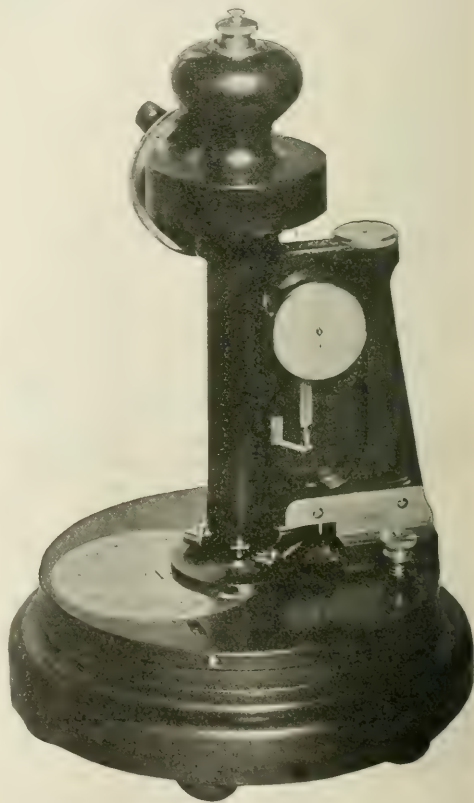


FIG. 3

This method of measurement is based upon the application of Hooke's law of elasticity—that the deflection of a steel spring is accurately proportional to the stress applied, provided that the elastic limit of the spring is not reached.

In order to avoid introducing a new set of units to the trade, the dial on the new tester was first calibrated against the Mullen tester. This was done as accurately as possible, using so-called perfect paper. This latter was a high quality drawing paper having as smooth and even a texture as it was possible to find, and had a bursting strength of approximately 100 lbs.

per sq. in.¹ After locating this point as exactly as possible on the new machine, the dial was then divided into equal units from 0 to 600 lbs. per sq. in., based on the deflection of the spring. This is the usual method of calibrating helical springs, such as spring balances, drawbar springs on railroad dynamometer cars, etc.

It is possible to calibrate the new machine with the Mullen in this way, because it has been found that the Mullen tester will give reliable results when used on flat sheets of well-made, even-textured paper. As will be shown later, however, the Mullen results tend to become erratic when the coarser texture of fiber facings and boards are encountered.



FIG. 4

In testing a flat, single sheet on the Webb machine, the sample is placed on the bedplate between the well and the plunger and held firmly with the clamp. This clamp is operated by a spring and cam and results in a constant pressure.²

After securing the sample in this manner, the dial is set at zero, and by turning the small handwheel the spring and plunger are moved downward inside the outer barrel as a unit until the plunger touches the

¹ Keuffel and Esser's "Ariston" Brand, caliper 0.0135 in.

² It has been found in the case of the Mullen machine that the results can be varied by using different clamp pressures on the variable pressure clamp used on that machine.

sample. Up to this point there has been no deflection in the spring, so that the dial does not begin registering until the plunger touches the sample.

At this point, the plunger's motion ceases and continued turning of the handwheel commences to build up compression in the spring, which compression is registered on the dial in terms of pounds per square inch. This is continued until the paper fails, when the plunger suddenly bursts through. The hand on the dial automatically stops at the instant of rupture, since the dial is adjusted to show only the compression in the spring.

For testing the complete corrugated board, the upper part of the instrument is slipped into the higher level in the bedplate, thus allowing the steel finger to be exposed (Fig. 4). This finger is shaped to fit exactly into one corrugation of the strawboard. By this means, each facing must be tested separately. The machine is so designed as to make it impossible to puncture the entire board at once.¹

The capacity of the tester is about 600 lbs. per sq. in., and the spring is sufficiently oversize to have a large factor of safety. Due to this, the deflection of the spring is at all times within its elastic limit. During the past twelve months, between 10,000 and 12,000 punctures have been made with one machine, and no variation has been noted in the action of the spring. Samples used in these tests have ranged from tissue paper to solid fiber board testing slightly over 500 lbs. per sq. in. Tests made one year ago on the "perfect paper" used for calibration have just been repeated, using the same sample. The results agreed with the former measurements within 2.0 per cent, which variation is no larger than the average variation between individual punctures.

It has been found that the readings on the Mullen tester on fiber boards can be varied to a considerable extent by varying the speed of the handwheel which builds up the hydrostatic pressure. Table II shows some typical Mullen results obtained on the same corrugated board by using varying wheel speeds.

TABLE II—MULLEN TESTS WITH VARYING WHEEL SPEEDS
SAMPLE NO. HS175

Handwheel Speed R. P. M.	Average of 10 Punctures Lbs.	Maximum Lbs.	Minimum Lbs.
30	181.1	195	147
120	192.0	209	165

In order to avoid this source of error in the new machine, the gearing is arranged in such a manner that the limits of speed at which the small wheel can be turned by hand make a hardly perceptible variation in the speed at which the plunger descends.

¹ In addition to the regular model, the Webb tester is made in a pocket size. This style resembles an ordinary micrometer. The operating principle is similar to that of the larger machine, namely, a helical steel spring actuating a steel plunger. In this case the spring is compressed directly by turning a knurled sleeve on the barrel and the values are read upon this barrel as in the case of a micrometer. The plunger and supporting finger are identical with those on the larger machine.

This smaller instrument has been calibrated against the larger one, and while not so sensitive is valuable as a preliminary, or minimum tester, since it will quickly indicate whether a box is above or below its specification. A loaded box can be tested by cutting a small slit in one of the flaps and inserting the steel finger. With this instrument, the box can be tested *in situ* without disturbing its contents. This model is compact and inexpensive and could be supplied to railroad inspectors, purchasing agents, etc.

Due to the method of its manufacture and to the nature of the raw materials used, fiber board usually contains many minute pieces of undigested wood and other impurities. These do not detract from the strength of the board in a shipping container, but when tested on the Mullen machine the soft rubber diaphragm will invariably find any such particle in its square inch of area and the rupture will start at this point. This causes an abnormally low reading and as a result the Mullen tends to reflect the average of the minimum values of a board instead of the true average. This may be demonstrated readily by applying the diaphragm to an area in which a pin-hole has been made and comparing the resulting low reading with that obtained from another area which has no pin-hole. Table III, illustrating this fact, shows the results of drilling holes of various sizes in the test area.

TABLE III—DEPRESSION OF MULLEN TEST CAUSED BY DRILLING A SINGLE HOLE IN THE MULLEN TEST AREA OF SAMPLE
AVERAGE OF 10 MULLEN TESTS

Diameter of Hole Inch	Drawing Paper 0.012 In. Thick	Fiber Facing Board 0.016 In. Thick	Fiber Facing Board 0.017 In. Thick
	Lbs.	Lbs.	Lbs.
None	97	98	80
0.013	93	84	76
0.026	89	79	73
0.052	72	61	60
0.104	58	63	48
0.208	51	43	35

In order to determine whether the smallest of the above holes was an actual source of weakness, or only a starting point for the Mullen break, a test area was punctured with six of these holes and the Mullen diaphragm applied. The break started at only one hole and the other five holes were not encountered by the break. In other words, six holes did not depress the Mullen reading more than one hole.

To avoid this source of error, the plunger of the new machine is made of metal. The small area attacked, together with the fact that the face of the plunger is metallic, tends to give a better average of the sample. Thus, a low reading will be reflected only when the plunger comes directly over an impurity. These impurities are, with few exceptions, smaller than the Webb plunger face and therefore do not have an abnormal effect on the Webb average results. It will be seen from Table III that one small impurity in a circle of over one inch diameter is sufficient to lower the Mullen result, whereas the Webb plunger would make about 150 punctures in the same area without encountering this speck.

As stated above, the two testers give similar results on the "perfect paper." When testing fiber boards, however, the new machine usually gives higher results than the Mullen and this divergence is, in general, in direct proportion to the percentage of minute impurities in the sample.

Table IV gives some typical instances. The impurities described above are designated "screenings."

The face of the Webb plunger has no sharp edges, and in making a puncture it does not cut its way through the sample, but tears the fibers apart as shown in Fig. 6. The use of a metal plunger also insures a definite area of contact, in contrast with the area of a

rubber diaphragm, which varies under different pressures.

TABLE IV—MULLEN AND WEBB TESTS ON FLAT SAMPLES OF VARYING TEXTURE

SAMPLE	Caliper Inch	Appearance	MULLEN RESULTS		WEBB RESULTS	
			Average	No. of Tests Averaged	Average	No. of Tests Averaged
"Perfect Paper"	0.0135	Very even	96.9	10	97.05	10
Arena Bond	0.0033	Even	34.0	7	33.80	10
Fiber Facing No. 205	0.017	Fairly smooth	101.0	10	108.00	10
Fiber Facing No. 169	0.018	Screenings	86.0	10	111.00	10
Fiber Facing No. 171	0.023	Screenings	103.0	10	123.00	10

In addition to the puncture test, the Webb machine is fitted with attachments for measuring tensile strength, percentage elongation, and also deflection of the corrugations when under compression. These linear measurements are recorded on a small micrometer dial, graduated in thousandths of an inch, which is geared to the plunger in such a way that it indicates and measures its downward movement.

The attachment for measuring tensile strength is not shown in Figs. 3 and 4, but consists of two clamps, one being stationary and attached to the upper frame of the machine, while the other is fixed to and actuated by the downward movement of the plunger in such a manner as to give a direct, vertical pull on the test strip. This attachment is designed to test the tensile strengths of the various components of a corrugated fiber container, such as the gummed taped joints, facing boards before and after bending, etc.

Tests on fiber sheets made in this manner indicated that most samples are much stronger in the "machine" direction than in the "cross" direction. Elongation tests indicated that the cross direction fibers often stretch from three to five times as much as those in the machine direction under the same tension. Table V shows some typical results illustrating this point.

TABLE V—TENSILE TESTS OF TYPICAL FACING BOARDS
TENSILE STRENGTH 1/2 INCH WIDTH

SAMPLE No.	MACHINE DIRECTION		CROSS DIRECTION		Machine- wise Elongation Divided by Crosswise Elongation
	Webb Units	Lbs. per 1/2 in. Width	Webb Units	Lbs. per 1/2 in. Width	
3-L	426	46	183	19.7	4.0
162	205	22	123	13.2	3.2

Due to these facts, the advancing Mullen diaphragm causes the cross fibers to stretch, thus throwing the load on the machine-direction fibers, which finally rupture. This very likely accounts for the fact that all Mullen ruptures are invariably "across the grain" of the paper (Fig. 5). Thus, it would seem that a Mullen test is in reality a test of the machine direction fibers only.

In order to study this effect, a test was made of a series of fiber facing boards having varying proportions of their fibers in the machine direction. These samples were similar in their other physical properties. The proportion of fibers in the machine direction was determined by tensile and elongation tests, as described elsewhere in this paper. It was found in every case that the samples having the greatest proportion of fibers in the machine direction showed higher

Mullen results than the samples whose fibers were more evenly distributed in all directions. A high Mullen test in this connection is not a true indication of strength, because, owing to the method of its manufacture, a loaded corrugated box has, with very few exceptions, eight of its twelve edges exerting tension across the machine direction fibers.



FIG. 5—TYPICAL BREAK MADE BY MULLEN TESTER ON 100 LB FIBER FACING. ACTUAL SIZE

In order to make a good shipping container, the fibers making up the structure of a box should be "felted" in all directions. The above tests show that to do this, it is necessary to increase the proportion of the cross-direction fibers. The only way to do this without increasing the thickness of the paper is to decrease the excess of fibers in the machine direction. The result is a lowering of the machine direction tensile strength, but a raising of the cross-direction tensile strength. Comparison of the breaks made by the two machines (Figs. 5 and 6) shows that the tendency of the round metallic Webb plunger is to take into account all of the fibers regardless of their direction.

These variations in the tensile strength of a fiber board (depending upon the direction in which the test is made) are emphasized by the use of a wedge-shaped plunger in place of the round plunger mentioned above. This plunger has a rounded rectangular face 0.10 in. long by 0.07854 in. wide and gives the same readings as the round plunger and the Mullen tester on the "perfect paper" described above. When substituted, however, for the round plunger and applied to fiber boards, fabrics, etc. (which have variations in tensile strength depending upon the direction of the test), the action of this wedge plunger is very marked. Thus, when the plunger is applied parallel to the machine direction, a much lower reading is registered than when applied at right angles to this direction. This action is explained by the fact that in the first instance the plunger's tendency is to cut only the weaker transverse fibers (or wool threads), while in the second instance the strong, machine-direction fibers (or warp threads) are cut.

This wedge plunger, therefore, offers a ready means of determining the minimum strength of a sample when it is not desirable to make actual tensile tests.



FIG. 6—TYPICAL BREAK MADE BY WEBB TESTER ON 100 LB FIBER FACING X 12

CONCLUSIONS

The Webb tester and its various attachments have been carefully investigated in this laboratory. In making these tests, several hundred samples of corrugated board, representing practically all the varieties known to the trade, have been collected. These samples were all studied and the data tabulated as follows:

- 1—Raw material used (as revealed by the microscope).
- 2—Physical properties, such as bending quality, thickness, etc.
- 3—Degree of water-proofing, if any.
- 4—Degree to which fibers had been "felted" or "formed," as indicated by tensile strength and elongation in machine and cross directions.
- 5—Appearance (impurities, "screenings," etc.).
- 6—Certified strength.
- 7—Actual Mullen tests of
 - (a) Components before assembling.
 - (b) Finished board.
- 8—Actual Webb tests.

Previous to the invention of the new tester, this laboratory had devoted nearly a year to attempting to adapt the Mullen machine to testing corrugated fiber products. No practical method was found for doing this.

SUMMARY

I—The Webb tester is correctly designed and constructed from a mechanical standpoint.

II—The Webb tester gives a more accurate measurement of the value of paper products (especially corrugated fiber board) than is possible by the use of the Mullen tester.

III—In addition to the puncture test, the Webb machine may be used for tensile tests, elongation tests, and compression tests. The tensile test, especially when "across the grain," is an important index of the value of a fiber box as a shipping container. This "across the grain" value may also be found more quickly by a puncture test, using the "wedge" plunger.

IV—The pocket-size model makes it possible to test corrugated boxes under conditions which are impossible at present.

V—Besides corrugated products, the Webb machine can be used for testing many other flat substances, such as paper, cardboard, "solid fiber" boards, gummed tape, fabrics, etc.

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LEAD IN PHARMACEUTICAL ZINC OXIDE

By W. D. COLLINS AND W. F. CLARKE

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Soon after the outbreak of the present war, difficulty was experienced in obtaining pharmaceutical zinc oxide which would meet the requirements of the *United States Pharmacopoeia*. When the matter was first considered, the statement was made that zinc oxide of the required purity was very easy to obtain. It was even stated that material bought for use as a pigment in painting might be more nearly free from lead than a certain sample of pharmaceutical zinc oxide which contained about 0.2 per cent of lead.

Mr. C. L. Black of the Philadelphia Station of the Bureau of Chemistry reported in May 1917 that analysis of such samples of zinc oxide as could be procured on the market at that time indicated that practically all the zinc oxide obtainable contained more lead than was permitted by the *U. S. P.* test. Some manufacturers at this time stated on the labels that the zinc oxide sold by them contained heavy metals slightly in excess of the *U. S. P.* limit. Prof. C. H. La Wall¹ published an article calling attention to this matter and made the suggestion that all samples of pharmaceutical zinc oxide should be tested for lead.

In order to learn whether it would be possible to obtain zinc oxide reasonably free from lead, samples were obtained on the market and from manufacturers, and the question was taken up with

the U. S. Geological Survey and with manufacturers of zinc oxide. It was learned from Mr. C. E. Sieben-thal of the U. S. Geological Survey that one company producing zinc in the United States owned a mine which contained no lead minerals and, therefore, should be able to produce zinc oxide free from lead. It would seem probable that zinc oxide made from electrolytic zinc should be free from lead. It was learned from manufacturers that zinc oxide was being made according to both of these principles, and that the products contained much less lead than the amount necessary to respond to the *U. S. P.* test for heavy metals.

TEST FOR LEAD IN ZINC OXIDE BY THE *U. S. P.* TEST FOR HEAVY METALS

In order to determine the sensitiveness of the *U. S. P.* test for lead in zinc oxide, two series of experiments were conducted entirely independently in order to establish the limits of sensitiveness. Different quantities of lead from a solution of lead nitrate were made up with zinc oxide and hydrochloric acid so as to give the concentrations of zinc and acid prescribed by the *U. S. P.* for the test for heavy metals. In one series of tests (W. F. C.), the hydrogen sulfide used was made according to the directions of the *Pharmacopoeia*. In the other series of tests (W. D. C.), the hydrogen sulfide used was prepared in the ordinary manner by the use of hydrochloric acid and ferrous sulfide and the gas was washed through water. No difference could be detected in the results by the two methods.

It was found that a sample of zinc oxide might contain as much as 0.05 per cent lead and fail to test for heavy metals. In some cases would be obtained and in others it would fail. The sample contained as much as 0.1 per cent, a test was always obtained and with any amount than 0.05 per cent there was rarely any doubt the response to the test.

SAMPLES

A number of samples of zinc oxide were purchased at various drug stores. Some samples were furnished by manufacturers and others were obtained from dealers through the regular purchasing office of the Bureau.

TABLE 1—ZINC OXIDE

SAMPLE NO.	Received	Dealer	Producer or Manufacturer	Lead Per cent	U. S. P. Test	Remarks
117	1-14-17	A	?	0.25	+	Purchased at local drug store
118	1-16-17	B	C	0.036	0	Purchased at local drug store
119	1-16-17	A	?	0.25	+	Purchased at local drug store
133	8-4-17	D	E	0.19	+	Purchased at local drug store
134	8-4-17	F	C	0.19	+	Purchased at local drug store
137	8-6-17	B	C	0.26	+	Purchased at local drug store
130	1918	H	H	0.041	0	From Bureau stock of reagents
148	9-27-17	I	I	0.006	0	Show sample from office of manufacturer
158	11-28-17	I	I	0.004	0	Sample sent by manufacturer
159	11-29-17	I	I	0.008	0	Sample sent by manufacturer
155	11-5-17	C	K	0.013	0	Purchased by Bureau Supply Office
178	2-1-18	H	I	0.004	0	Purchased by Bureau Supply Office
187	2-4-18	L	I	0.008	0	Purchased by Bureau Supply Office
METALLIC ZINC						
149	1914		M	0.026		Analysis on label, lead 0.01 per cent
145	1917	N	M probably	0.094	..	Analysis on label, lead none
146	9-26-17		K	0.017		Sample furnished by manufacturer
PIGMENT ZINC OXIDE						
145	8-4-17	O	..	0.13	Trace	About 22 per cent barium sulfate
136	8-4-17	P	..	53.2	Heavy	

¹ *Am. J. Pharm.*, **89** (1917), 353-5. In a later article (*Ibid.*, **90** (1918), 499), Professor La Wall notes that *U. S. P.* zinc oxide is now on the market. He proposes tests for lead which will detect 0.03 per cent PbO in zinc oxide, while the present *U. S. P.* test under the best conditions will detect 0.05 per cent.

Samples of zinc oxide were also purchased at two paint stores. A few samples of metallic zinc were examined for their content of lead.

METHOD OF ANALYSIS

Lead was determined by the well-known method of separating as sulfate and weighing as chromate. From 5 to 40 g. of zinc oxide or zinc were dissolved in water and sulfuric acid, with a slight excess of acid. The volume was usually about 100 cc. for 10 g. of zinc oxide. Alcohol (95 per cent) was added in quantity just short of that necessary to start precipitation of the zinc sulfate, usually making about one-third of the final volume. The solution was allowed to stand over night; the lead sulfate was filtered off on asbestos, washed with 50 per cent alcohol, and dissolved in ammonium acetate. The lead was reprecipitated as chromate, after acidifying with acetic acid, by adding potassium dichromate solution. After standing over night, the lead chromate was filtered on asbestos in a weighed Gooch crucible, dried to constant weight at 110°, and weighed. The accompanying table gives descriptions of the samples and the results obtained for lead, and also the results of testing according to the *United States Pharmacopoeia*.

SUMMARY

For a short time after the beginning of the war it was not possible to procure zinc oxide of the U. S. P. standard produced in the United States.

The U. S. P. test for heavy metals will not detect less than 0.05 per cent of lead in zinc oxide.

It is possible at the present time to obtain zinc oxide which, with respect to the presence of lead, is of much higher quality than is called for by the requirements of the U. S. P.

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U. S. DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

AN EFFICIENT LABORATORY FUNNEL FOR FILTERING NEUTRAL LIQUIDS, ESPECIALLY THE VOLATILE ORGANIC SOLVENTS

By T. B. ALDRICH

Received October 23, 1918

Those who have had occasion in the laboratory to collect precipitates suspended in ether, chloroform, acetone, alcohol, or mixtures of these organic solvents, especially by forced filtration, have no doubt at times experienced trouble when using the ordinary funnel and especially the Buchner funnel.

In the case of aqueous solutions, the filter paper, after being moistened and pressed closely to the funnel for the purpose of removing bubbles of air that interfere with filtration, adheres closely to the glass and filtration is ordinarily rapid, while in the case of ether, for example, the solvent being volatile passes away rapidly, and channels and spaces are formed between the paper and the funnel, the paper tending to lift from the glass. This is especially true when filtration is interrupted for a short time; in any case the formation of channels and spaces interferes with rapid filtration. When the Buchner funnel is employed

these troubles are aggravated since the precipitate and liquid tend to creep under the paper filter, especially if continuous vacuum is not maintained, thus requiring a second filtration.

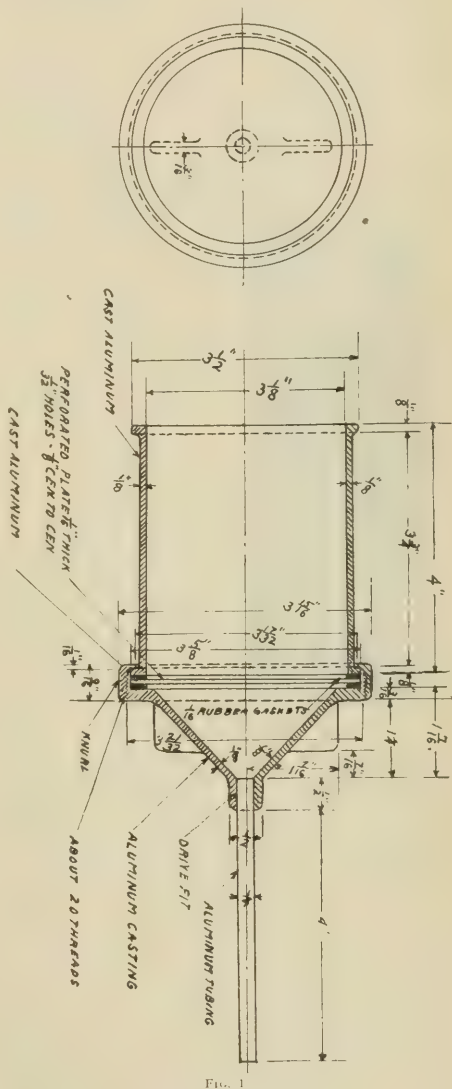


FIG. 1

The advantage of the funnel to be shortly described lies in the fact that the filter paper is clamped securely between two plates by a screw thread so that it cannot lift even when the filtration is interrupted, and thus allow the formation of channels and passages for the liquid and precipitate underneath. There is no necessity for second filtrations, and a more rapid filtration is also effected by this arrangement.

DESCRIPTION

The funnel is of aluminum and consists essentially of four parts having the following dimensions: a cast hollow cylinder approximately 4 in. high, $3\frac{1}{2}$ in. in diameter, walls $\frac{1}{8}$ in. thick, with a small flange at the top and a heavier one at the bottom, both being on the outside; a plate $\frac{1}{16}$ in. thick, perforated with $\frac{1}{32}$ in. holes ($\frac{1}{8}$ in. center to center) extending to within $\frac{1}{8}$ in. of the circumference; a ring $\frac{3}{16}$ in. wide and $\frac{1}{8}$ in. thick, threaded on the inside and milled on the outside, having a shoulder (or offset) on the upper inside which engages the lower upper surface of the shoulder of the cylinder, this latter preventing the ring from passing over the lower end of the cylinder; a cone-shaped lower portion with stem having also a flange at the top $\frac{1}{4}$ in. thick and threaded on the outside so as to mesh with the threads on the inside of the ring.

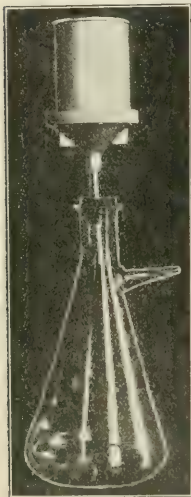


FIG. 2

In preparing the funnel for filtering it is only necessary to have the lower flange of the cylinder, the filter paper (placed on top of the plate), the perforated plate, the gasket (placed between the flange of the cone and plate), and the flange of the cone flush with one another, pass the ring with flange or shoulder uppermost over the top of the cone, screwing as tight as necessary to secure a perfect joint. A key made of hard wood and carrying two slots which engage two offsets shown in the drawing and plate, opposite each other on the lower part of the cone, facilitates the operation of tightening and loosening the parts.

Another smaller funnel having approximately the dimensions $2\frac{3}{4}$ in. \times $1\frac{1}{2}$ in. but in which the perforated plate is not separate but a part of the cone has the advantage that the rubber gasket is eliminated. In this funnel the perforated plate is depressed $\frac{1}{16}$ in. below the upper edge of the cone flange and brazed in. Here it is only necessary to place the filter paper on the top of the perforated plate and screw the ring over the cone.

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A CONVENIENT AND EFFICIENT DIGESTION APPARATUS FOR THE DETERMINATION OF CRUDE FIBER

By HOWELL D. SPEARS

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The official method of the Association of Agricultural Chemists for the determination of crude fiber in feedingstuffs calls for the use of a reflux condenser connected to the digestion container by means of a rubber stopper. The waste of time in connecting and

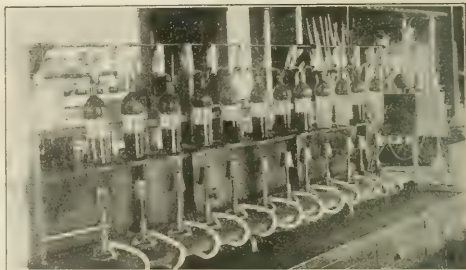


FIG. 1—THIS PHOTOGRAPH SHOWS THE APPARATUS IN OPERATION AND THE DRAWING BELOW MAKES CLEAR THE CONSTRUCTION OF THE CONDENSER FLASKS

disconnecting such an arrangement, where many determinations are to be made, and certain difficulties in its manipulation led to the construction of the simple apparatus described herein, which is designed for use with tall beakers as the digestion containers. Its convenience and efficiency have been proved by several years' satisfactory use in the feedingstuffs laboratory of the Kentucky Agricultural Experiment Station. While there may be a slight loss of water from evaporation during the boiling, on account of the condensers not being attached to the digestion containers by a tight joint, yet it is believed that the concentration of the solvents thus brought about is not enough to cause an appreciable error in the results.

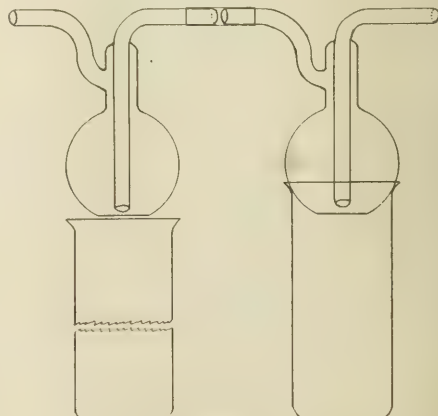


FIG. 2

The condensers are a series of round flasks, with intake and outflow tubes, connected by rubber tubing, through which flows the water for cooling. They are

suspended by loops of sheet zinc or tin, so that it is easy to lift any one of them for the purpose of putting a beaker in place or removing it or for washing down particles from the sides. The flasks are about 2 $\frac{7}{8}$ in. in diameter, so as to rest properly in the mouth of an extra tall beaker 2 $\frac{7}{16}$ in. diameter, 6 in. tall, and of about 375 cc. capacity.

The addition of a few drops of amyl alcohol to prevent foaming also prevents material from creeping up the sides of the beakers.

The following are some of the duplicate determinations made with this apparatus.

FEEDSTUFF	CRUDE FIBER CONTENT	
	I Per cent	II Per cent
Cottonseed Meal.....	15.28	15.23
Cottonseed Meal.....	12.00	11.95
Cottonseed Meal.....	10.45	10.35
Cottonseed Feed.....	26.70	27.25
Brewer's Dried Grains.....	14.43	14.73
Brewer's Dried Grains.....	14.13	13.68
Distiller's Dried Grains.....	11.20	11.15
Distiller's Dried Grains.....	12.85	12.98
Alfalfa Meal.....	31.10	31.80
Wheat Bran and Cob.....	17.95	18.00
Wheat Bran.....	10.75	10.53
Wheat Shorts.....	9.28	9.20
Mixed Feed (Wheat and Corn).....	11.98	11.76
Mixed Feed (Corn, Oats, and Alfalfa).....	16.78	16.93
Rye Feed.....	4.60	4.45
Hominy Meal.....	3.95	4.13
Chick Food.....	2.93	2.88

KENTUCKY AGRICULTURAL EXPERIMENT STATION
LEXINGTON, KENTUCKY

ADDRESSES AND CONTRIBUTED ARTICLES

A REVIEW OF THE AMERICAN PATENT LITERATURE ON ARSPHENAMINE (SALVARSAN) AND OTHER ARSENICALS

By H. F. LEWIS

Received November 22, 1918

At the present time there is much interest in the United States patents on the aromatic arsenic compounds due to the manufacture of these preparations in America. It has recently been necessary in connection with the work of the Color Laboratory to study the United States patent literature in this field and in order to prevent a duplication of work, the results of the investigation are herewith presented.

For some time the value of inorganic arsenic salts had been known in the treatment of trypanosomiasis. Much of the early work was conducted by the Liverpool School of Tropical Medicine, but the inorganic salts they employed had the disadvantage of being toxic in dosage sufficient to have great effect on the trypanosomes.

In the year 1902, the Vereinigten Chemischen Werken, A-G, Charlottenburg, introduced the sodium salt of *p*-aminophenylarsenic acid as an almost non-toxic arsenical, under the name atoxyl.¹ This compound permits 40 to 50 times as much arsenic to be administered as in the case of sodium arsenite.

In the same year, Ehrlich and Shiga² started their researches on the subject of chemico-therapeutics, the treatment of parasitic diseases through the injection of chemicals. They studied the effect of atoxyl on trypanosomes, but the strain they used, which happened to be the only one at hand, lately was found to be the only one nonreactive with arsenicals, and thus they observed no influence.


A different result was obtained in 1905 in the Liverpool Tropical Institute by Thomas and Breinl.³ They used a strain of trypanosome, which was extremely sensitive to arsenic compounds and so they were able to ascertain a favorable action on trypanosomiasis.

When Ehrlich⁴ returned to the study of atoxyl in 1905, he made the discovery that this compound is the sodium salt of *p*-aminophenylarsenic acid and not *m*-arsenic acid anilid, as had been stated.⁵ This discovery opened the way to many new syntheses of compounds possessing greater therapeutic value than the parent atoxyl.

Atoxyl was first used as a cure for sleeping sickness and this led to its use in diseases caused by the *Spirillaceae* and especially in the cure of syphilis. In this case, greater doses were necessary and disagreeable after-effects were obtained, blindness being

caused in many cases. The advent of many new remedies, in addition to the disagreeable after-effects, caused a great diminution in the use of atoxyl.

Strange to relate, atoxyl has no action on the trypanosomes *in vitro*. The fact that this compound has such a marked action on trypanosomes in the human body points to a change taking place in the structure of atoxyl after it enters the body. This Ehrlich and others' claim to be due to the reduction of


atoxyl to *p*-aminophenylarsenious oxide, , a compound in

which arsenic is trivalent, that is, unsaturated. On the basis of the Ehrlich theory of immunity, the unsaturated arsenic will unite with the trypanosome, forming an arsenocolor.

Owing to the harmful after-effects of too great a dose of atoxyl, the efforts of investigators were directed toward obtaining compounds of arsenic that would be of value therapeutically and which would at the same time be without the harmful after-effects. Such known aryl arsenic compounds as atoxyl, arsenobenzene,⁶ oxypheylarsenic acid, and phenylglycylarsenic acid⁷ were used as starting materials in these syntheses.

The first American patent on the general subject was applied for by Ehrlich and Bertheim,⁸ who stated that when *p*-aminophenylarsenic acid is boiled with acids, acyl derivatives may be obtained. These are of the type $C_6H_4(NHCOCH_3)AsO_2H_2$ (1:4). This patent was assigned to Farberwerke vorm Meister Lucius and Brueuning, as are all of Ehrlich's patents.

A. Michaelis and C. Schulte⁹ in 1881 and 1882 showed that by reducing either phenylarsenic acid or phenylarsenious oxide with the proper agents, such as phosphorous acid, the arsenobenzene,

$As = As$, , could be produced. Ehrlich and Bertheim⁸ formed

homologues of arsenobenzene by reducing *p*-arylglycylarsenic acid and obtained arsenoarylglycine, of the type $(COOH-CH_2-NH(4)-Ar)(1)OAs = As$. These compounds are used for the same purpose as atoxyl. They are insoluble in water but readily soluble in alkalis.

In the Nobel lecture, delivered in Stockholm, December 11,

¹ Ehrlich, *Ber.*, **42** (1909); *Munch. med. Wochschr.*, **1909**, No. 5. Roehl, *Berl. klin. Wochschr.*, **46**, No. 11; *Z. Immunitäts, II Abt. Ref.*, **1909**, 496.

² Michaelis, *Ann.*, **320** (1902), 275.

³ Ehrlich, *Ber.*, **42** (1909), 29.

⁴ U. S. P. 907,016. Applied for, Oct. 3, 1907. Granted, Dec. 15, 1908.

⁵ *Ber.*, **14** (1881), 912, and **15** (1882), 1952.

⁶ U. S. P. 888,321. Applied for, Nov. 13, 1907. Granted, May 19, 1908.

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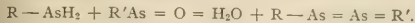
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Two patents by Robert Kahn¹ describe the arsines, $R-AsH_2$, compounds which are found in the reduction of arylarsenic acids by hydrogen in acid solution, and the reaction between these arsines and arylarsenoxides, which leads to the formation of arseno compounds according to the equation:



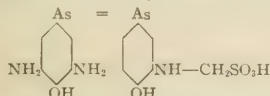
In this way he prepared 4-aminobenzene-arseno-4-oxybenzene.

Ehrlich and Benda² reduced 4-amino-3-oxyphenylarsenic acid and obtained the 4,4'-diamino-3,3'-dioxarsenobenzene. This is a compound of the same type as salvarsan, differing in the orientation of the amino and oxy groups.

Ludwig Benda³ describes the 5-nitro-2-aminobenzenearsenic acid obtained by heating *p*-nitraniline with arsenic acid, and also the 2,5-diaminobenzenearsenic acid,⁴ which results from the reduction of the above nitraninobenzenearsenic acid with a ferrous oxide-salt solution.

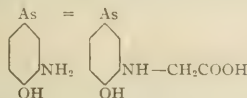
Due to the ease with which salvarsan could be re-oxidized by the air to toxic products, the attention of investigators was directed toward producing compounds that would be more stable. The dihydrochloride had the additional disadvantage of being acid. For these reasons, we find derivatives of diaminodioxarsenobenzene patented.

Georg Korndorfer⁵ treated salvarsan with a mixture of formaldehyde and bisulfite. In this way an acid of the structure



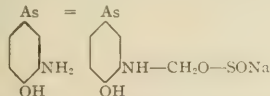
is obtained whose salts are readily soluble in water and give a neutral reaction.

Chloroacetic acid or its homologues will react with diaminodioxarsenobenzene and form derivatives of the type:



The salts of these acids are also soluble in water, giving a neutral reaction.⁶

When a solution of diaminodioxarsenobenzene is treated with a solution of "hydraldit" (formaldehyde sulfoxalate) and sodium carbonate added, a new salt is formed, of the general structure,



This compound is readily soluble in water, giving a neutral reaction and is very much less easily oxidized to the arsenious oxide derivative than is the original diaminodioxarsenobenzene. The entering group possesses enough reducing power, so that its influence is felt on the *o*-arseno group. Such a derivative is sold under the trade mark "Neo-Salvarsan."⁷ It may be

¹ U. S. P. 1,026,094. Applied for, July 19, 1911. Granted, May 14, 1912. U. S. P. 1,033,904. Applied for, July 5, 1911. Granted, July 30, 1912.

² Ehrlich and Benda, U. S. P. 1,023,101. Applied for, Aug. 7, 1911. Granted, June 4, 1912.

³ L. Benda, U. S. P. 1,036,784. Applied for, Dec. 28, 1911. Granted, Aug. 27, 1912.

⁴ L. Benda, U. S. P. 1,040,260. Applied for, Feb. 3, 1912. Granted, Oct. 8, 1912.

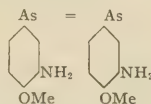
⁵ U. S. P. 1,024,993. Applied for, Feb. 24, 1912. Granted, Apr. 30, 1912.

⁶ Stolz and Flacher, U. S. P. 1,048,002. Applied for, Mar. 16, 1912. Granted, Dec. 24, 1912.

⁷ Korndorfer and Reuter, U. S. P. 1,053,300. Reissue, 15,848. Applied for, Apr. 30, 1912. Granted, Dec. 15, 1914.

injected either directly in water or in a solution of sodium carbonate.

The other important derivative of salvarsan, sold under the trade mark of "Salvarsan Natrium" or "Sodium Salvarsan," is the sodium diphenolate of the formula



where Me signifies an alkali metal. These alkaline derivatives are best produced by treating an alcoholic suspension of the base with alcoholates of the alkali metals, or with the solutions of the alkaline hydroxides or carbonates. They are readily soluble in water, giving a slight alkaline reaction.¹

Sodium salvarsan possesses the same ease of oxidation to the toxic arsenic oxide as does salvarsan, so Ehrlich and Reuter² proposed to prevent this. They found that by mixing the phenolate with reducing agents such as hydrosulfite or sulfoxalate, a more stable combination can be effected.

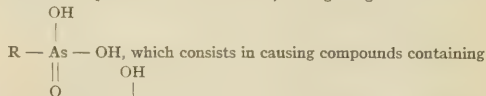
A mixture of the two solutions is made and the new combination is precipitated by pouring into an ether-alcohol solution.

* These operations are carried out in an atmosphere of nitrogen.

Nitroacetylaminophenylarsenic acid, obtainable by the action of arsenious acid on the diazo compound of acetylnitro-*p*-phenylenediamine, can be transformed into nitro(4)-amino(4)-phenylarsenic acid by heating with saponifying agents.³

By starting with diazotized dinitraniline ($\text{NH}_2\text{NO}_2\text{NO}_2 = 1:2:4$) and treating with arsenious acid in the presence of hydrochloric acid, the dinitrophenylarsenic acid of the constitution $\text{NO}_2\text{C}_6\text{H}_3(\text{NO}_2)\text{AsO}_2\text{H}_2$ is obtained.⁴

A process very similar to the one described in the above patent is that of H. Bart.⁵ This consists in the production of aryl substituted products of arsenic acids, having the general formula



the group $-\text{As}-\text{OH}$ to react on aryl diazo compounds having the general formula $\text{R}-\text{N}=\text{N}-\text{OH}$, by means of heat. Such a reaction, for example, would be illustrated by that between the diazo compound of *p*-nitraniline and arsenious acid in hydrochloric acid solution.

The dinitromethylnitramino derivative of phenylarsenic acid and its arseno reduction compound have been prepared by Ach and Rothmann.⁶ The acid is formed by nitrating *p*-dimethylanilinearsenic oxide and this on reduction with tin and hydrochloric acid gives dimethylaminetetraminoarsenobenzene.

For preparing the various nitroaminophenylarsenic acids, the method generally used is the nitration of aminophenylarsenic acids (D. R. P. 231,969 and 232,879). Ach, Rothmann, and Hatzig⁷ introduce an amino or substituted amino group in the various nitrophenylarsenic acids through a halogen substituted in those acids.

¹ Ehrlich and Bertheim, U. S. P. 1,059,983. Applied for, July 24, 1912. Granted, Apr. 29, 1913.

² Ehrlich and Reuter, U. S. P. 1,078,135. Applied for, Nov. 15, 1912. Granted, Nov. 11, 1913.

³ L. Benda, U. S. P. 1,075,537. Applied for, Nov. 6, 1912. Granted, Oct. 14, 1913.

⁴ L. Benda, U. S. P. 1,075,538. Applied for, Nov. 6, 1912. Granted, Oct. 14, 1913.

⁵ U. S. P. 1,061,587. Applied for, Dec. 27, 1910. Granted, May 13, 1912.

⁶ U. S. P. 1,075,279. Applied for, Mar. 31, 1913. Granted, Oct. 7, 1913. U. S. P. 1,081,079. Granted, Dec. 9, 1913.

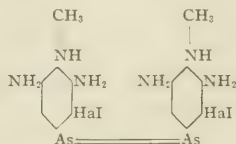
⁷ U. S. P. 1,163,496. Applied for, Dec. 20, 1913. Granted, Dec. 7, 1915.

When the above aminonitrobenzenearsenic acids, for instance, amino(4)-dinitro(3:5)-phenylarsenic acid,¹ are treated with reducing agents as tin and hydrochloric acid, polyaminoarsenobenzenes are formed, *i. e.*, amino(4)-dinitro(3:5)-benzenearsenic acid gives the 3:4:5:3':4':5':hexaminoarsenobenzene.²

Substituted chlorbenzenes with the group —N—R in the meta position to the chlorine give, when treated with arsenious chloride and oxidized, the chloro(2)-amino(4)-phenylarsenic acids. In this group R designates an alkyl group and R' an univalent radical. The compound used as an illustration is

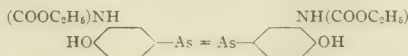
$$\text{CH}_3 \begin{array}{c} \text{H} \end{array} \text{N(4)-Cl(2)phenylarsenic acid.}^3$$

Nitration of the methylaminochlorphenylarsenic acid described previously introduces three nitro groups, with the formation of methylnitramino(4)-dinitro(3:5)-chloro(2)-phenylarsenic acid. This upon reduction with tin and hydrochloric acid gives a bis-methylaminotetraaminoarsenobenzene, halogenated in the nucleus in the position ortho to the arseno linkage, and having the following structure:



This derivative is therapeutically more active than the non-halogenated derivative of the same type (U. S. P. 1,081,079).⁴

Some new arsenobenzene derivatives have been prepared by Ehrlich and Berthelm.⁵ In the treatment of the sodium salt of amino-oxyphenylarsenic acid with ethylchlorocarbonate, oxyphenylurethane is formed. This on reduction gives arseno-oxyphenylurethane. It has the formula



Substituting acetic anhydride for the ethylchlorocarbonate gives the diacetamino derivative of diaminodioxarsenobenzene when the above procedure is carried out. Oxyphenylurea-arsenic acid on reduction gives dicarbamidodioxarsenobenzene.

A series of patents on the metallic addition products of diaminodioxarsenobenzene has been taken out by Ehrlich and his assistants.

Ehrlich, Reuter, and Karrer⁶ found that arseno compounds containing the radical $\text{As} = \text{As}$, when combined with the salts of such metals as gold, copper, platinum, palladium, silver, etc., will form addition products. These products combine the therapeutic value of the arseno compound with that of the metallic salts. Such a combination is that between 3,3'-diamino-4,4'-dioxarsenobenzene dihydrochloride and copper chloride.

By dissolving the above copper complex in caustic alkali

¹ *Ber.*, 45 (1912), 56.

² Ach, Rothmann, and Dieterich, U. S. P. 1,156,044. Applied for, Mar. 24, 1913. Granted, Oct. 12, 1915.

³ Ach, Rothmann, and Dieterich, U. S. P. 1,156,045. Applied for, Jan. 26, 1914. Granted, Oct. 12, 1915.

⁴ Ach, Rothmann, and Dieterich, U. S. P. 1,180,627. Applied for, June 22, 1914. Granted, Apr. 25, 1916.

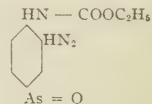
⁵ U. S. P. 1,077,462. Applied for, Dec. 3, 1912. Granted, Nov. 4, 1913.

⁶ U. S. P. 1,091,881. Applied for, Jan. 25, 1913. Granted, Mar. 13, 1914.

and precipitating with alcohol, there is obtained a compound of therapeutic value in the cure of sleeping sickness.¹

Arseno azo dyestuffs have been obtained by reducing with hypophosphorous acid azo dyestuffs containing an arsenic acid group. This reduces the arsenic acid without having effect on the azo linkage.²

The substitution of a carboethoxy group for one of the hydrogens in an amino group of *p*-aminophenylarsenic acid or a polyaminophenylarsenic acid gives rise to a series of compounds of the general formula



which may be used as specifics for hog cholera.³

Diaminodioxarsenobenzene has been combined with hexaminoarsenobenzene and its homologues, forming compounds of unknown constitution that are claimed to possess therapeutic value. The particular one patented is the result of condensing diaminodioxarsenobenzene with hexa-aminoarsenobenzene.⁴

A recent American patent has been granted to Antoine Mouneyrat, of Paris. It deals with a new method of preparing *p*-oxy-*m*-nitrophenylarsenic acid, by starting with *p*-methoxyphenylarsenic acid.⁵ This acid is nitrated and the methoxy group replaced by a hydroxy group through boiling with an alkali. This nitro compound is then reduced by electrolysis. He also describes a series of valuable arsenic-phosphorus compounds obtained by the action of phosphorus oxychloride on the above amino-oxyphenylarsenic acid.

The salts of the compound dimethylaminotetraaminoarsenobenzene, whose properties and method of manufacture have been described,⁶ are found to dissolve in the alkaline carbonates and bicarbonates, forming preparations useful for therapeutic purposes.⁷

A similar patent was taken out by Ach and Dieterich⁸ and deals with the formation of a soluble derivative of the bis-methylaminotetraaminoarsenobenzene substituted in the benzene nucleus. Such a compound is the hydrochloride of 2,2'-dichloro-4,4'-bis-methyl-amino-3,3'-5,5'-tetraminoarsenobenzene. These soluble derivatives are obtained by the action of a bicarbonate. A process for the preparation of a soluble, stable, metallic derivative of dioxidiaminoarsenobenzene has been described by Jean Denysz.⁹ He mixed a methyl alcohol solution of antimony chloride and a methyl alcohol solution of mercuric iodide. Ether will precipitate a yellow-red substance having an acid reaction. It is easily soluble in slight excess of caustic soda. The alkaline solution of this substance in methyl alcohol can be precipitated again by ether, giving a sodium compound of dioxidiaminoarsenobenzene, mercuric iodide, and antimony which is easily soluble in water. It is claimed that the products have great therapeutic advantage in that they are appreciably more active and less toxic than the arsenobenzene compounds so far subjected¹⁰ to treatment.

¹ Ehrlich and Karrer, U. S. P. 1,117,352. Applied for, Jan. 27, 1914. Granted, Feb. 9, 1915.

² Ehrlich and Karrer, U. S. P. 1,120,700. Applied for, Feb. 2, 1914. Granted, Dec. 15, 1914.

³ A. H. Heitman, U. S. P. 1,119,279. Applied for, Apr. 5, 1913. Granted, Dec. 1, 1914.

⁴ Karrer, U. S. P. 1,214,927. Applied for, Dec. 10, 1915. Granted, Feb. 6, 1917.

⁵ Michaelis, *Ann.*, 320 (1902), 299-300.

⁶ U. S. P. 1,081,079.

⁷ Ach, Rothmann, and Giemsa, U. S. P. 1,265,864. Applied for, June 10, 1914. Granted, May 14, 1918.

⁸ U. S. P. 1,265,865. Applied for, Jan. 15, 1915. Granted, May 14, 1918.

⁹ U. S. P. 1,269,792. Applied for, July 28, 1916. Granted, June 18, 1918.

In conclusion, it is well to direct attention to the report on "Synthetic Drugs,"¹ published by the Subcommittee on Synthetic Drugs of the National Research Council. In order that the American houses manufacturing German-owned patented synthetic drugs may have their investments protected, the license permitting their manufacture has been granted for the life of the patent and not for the duration of the war alone. At the same time, the obligation has been imposed upon all licensees to use the new official names of these drugs. The new official names for salvarsan, neo-salvarsan, and sodium salvarsan are arspenamine, neo-arspenamine, and sodium arspenamine.

COLOR LABORATORY, BUREAU OF CHEMISTRY
U. S. DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

RELATIONSHIPS IN CHEMISTRY²

By J. W. BECKMAN

Received December 21, 1918

There are some matters which have impressed themselves upon me during the last year most emphatically which I wish to present and so bring them to your attention and serious thought.

To make myself clear in the following discussion, I am going to take the liberty of classifying chemists under two heads: the inside chemist, to which class, in a general way, belongs the man engaged in chemical work in the university, not including the student; and the outside chemist, to which class belong all other chemists occupied in practical application and research in chemistry. This is, as you fully understand, not a hard and fast classification; the different groups naturally overlap.

There was a time, and it was not long ago, when there was, I believe, a feeling existing between the outside chemist and the inside chemist. It was not one that was distinctly tangible or that could be attributed to any special reason or that had any just cause.

The inside chemist, whose duty primarily consists in continuing to bring forth new generations of chemists, was liable to look upon his own offspring as a being somewhat inferior to himself; his offspring had only glanced through frosted windows into the holy of holies of theoretical chemistry. The young chemist had spent too short a time, as a rule, in the university, in the atmosphere of the inside chemist, to absorb more than a smattering, in many cases, of the deeper meaning of chemical laws. These embryo chemists formed later the increasingly growing number of outside chemists. It was therefore natural that the feeling on the part of the inside chemist of contempt for and of superiority to the outside chemist was continued in an unabated stream. There was a tendency among the inside chemists to look upon their work as a sacred work, a work which gave them mental stimulus, and which at times perhaps gave them mental bliss. As an opiate fiend obtains physical bliss from his narcotic, so the inside chemist got intellectual bliss from his intellectual narcotic. From time to time, as a miser will of a night take out his gold and let it trickle through his fingers and again lock it up and enjoy this pleasure, so would the inside chemist from time to time take out the precious discoveries he had made and ventilate them in an abstract way, and again lock them into the sanctuaries of his research.

The outside chemist, as I have stated before, is really a product of the inside chemist. As time went on and the influences which he had absorbed in the university gradually were rubbed off in the hard outside world and he was brought face to face with the realities in life and in chemistry, he began to look back upon the inside chemist with somewhat of a naive contempt.

Because the inside chemist dealt with complex laws and

theories in chemistry and the outside chemist dealt, in many cases, with pipes and tanks, and weights of solutions, etc., the outside chemist began to estimate himself as the most important man because he was dealing with more tangible things; he began to look down upon the inside chemist with a feeling of superiority and thought that the inside chemist was an impractical old fogey.

Each seemed inclined to go his own way. The inside chemist was not interested as to how his discoveries could help the outside chemist, excepting in so far as he might sow some seeds regarding his discoveries in the new generation of chemists. The outside chemist, who had grown away from the inside chemist's influence, had a hard time in many cases to absorb, or reasonably understand, the discussions he might have had with the inside chemist along the lines of the latter's discoveries—discussions which might have been to their mutual advantage—and his final analysis was that they did not concern him in his special activities anyway.

I may have drawn my picture somewhat harshly, but I think that we all recognize the fact that there did exist a degree of lack of understanding between the inside chemist and the outside chemist.

The war in its activities has wrought, I believe, a very radical change in the attitude of the two chemists, and it is a change which is to everyone's advantage and one that is of vital importance to the chemical development of the country, and for that reason, if for no other, should be maintained and encouraged in every way.

Through dire necessity the outside chemist has been forced to seek out the inside chemist and get his advanced viewpoints on many of the apparently most simple chemical processes of manufacture, for the purpose of speeding up war work, increasing efficiency, and avoiding waste. The inside chemist may never have known anything about valves and pipes, kettles and other things, excepting possibly in the abstract, but he has, through his careful research and through his trained mental capacities, a fountain of information, which, unlocked and coupled with the practical knowledge of the outside chemist, has contributed to the chemical development of the country in a manner which has brought results, in a few years, undreamed of as being possible to achieve under conditions as they existed before. In other words, the inside chemist and the outside chemist have finally met on the same ground; they have been called to the same council chamber and have been forced to discuss together problems of vital importance to the national welfare in a language that both of them understood. The outside chemist may often have had a hard time to put his ideas and his observations into terminology which was not offensive to the trained ear and mode of expression of the inside chemist, while the inside chemist may equally well have had a hard time to express his viewpoints and his ideas in the language which was acceptable and easily understood by the outside chemist; but they have done it, as shown by the surprising and marvelous results of the last few years.

The inside and the outside chemist have joined hands and have learned to speak the same language, both of them perhaps still falteringly, but it is accomplished, and as time goes on, the inside chemist will realize that any discovery which he may make and which he keeps locked up as a miser keeps his gold locked up, without trying to see whether it will better conditions in the outside world, is a useless discovery and his time is wasted and he himself might be considered as lacking in morality.

The same may be said of the outside chemist. If the outside chemist, through sheer stubbornness, through lack of perseverance, and through ignorance, is unwilling to give an ear to the inside chemist's advice, he shows himself morally unfit to further the chemical development of the country.

¹ J. Stieglitz, *J. Am. Med. Assoc.*, 70 (1918), 536-7.

² Address delivered at the 1918 annual meeting of the California Section of the American Chemical Society.

I am fully convinced that a new generation of chemists is going to grow up from now on as a result of the war. The outside chemists, who are the offspring of the inside chemists, will be no more and the inside chemists will be equally eliminated. We will have a new type with a broader viewpoint in all these matters. We will look to the theoretical chemist with regard and appreciation equal to that which we show the technical and applied chemist. Our chemical development will die out just as quickly as it has grown if we are unwilling to continue to appreciate the fact that all chemists are interdependent, that chemistry is not chemistry without theoretical foundation, and that theoretical knowledge is worthless to man without its application in some way for his improvement.

My feeling is that the meetings of the Local Sections of the AMERICAN CHEMICAL SOCIETY, such as we attend to-night, are of the greatest importance to our future chemical development. The men who interest themselves primarily in the applied chemistry should make an effort to follow the discoveries of those chemists who read papers on theoretical chemistry and discuss them in the meetings. It may sometimes be a mental effort to do so, but it is worth while, while the theoretical men should take equal interest in discussing papers on applied chemistry, bringing their viewpoints and their buried theoretical knowledge to the vision of the applied chemist. There should be a feeling of give-and-take at such discussions. It should not be a disgrace for a man to show his ignorance in theoretical chemistry, nor should it be a disgrace for a theorist to show his ignorance as to applied chemistry. We do not live in the days of Michael Angelo and consequently it is impossible for us all to be able even to discuss all the different sides of our own science faultlessly and always intelligently.

It occurs to me to ask in this connection, if we are not making a mistake, as a Society, in having two publications, one of them publishing matters dealing with applied chemistry, and the other one dealing with theoretical chemistry. Should we not, as a Society, show our belief in the unity of chemistry by issuing one single journal dealing with chemistry as a whole? As it is now, the theoretical chemist reads the *Journal of the American Chemical Society* and lays aside, unread, the *Journal of Industrial and Engineering Chemistry*, and the chemist interested in applied chemistry reads only the *Journal of Industrial and Engineering Chemistry* and puts aside the *Journal of the American Chemical Society* unread. My belief is that if these journals were published jointly in the same volume, we would be forced to glance over all the articles occurring in it and the line of demarcation between applied chemistry and theoretical chemistry would be quickly eliminated.

We have on the Pacific Coast, I believe, a special responsibility to each other. We are far from the large centers of chemical activity and consequently are thrown more intimately together. We will have to learn to depend much more on each other than we have done up to the present time. The war has brought with it many worries and troubles, but has also helped us, in many cases, to clarify our viewpoints and put new stimulus and new understanding into our efforts. Our development out here, if it is going to increase at all and be successful, is dependent on a most intimate coöperation and understanding between all the different branches of chemistry and its application.

SAN FRANCISCO, CALIFORNIA

RECONSTRUCTION IN THE ZINC INDUSTRY¹

By J. A. SINGMASTER

Received November 27, 1918

It is peculiarly appropriate that we should be met so near Bethlehem to discuss the problems which the zinc industry is facing, for it was there that two of the greatest contributions

¹ Address delivered before a recent meeting of the Lehigh Valley Section of the American Chemical Society.

America has made to the metallurgy of zinc were conceived and commercially applied. I refer to Wetherill's process of manufacturing zinc oxide directly from the ore, still known by the inventor's name, and to the Wetherill magnetic ore separator, which not only made Franklin, New Jersey, the world's greatest zinc mine but has been applied to ore concentration the world over as well. These two inventions were the scientific basis of the New Jersey Zinc Company, as we know it.

A few figures are necessary to give some of you an idea of the situation the zinc industry finds itself in to-day. At the outbreak of the war the world's annual production of spelter, or metallic zinc, was one million tons in round figures. One-third of this amount, 335,000 tons, was produced in America and the balance in Europe, practically all of the latter in Germany and Belgium. With the seizure of Belgium nearly all of the European capacity fell into the hands of the Germans, leaving the Allies dependent, primarily, on us for their supply of spelter—an indispensable war material. America's response was an increase of capacity to about double its pre-war production. Belgian and German smelters are probably intact, all of them, with a few small exceptions, being out of the zone of actual fighting; so with the advent of peace we expect to again meet a competition which sent metal into this country in the face of a tariff during pre-war times. The American zinc industry is therefore confronted with the problem of profitably disposing of two pounds of zinc where one was sold five years ago.

It seems a logical sequence of such a condition that we should concern ourselves, therefore, not so much with quantity production and the economies that come with large outputs, as with questions of quality, of making zinc and zinc products with special characteristics, specifically designed to meet the demands of different trades and of making new zinc products. We do not lose sight of the necessity of carefully controlling and improving manufacturing processes so as to effect economies in labor and materials, but we believe the chief rôle of chemical and physical science in this period of reconstruction will be along quality lines. We have here a branch of metallurgy which differs from the mere extraction of metals from their ores, a comparatively new development, which has been happily called "manufacturing metallurgy." Its successful application demands careful and painstaking research and control, both chemical and physical. With this in mind the Zinc Company has increased its force of chemists and physicists very largely, and is now completing a new laboratory building at Palmerton for chemical and physical control and research work. This laboratory will have some 30,000 sq. ft. of floor space and embodies the best features of modern laboratory construction.

A brief survey of some of the actual developments of "manufacturing metallurgy" in the zinc industry, among which rolled zinc is the most interesting, will perhaps illustrate the field covered by this branch of chemical and physical research to the best advantage.

Zinc was rolled about thirty years ago in Bethlehem in a small way. The operation was not well understood, and the uses of the sheet in this country were very limited, so rolling was abandoned after a short time. To-day the situation is changed and sheet zinc promises to be an outlet for a large tonnage of the metal here, as it has been abroad. You will be interested to know that zinc rolling has recently been resumed in the Lehigh Valley, and that we now have a large mill in operation at Palmerton.

The influence of chemical composition and physical conditions on the character of the rolled product are being carefully studied. As a result, sheet zinc with specific properties for certain purposes has been produced and has already established itself in the trade. I wish to call your attention to some samples of drawn cups made of zinc which is designed especially for this purpose, as an illustration of an entirely new departure. Rolled zinc has

reached a point with us where it is no longer "just rolled zinc," but, like brass and steel, is to be had with physical and chemical properties varied to suit the uses of the buyer. I do not mean to convey the idea that zinc can be substituted indiscriminately for other metals, nor that we have exhausted the possible variations which can be given it. It has its limits, as do all metals. Our study of the requirements of a number of trades has already resulted in the economical substitution of zinc, designed specifically for the purpose, for aluminum, brass, copper, and steel. Rolled zinc rod and drawn wire have also been made and have found some commercial application.

Another interesting chemical development has been the production of metallic zinc 99.995 per cent pure in considerable quantity, and the manufacture on a large scale of zinc oxide

meeting the *United States Pharmacopoeia* specifications. Both of these products were imported before the war and were sometimes inferior in quality. Our products are suitable for all kinds of chemical, analytical, dental, and pharmaceutical work.

We believe, therefore, that the application of chemistry and physics will play a most important rôle in the zinc industry during the present period of readjustment. We would like, in conclusion, to say that we believe our problems, not only in the zinc, but other industries as well, should be faced with an optimistic spirit. The best equipment, the most highly trained mind, will not avail unless the driving power of enthusiasm is behind our work. Let us all approach our problem with this spirit so necessary to-day.

THE NEW JERSEY ZINC COMPANY
NEW YORK CITY

PERKIN MEDAL AWARD

The Perkin Medal for 1919 was conferred on Frederick G. Cottrell, in recognition of his notable work in the field of electrical precipitation, at the meeting of the New York Section of the Society of Chemical Industry, held at the Chemists' Club, January 17, 1919. Remarks by Mr. Charles E. Sholes, chairman of the Section, and by Mr. Charles McDowell, chairman of the Chemicals Division of the War Industries Board, were followed by the presentation of the medal to Dr. Cottrell by Dr. C. F. Chandler. The address of acceptance by Dr. Cottrell followed and remarks in appreciation of Dr. Cottrell by Mr. Buckner Speed.

The usual informal dinner was held before the meeting in the dining hall of the Chemists' Club, giving the members the opportunity of meeting Dr. Cottrell.—[Editor.]

PRESENTATION ADDRESS

By C. F. CHANDLER

It is my privilege and very pleasant duty, as senior past president of the Society of Chemical Industry, residing in this country, to present to Frederick G. Cottrell, B.S., A.M., Ph.D., the thirteenth impression of the Perkin Medal, in recognition of his most original and valuable work in applied chemistry.

Dr. Cottrell was born in Oakland, Cal. in 1877, where he received his early education. The degree of bachelor of science was conferred upon him by the University of California in 1896. He continued his scientific studies at the University of Leipzig, graduating in 1902.

Returning at once to America, he became instructor in physical chemistry at the University of California, later assistant professor.

This position he held till 1911, when he joined the staff of the Bureau of Mines in Washington. Here he was at first the consulting chemist; then successively chief of physical chemistry, chief chemist, and finally chief metallurgist, which position he still holds.

After graduating at the University of California, he continued his work there, devoting his attention to studies of hydriodic acid, liquid and gaseous, which enabled him to greatly increase our knowledge of the physical and chemical properties of this substance. His papers on this subject were published in the *Journal of the American Chemical Society*, 1896 and 1899, and in the *Journal of Physical Chemistry* in 1898.

In 1900 he published a very elaborate investigation on manganese sulfate in the *Journal of Physical Chemistry*. This investigation was made with a view to throwing light upon the very interesting case of equilibrium in systems of manganese sulfate and water. His first publications, while in Germany, related to the genesis of some of the double and triple salts of magnesium, occurring in the Stassfurt saline deposits.

Dr. Cottrell's inaugural dissertation was entitled "The Residual Current of Galvanic Polarization Considered as a Problem of Diffusion." It was published in 1903.

From this date on he continued to publish reviews and investigations too numerous for me to refer to here. Specially interesting are papers on liquid air plants, 1905 and 1906.

Dr. Cottrell's most elaborate and valuable investigations relate to electrical precipitation of particles of liquids and solids begun in 1906 with his work on sulfur trioxide fumes which are not easily absorbed by water. It had long been known that electric brush discharges cause fog to clear. Sir Oliver Lodge had worked along this line. Dr. Cottrell describes his first fundamental experiment in his paper on "The Electrical Precipitation of Suspended Particles," published in the *Journal of Industrial and Engineering Chemistry*, August 1911.

As this shows the beginning of one of the most important contributions to industrial chemistry, I feel that I can afford to consume two or three minutes of the time allotted to me to quote this experiment:

It may be of interest to note that the clue to the solution of this difficulty came from an almost accidental observation. Working one evening in the twilight when the efficiency of the different points could be roughly judged by the pale luminous discharge from them, it was noticed that under the particular conditions employed at the time, this glow only became appreciable when the points had approached the plates almost to within the distance for disruptive discharge, while at the same time a piece of cotton-covered magnet wire which carried the current from the transformer and commutator to the discharge electrodes, although widely separated from any conductor of opposite polarity, showed a beautiful uniform purple glow along its whole length. The explanation lay in the fact that every loose fiber of the cotton insulation, although a relatively poor conductor, compared to a metallic point, was still sufficiently conductive from its natural hygroscopic moisture to act as a discharge point for this high potential current and its fineness and sharpness of course, far exceeded that of the sharpest needle or thinnest metallic wire. Acting on this suggestion it was found that a piece of this cotton-covered wire when used as a discharge electrode at ordinary temperature proved far more effective in precipitating the sulfuric acid mists, which were then the object of study, than any system of metallic points which it had been possible to construct. Perhaps the greatest advantage thus gained lay in the less accurate spacing demanded between the electrodes of opposite polarity in order to secure a reasonably uniform discharge.

The first installation of his system was made at the plant of the Hercules Powder Company, at Pinole, Cal., where there was a small contact sulfuric acid plant. There he used a 6,600 volt, alternating current, rectified into a direct current by a motor-driven contact apparatus, and sent this current, by means of pubescent (hairy) asbestos electrodes, through the wet sulfur trioxide fumes, and obtained precipitation.

This process, though successful, was not sufficiently profitable

to warrant extensive use. It would probably have died had it not been that the nearby Selby smelter was in trouble. This smelter had a large plant near one of the tunnels of the Southern Pacific Railroad, and with certain winds, the fumes of sulfur trioxide from the silver-dissolving house would fill this tunnel with choking fumes, and finally legal proceedings were started to close the smelter plant. At this juncture Dr. Cottrell erected a small electric plant which met the difficulty completely and is running to-day, yielding dilute sulfuric as a by-product.

But for the above-mentioned legal proceedings, the Cottrell process might never have materialized. The knowledge that fumes and smoke could be Cottrellized made the fume-pestered farmers all over the West sue the smelters, right and left, and satisfied the courts and juries that they were not asking the impossible of the smelters.

The story of the Cottrell process' for several years has been told in the news columns of the papers. Not alone has he taken the sting out of sulfuric acid waste fumes of smelters, he has brought down poisonous arsenic, saved metal dust otherwise going to waste, saved the orange groves from cement kiln smoke, and recovered potash from that cement smoke to put on those very orange groves for fertilizer. The dust in the air, which was death to the trees through the clogging of the tender pores of their leaves, when duly Cottrellized and sacked and emptied on their roots, has given them new strength and life.

It would take a long time to give you a realizing idea of the marvelous extension of this Cottrellizing invention. I will content myself by giving you one example which I saw in the *Evening Post* of January 11 last:

Montana now has the tallest chimney stack in the world, by a dozen feet, and in other dimensions it is immensely greater than its rivals. This is the recently completed stack of the Washoe reduction works of the Anaconda Copper Mining Company, which is 585 ft. $1\frac{1}{2}$ in. in height. The outside diameter of the base, built in the form of a truncated octagonal pyramid, is 86 ft., and the walls are 5 ft. 4 in. thick at this point. The stack contains the equivalent of 6,672,214 common brick. Conducted through a vast flue system from the furnaces, the smoke will pass into chambers where will hang 111 miles of chains, electrified by a high-tension current. All the particles in the gases are electrified by contact as they pass through the links, and are violently repelled to be attracted by great plates between which the chains are suspended. These plates are grounded to form a negative pole. When they are thickly coated, the circulation will be diverted, the current shut off, and the accumulations will drop into hoppers.

Dr. Cottrell's more recent work of investigation has had to do with the securing of helium gas for war balloons, which being absolutely incombustible, is a wonderful substitute for inflammable hydrogen, while it is only slightly inferior in ascensional

power. The helium is obtained from certain gas wells, by liquefying out all the other constituents.

I think I must cut my story short at this point and leave to Dr. Cottrell himself and Mr. Speed the pleasure of telling you of the doctor's varied work at the Bureau of Mines and among the Field Experiment Stations, as well as about the "Research Corporation, an Experiment in Public Administration of Patent Rights," in which he takes such an active interest. I must say one more word: Dr. Cottrell has been granted many patents for his inventions and has generously donated them to the use of the public.

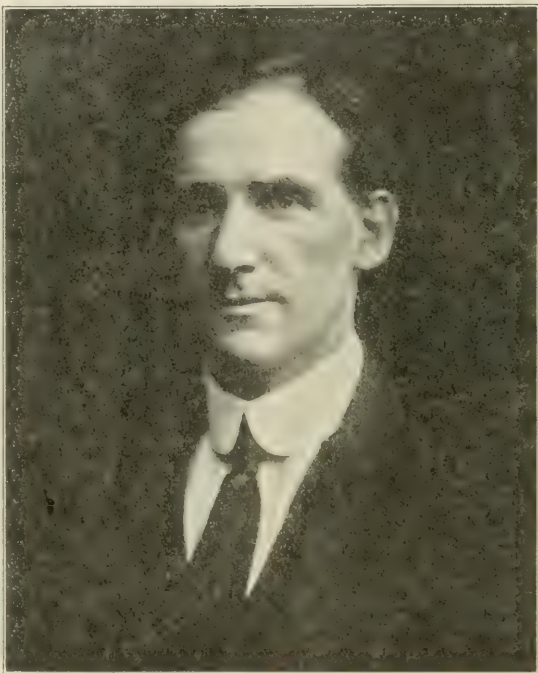
CONFERRING THE MEDAL

Dr. Cottrell, it gives me the greatest pleasure, as the representative of the affiliated chemical and electrochemical societies of America, to place in your hands this beautiful Perkin Medal, as a token of the appreciation and affection of your fellow chemists.

NEW YORK CITY

ADDRESS OF ACCEPTANCE

By FREDERICK G. COTTRELL
MR. CHAIRMAN, DR. CHANDLER, LADIES AND GENTLEMEN: It is with a profound sense of appreciation on the one hand and of added responsibilities on the other that I accept this symbol of your approbation, friendship and confidence. I value the two former more than words can express, and this beautiful emblem will ever serve to keep clearly before me the responsibility to justify your confidence by striving to maintain unbroken the long line of high traditions of public service with which the Perkin Medal is associated on both sides of the ocean. I wish to thank you, Dr. Chandler, for this medal and for your kind words, and through you, the mem-



FREDERICK G. COTTRELL, PERKIN MEDALIST, 1919

bers of the Awarding Committee and the societies which they represent.

I am aware that it has been customary for the recipient of this honor to review the history of the subject particularly cited in the award, but the present year has witnessed the breaking of so many precedents and I have already on former occasions so thoroughly told you all that I know about electrical precipitation, that to-night I shall take the liberty of dealing chiefly with quite another subject, though one which attracted my serious attention and study even earlier than electrical precipitation.

This is the industrial liquefaction and separation of the so-called permanent gases. My justification for this particular selection lies in the general interest at present in scientific problems whose solutions have been accelerated by the pressure of war needs, the case in point forming an interesting example

in connection with the production of helium as a balloon gas.

Before turning to this, however, it may interest you if I briefly outline a few recent developments in administration of patents which, though not specifically referring to electrical precipitation, have to a certain degree, perhaps, been a by-product of the successful administration of the precipitation patents by the Research Corporation.

Despite all the criticism which one hears of our American patent laws I am disposed to look on them as remarkably satisfactory as far as they go and to feel that what is needed is not so much radical changes in the form and method of granting a patent as in the provisions for adequate administration, guidance, and control in the interests of all concerned after it leaves the patent office.

The prime object to me in the formation of the Research Corporation was to furnish an experimental laboratory, as it were, in this most interesting branch of economics, and I have always looked upon the precipitation patents chiefly as mere kindling to start a fire under its boiler. If they have been able to generate some steam on their own account, it is of course gratifying, but that still does not distract my attention from the original aim.

The public's interest in the administration of patents has had surprisingly little attention when we compare it with other great problems of monopoly, such as the railroads and the great fabric of corporate business. The patent laws as enacted in the early part of last century were entirely adequate to the simple structure of industry and economic life of the time, and it is amazing that they have functioned so well through all the growing complexity ever since.

The attempt to work out in Congress sweeping reforms in the patent laws on the basis of our present knowledge would be a most difficult and even dangerous task, as is well illustrated by the hearings on the Oldfield Bill of a few years ago. This is chiefly because we have little or no experimental data on what would happen if we tried by mandatory legislation to force at once on all patentees or their licensees and assignees new business methods which, although conceived in the most helpful spirit of fair play to all, would, when tried in practice, undoubtedly encounter innumerable unforeseen complications which might work great individual injustice besides actually hindering general industrial development. For this reason the somewhat unique sort of experimental work on patent administration purely in the public interest, which the Research Corporation is doing, appears highly important. Heretofore the study of patent questions has of necessity been approached almost wholly from the standpoint of one or another of the special interests concerned, such as the inventors, the patent bar, or the large companies purchasing or operating under patents; while the broad, general interests of the whole public have not, as a rule, had the advantage of intensive continuous study and presentation by any agency wholly devoted to this purpose.

The most recent evidence of growing interest in this subject is a bill (S. 5263), introduced in the United States Senate on January 2 by Senator Kirby, chairman of the Committee on Patents, which provides:

That the Federal Trade Commission be, and hereby is, authorized and empowered to accept assignment of, or license under, to develop, to issue, or refuse to issue licenses under, to encourage the industrial use and application of, and otherwise to administer, on behalf of the United States, under such regulations and in such manner as the President shall prescribe, inventions, patents, and patent rights which said Commission deems it to the advantage of the public to be so accepted, as these may from time to time be tendered it by employees of the various departments or other establishments of the Government, or by other individuals or agencies, and to cooperate, as necessity may arise, with scientific or other agencies of the Government in the discharge of the duties herein set out.

That the Federal Trade Commission be, and is hereby,

authorized and empowered to collect fees and royalties for licensing said inventions, patents, and patent rights in such amounts and in such manner as the President shall direct, and shall deposit the same with the Treasurer of the United States; and of the total amount of such fees and royalties so deposited a certain per centum, to be determined by the President, shall be reserved, set aside, and appropriated as a special fund to be disbursed as directed by the President to remunerate inventors for such of their inventions, patents, and patent rights contemplated by this Act as may prove meritorious and of public benefit.

This bill had its inception in the need felt for more adequate means of carrying the scientific developments made in the government laboratories through to the public in their most useful and available form, and was sent as a suggestion in nearly its present form by Secretary Lane to President Wilson last August and referred by the President to the Federal Trade Commission for comment. During the war this latter body has administered enemy-owned patents in much the same manner and, therefore, already has much of the machinery and experience needed. The Commission, after careful study of the matter, reported favorably on the proposal, and one of the President's last acts before sailing for Europe was to send the bill with a strong recommendation to Chairman Smith of the Committee on Patents in the House, where hearings are soon to be held upon it. In the meantime, it has been introduced in the Senate to expedite its consideration by both houses. As the bill is attracting wide interest and no opposition seems to have developed from any quarter, its early passage is anticipated. This would be especially useful just now when the output of the government's laboratories has been so increased by war activities and we are faced with the problem of dealing with many incidental discoveries and inventions coming therefrom, but having a predominatingly peace-time significance.

No matter how potentially valuable a purely scientific discovery is, it seldom benefits the public-at-large until it is carried through to industrial and commercial development and connected with the well-established avenues of trade. This is what the present bill is primarily intended to do. Incidentally, also it automatically provides the expenses for its own administration as well as means whereby a modest pecuniary recompense may be awarded the discoverer or inventor of anything which through this channel eventually proves of material benefit to humanity. There are also signs of similar interest stirring in Canada, and across the water, which it may be hoped presage a general and more active recognition of just these responsibilities on the part of Government. It is, of course, particularly in the case of patents on broad fundamental projects that such an administration is of most importance to the public. The subjects both of electrical precipitation and of liquefaction of gases, to which we now turn, may serve excellently as suggestive examples.

The fact that my own connection with this latter work has been more from the administrative than the strictly technical or scientific side would make me hesitate to present it on the present occasion if it were not that looking back over the history of electrical precipitation a similar condition is evident, forcing me to the conclusion that even there my most useful services were in securing for the earlier fundamental suggestions of Sir Oliver Lodge and others the sympathetic consideration and practical large-scale development along lines of well-recognized engineering practice which they deserved but which had heretofore been lacking.

In 1904 it fell to my lot to set up and operate a liquid air plant of the Hampson type at the University of California. In studying that installation, I became greatly impressed with the ultimate possibility of producing very cheap industrial oxygen by liquefaction and distillation of air, but was equally impressed with the very crude thermodynamics which, from a modern engineering standpoint, all the then common systems

represented. Shortly thereafter I published two articles emphasizing some of these points and commenced experimental work along this line.¹ But pressure of other duties and lack of facilities prevented my carrying the latter very far. Ever since then, however, I have preached the importance of development in this field and have tried to follow up and post myself on each new attempt that came to my attention.

In assuming charge of the Metallurgical Division of the Bureau of Mines in 1916, it seemed that the quest for really cheap oxygen had become more than ever a large and legitimate part of my regular work; but, realizing my own limitations and the Bureau's inadequacy of material facilities, I strove to suggest, stimulate, and collect inventions and developments rather than attempt to originate anything in this highly technical field.

In connection with the Bureau's laboratories at the International Exposition at San Francisco in 1915, we had already made a strenuous effort to interest the commercial oxygen companies in a cooperative experiment for the application of oxygen or enriched air to metallurgical furnace practice, largely in the hope of stimulating interest in the whole subject, but the project failed to receive sufficient support to be undertaken.

Oxygen as sold to-day in steel cylinders is so expensive that it usually fails to suggest even faintly the ultimate possibilities for low cost production, in which latter case it would of course simply be piped at moderate pressure straight from the separating plant to the furnace. Thus, \$200 a ton for even moderately pure oxygen is a very low price in steel cylinders to-day, whereas on the very large scale where unit cost of plant, overhead, sales expenses, and the like are greatly reduced and compression into cylinders, transportation of same, etc., are completely eliminated, we come down to the power consumption for the actual separation as the largest and dominant factor of ultimate cost. Let us see what limits this sets. The individual steps in the process of liquefaction and separation of gaseous mixtures may all be made thermodynamically reversible to much the same extent in practice as are those of the steam engine and the air compressor. The chance for inventive skill lies chiefly in the selection of these individual steps from the alternatives long since clearly recognized and their combination into a consistent series. The difference in efficiency of present commercial processes resides in the acumen with which this choice and combination has been carried out and in the mechanical perfection of the apparatus in which the system is embodied.

The final measure of theoretical efficiency is, of course, the degree to which reversibility in the thermodynamic sense has been approached. Air, for example, is only a mixture and not a chemical compound of oxygen and nitrogen, and therefore no energy has to be supplied in its separation to overcome chemical affinity, but we do have to overcome what we may call the force of diffusion of the two gases in effecting their separation. In other words, we have to deal purely with that elusive second law of thermodynamics and not with the first. Thus, figured mechanically, the work necessary to separate 5 volumes of air at atmospheric pressure into one volume of oxygen and 4 volumes of nitrogen each at atmospheric pressure is simply that of bringing each of the partial pressures of the two gases as they existed in the mixture up separately to that of the total pressure of the original mixture. Or it is the work necessary to compress the oxygen from the 5 volumes at 1/5 atmosphere to one volume at one atmosphere plus that to compress 5 volumes of nitrogen at 4/5 atmosphere into 4 volumes at one atmosphere, all isothermally. To put this even more concretely, if our heat interchangers and stills were thermodynamically perfect in their operation it would only be necessary to compress the original air to a pressure of approximately 10 lbs. per sq. in. above atmospheric to effect its complete separation into pure oxygen and pure nitrogen

each at atmospheric pressure. Per ton of oxygen separated this figures out 60 horse power-hours on the basis of isothermal compression. This is, of course, the theoretical limit for a perfect reversible cycle, which cannot be attained in practice, but we may hope to approach it to much the same degree that we have the corresponding limit in the steam engine and the air compressor, say 50 per cent as at least a legitimate goal for early endeavor. It seems doubtful whether any large-scale air separating plans at present in service are greatly exceeding 10 per cent. But even 10 per cent would mean oxygen at a power cost of only 600 horse power-hours per ton, which in itself should present startling possibilities to the minds of most chemists and metallurgists.

But why has there not been more actual development? This is chiefly due, I believe, to the very magnitude of the project, requiring as it does the closest coöperation and support of the whole undertaking from both the users and producers of the oxygen. The transition from the present bottled oxygen stage of the industry to that of production directly at and as a part of the large metallurgical plant, let us say, where it is to be used, means not only a complete re-design and development of larger production units, but a complete reorganization of sales and business policy probably representing a licensing of equipment rather than manufacture and sale of product, a procedure which, to a well-established business concern, presents many drawbacks and dangers to their existing business. On this very account, the metallurgist on the other hand has never had the firm offer of oxygen in quantity and at a price to be within possible range of his operations except for such purposes *de luxe* as acetylene welding and burning out frozen tap holes. Consequently, he has never felt justified in the expensive development of oxygen or enriched air furnaces which, if successful, would in all probability necessitate very fundamental alterations in both equipment and practice.

Some experiments in this direction were indeed undertaken in Belgium before the outbreak of the war but were on an entirely inadequate scale to furnish conclusive results, and, from the nature of the problem, its solution is bound to be an expensive undertaking, but one fully justified by the prospect of results attainable.

Let us consider for a moment the tremendous efforts already expended to concentrate up to the limit ores and all the other raw materials entering a furnace, and then remember that we are still adding the oxygen with four times its weight of inert nitrogen, all of which reduces the intensity of the chemical reactions and causes waste of valuable fuel to say nothing of additional expense due to excessive size of equipment.

But to return to the narrative. It was in March 1916 that Director Manning, of the Bureau of Mines, handed me a memorandum of a conversation he had chanced to have in New York with some business men concerning a new process for air separation. The information had filtered through several non-technical hands until it had become more amusing than instructive; but, as it gave some definite addresses, I filed it with similar "clues to great inventions" and later tried to run it down to see if it had any foundation. The trail led me back with some little wandering to Mr. Fred E. Norton, of Worcester, Mass., a graduate in 1891 of the Massachusetts Institute of Technology, who had since had responsible engineering experience pretty much all over the world, and I at once became interested in earnest.

His story for our present purpose begins with his leaving the position of chief designer of the turbine department at the Lynn Works of the General Electric Company in 1913, to enter the employ of Mr. E. A. W. Jefferies and undertake the engineering development of a process of air separation patented by the latter and which he had made arrangements with the General Chemical Company to try out at one of their plants. After

¹ Refer to list of published articles in Bibliography, p. 154.

spending between \$50,000 and \$100,000 on this project the General Chemical Company decided to drop it. Messrs. Jefferies and Norton then pooled their patents as the Jefferies-Norton process and, with the financial help of a few friends, continued experimental development in a smaller way for the next few years.

The parts of their process particularly attracting my attention were those Mr. Norton had introduced after cessation of the work at the General Chemical Company and which radically changed the fundamental cycle upon which he, in common with others, had been working previously.

I found that, after making application for patents, they had discussed the work very freely with those who should be best able to judge of its merits and possibilities, but had made little progress toward securing practical and financial backing toward large-scale development. On attempting to investigate this situation, I found all sorts of impressions and rumors abroad as to just what the system really was. Many of those I talked with seemed to look upon it as a sort of perpetual motion scheme and were sure there was a flaw in the reasoning somewhere, although they had never run it down themselves, but understood that this one or that one had done so. I had a good deal of work and not a little incidental amusement in following back to their source most of these clues and finally satisfied myself that if there really was anything fundamentally impossible in the cycle no one of those I was able to reach had been able as yet to put his finger on it.

Following our custom in the Bureau in such cases, an effort was made to put Mr. Norton and his associates in touch with people who might have sufficient use for such a process to justify their aiding in its further development, but for the reasons above cited I fully realized the difficulties and uncertainties in the way of definitely securing such cooperation.

At the same time as the above development, but quite unknown to me, another thread of the present story was being spun in England. It so happened that Dr. R. B. Moore, now of the U. S. Bureau of Mines, had worked with Sir William Ramsay in his ever memorable investigation on the rare gases of the atmosphere. Under date of February 28, 1915, Sir William wrote to Dr. Moore:

I have been investigating blowers, *i. e.*, coal damp rushes of gas, for helium for our government. There does not appear to be any in our English blowers but I am getting samples from Canada and the States. The idea is to use helium for airships.

The importance of this proposed use of helium for balloons and particularly for airships of the Zeppelin type lies in the absolute inertness and non-inflammability of helium and the fact that it is of all known substances the next lightest to hydrogen, having about 92 per cent of the latter's buoyant effect. It also shows only about half the rate of diffusion and consequent wastage through the balloon fabric. As the fire hazard not only from incendiary bullets in war but also from atmospheric electricity and the Zeppelin's power plant in both peace and war, has constituted the greatest drawback to the development of lighter-than-air craft, it is difficult to overestimate what an available supply of this gas may eventually mean in the art.

At the time of the receipt of Sir William's letter the United States was not as yet in the war and nothing immediately came of the suggestion in this country. Dr. Moore remembered, however, that in 1907 Dr. H. P. Cady, of the University of Kansas, had found over 1 per cent of helium in some natural gases from Kansas.

In a recent letter, Dr. Moore says:

In April 1917, when we entered the war, Sir William Ramsay was dead. Two or three days after war was declared, I attended a meeting of the AMERICAN CHEMICAL SOCIETY in Kansas City, April 10-14, 1917. At the general session, Mr. Seibel, of the University of Kansas, who had been working with Doctor

Cady,¹ gave a paper on krypton and xenon in some of the natural gases of Kansas. At the end of his paper, he expressed regret, that at such a time, when every one was thinking of war problems, his paper was of a purely scientific nature and had no practical bearing on the war. I immediately got up and said that I did not agree with Mr. Seibel, as the presence of helium in these wells could, and should, have a very practical bearing on the war, as this gas could be extracted in quantity from the natural gas and used for balloons and Zeppelins. I pointed out some of the natural advantages of helium over hydrogen, and quoted Sir William Ramsay's letter. The general attitude of those present was one of skepticism, and I finally asked Doctor Cady for his opinion. He stated that he believed the thing could be actually done, but was very doubtful whether it could ever be made practical on account of the cost. At the close of the session, Mr. Seibel came to me and asked if I really meant what I said, or whether I was joking, and I told him that I most certainly meant every word that I had said.

That same day I talked to Doctor Parsons, who was present at the meeting, and who was returning to Washington almost immediately. I told him what had happened, and told him that I believed the matter should be taken up by the Bureau at once, and presented to the War Department. He promised that he would do this as soon as he got to Washington, and I know that he did take the matter up with other Bureau officials.

News of Ramsay's suggestions also reached this country through other channels and eventually came to our attention, Professors Satterly and Patterson of the University of Toronto having commenced experimentation on the subject on January 1, 1916. Col. G. A. Burrell, head of the Research Division of the Chemical Warfare Service, also tells me that Cady's experiments had suggested similar possibilities to him.

However, no definite step toward securing action seems to have been taken in the United States until June 1, 1917, on which date Messrs. Moore and Burrell, at that time both of the Bureau of Mines, called on Colonel Chandler, in charge of the balloon service for the Army, and explained the whole subject to him. He was intensely interested, at once realizing its potentialities, and asked that a report be made to him, giving all available details. He also took the matter up with Mr. G. O. Carter, in charge of hydrogen plants for the Navy, who had had several years' practical experience in the Linde Air Products Company with the liquefaction and separation of gases by their process. Mr. Carter also immediately appreciated the importance of the subject and urged this upon the attention of his superiors in the Navy.

Up to this time in the whole world there had probably not been more than 100 cu.ft. of helium separated as a pure substance, and its usual price in the small lots in which it was sold was at the rate of about \$1700 per cubic foot.

About this time I was called into the conferences and was much impressed by the weight which the British Admiralty apparently laid upon the cost of separation of the gas as a determining factor in its practical availability. I was given to understand that they had figures on the basis of the well-known commercial process of gas liquefaction and separation and were unable to see how production could be hoped for at less than \$60.00 to \$80.00 per thousand cubic feet, which they felt to be practically prohibitive for the program then in mind. It was at this stage that I suggested turning to Mr. Norton at least for a plan and estimate of what he thought might be accomplished along the new lines he had been following, and we accordingly wired for him. On Monday, June 4, 1917, we spent practically the whole day in thrashing out the subject with Mr. Norton, Mr. T. B. Ford,² then in charge of the Low Temperature Laboratory at the Bureau of Standards, and Mr. O. P.

¹ H. P. Cady and D. F. McFarland, "The Occurrence of Helium in Natural Gas and the Composition of Natural Gas," *J. Am. Chem. Soc.*, **29** (1907), 1524-36.

² Mr. Ford not only rendered valuable service in these early conferences but took a most helpful and important part throughout the later stages of the work both at the Bureau of Standards and in a trip he made to the plants in Texas. He was engaged in this work when suddenly stricken down a few months ago with influenza. His death came as a shock to us all, terminating as it did a career of great promise.

Hood, chief mechanical engineer of the Bureau of Mines. As a result, Mr. Norton was asked to act as a consulting engineer of the Bureau of Mines and prepare plans and estimates for an experimental plant.

Dr. Moore then returned to his station at Denver. Shortly thereafter I left on a several months' circuit of our western experiment stations, and the supervision of the project for the Bureau of Mines devolved entirely on Mr. Burrell.

In due course a formal report by the Bureau of Mines was transmitted through Secretary Lane to the War Department, and although this report was as yet fragmentary and based on very inadequate data concerning the practical conditions to be met in the field, the Air Craft Board on July 31, 1917, recommended an allotment of \$100,000, half each from the Army and Navy, which became available for the use of the Bureau of Mines on August 4.

A detailed survey of field conditions, to determine the best available supply of natural gas for the purpose, was at once begun, as was also the preparation of working drawings for the experimental separation plant.

The general supervision of this was for a short period at this time placed in the hands of Prof. W. H. Walker of the Massachusetts Institute of Technology who had come to Washington to assist in the chemical warfare work. I believe it was his suggestion, for purposes of military secrecy, to use the word "Argon" as a code term for helium in all our correspondence on the subject, it being thought that as real argon is also an inert gas but too heavy to be of any value in balloons and is already used to a large extent in the incandescent electric lamp industry, this would serve as particularly effective camouflage. This has in fact so effectively confused the two words in the public's mind that it will take some little effort to clear up the situation, and I would therefore bespeak your help in holding strictly to the true name, helium, whenever referring to the subject, now that all secrecy in the matter has been abandoned.

Even though we had been drawn into this work primarily through the desire of the British authorities to find a more economic process than those already known to them, it was now felt that the project had taken on such magnitude that the whole field should be carefully canvassed *de novo*. Mr. Burrell therefore next communicated with the two well-established operating companies controlling, respectively, the Linde and Claude systems of gas liquefaction and distillation, to determine whether it would be possible to work out a plan of general coöperation and pooling of information and facilities for this specific war purpose. Due to questions of trade secrets and other business relations, this did not, however, prove practicable, though both companies expressed themselves as anxious to coöperate individually with the Government and as entirely willing to undertake independent efforts and the erection of plants of their own respective designs at cost, or even less, and have ever since most cordially furnished every aid in their power to make the work as a whole a success.

At this juncture a special commission from the British Admiralty, headed by Commander Cyprian D. C. Bridge, arrived in this country to collect data and exchange ideas on what was being done, and from the resulting conferences the possible importance of the work in hand became so evident that the Aircraft Board on October 17, 1917, recommended that a further allotment of \$500,000 be made jointly by the Army and Navy to permit of immediately starting construction of complete plants under all three processes.

In accordance therewith, Mr. Norton was directed to prepare plans for a somewhat more complete plant embodying his process than had originally been contemplated as a first step. This brought the total estimated cost of the plant to about \$1,500,000.

In making the actual allotment, however, the Navy placed upon its half of the \$500,000 the restriction that none of it should be used on the Norton project. When this was called to the attention of the Army the latter decided to follow the Navy's lead as they were very largely relying upon it for guidance and had designated Mr. Carter to represent them jointly in the matter.

While thoroughly realizing the expediency of the Navy's policy in making sure that the plants under established processes should be adequately financed and pushed with all possible rapidity to completion, the curtailment of support for the newer and more experimental portion of the program was a serious disappointment to those of us in the Bureau of Mines who had made a careful study of the Norton project and felt strongly as to the importance of giving it a thorough trial. The representatives of the British Admiralty also stated frankly that their main interest lay in the experiments on this process as there was no particular doubt in their minds that either of the other processes could produce the gas, the only question being one of cost, and on this no one responsibly connected with either of the two old processes had been willing to even hold out any definite hopes of producing helium below the cost of \$80.00 a thousand cubic feet, which the Admiralty at that time considered prohibitive for its chief purposes.

The matter was consequently taken up afresh with the Aircraft Board and after considerable discussion that body on December 11 recommended to the Army and Navy a further joint appropriation of \$100,000 specifically for the Norton project. The Army immediately acquiesced with regard to its half, but the Secretary of the Navy, feeling the need of further outside advice in the matter, requested the National Research Council to investigate the project with special regard to its theoretical soundness and its apparent chances for practical success.

The Council appointed for this purpose a committee of five consisting of Prof. Harvey N. Davis, of Harvard University, Drs. Edgar Buckingham and Chas. W. Waidner of the Bureau of Standards, Dr. W. S. Landis, of the Air Nitrates Corporation, and Mr. S. L. G. Knox, consulting mechanical engineer and later scientific attaché at the American Embassy at Rome. This committee after very careful comparative study of the three processes concurred in the Aircraft Board's recommendation of the additional \$100,000, which was then immediately made available by the Army and Navy.

This was early in February 1918, the controversy over the support of the project having delayed the starting of construction of the Norton plant by something over two months.

In the meantime contracts had been closed with the Linde Air Products Company and with the Air Reduction Company for the construction and experimental operation of a Linde and a Claude plant, respectively, each for an estimated daily production of about 7000 cu. ft. of helium, and construction was well along on each. These plants were to be located at Fort Worth, Texas, and operate on a natural gas containing about 0.9 per cent by volume of helium, of which the Lone Star Gas Company was bringing some 20,000,000 cu. ft. daily through its pipe line from the wells at Petrolia, over a hundred miles northeast of Fort Worth, to that city for domestic and industrial consumption. After the extraction of the helium the residual gas was to be returned to the company's mains for its ordinary fuel purposes.

After careful study of field conditions it was decided to locate the Norton plant at Petrolia in direct proximity to the wells, a procedure which had not been deemed practical for the other two plants on account of their larger demands for power and water supply.

Parallel with the Bureau of Mines' work on processes of extraction, Dr. A. F. Rogers, of the U. S. Geological Survey, undertook a reconnaissance of all natural gas fields in the United

States with regard to their possible helium supply, as this might be judged from sampling and analysis of existing wells combined with a study of geological considerations. As the results of this study are expected to be issued soon as a monograph by the Survey, no attempt will be made to deal with them here.

The Bureau of Standards also undertook the determination of certain physical properties of the gases, more especially the latent and specific heats and specific volumes of methane over a wide range of pressures and temperatures, and the diffusion of helium through balloon fabrics, all of which it is expected will also be published in due time by that Bureau.

In order to properly coordinate all the different agencies concerned, the conduct of the helium work as a whole was about this time placed in the hands of a committee consisting of one representative from each of the three departments chiefly concerned. Mr. G. O. Carter, as chairman, represented the Navy, Dr. Harvey N. Davis, the Army, and Mr. Geo. A. Orrok, the Interior.

The Linde plant, costing in round figures \$300,000, was the first to be contracted for and have its construction started. It commenced operation March 6 and on March 22 produced gas containing 28 per cent helium. By April 21 this purity had reached 50 per cent, the yield being at first small but both quantity and purity steadily increased up to a maximum daily production on September 6, of 7755 cu. ft. of 67 per cent purity, with average production of say 5000 cu. ft. at over 70 per cent purity, which was then further purified in a second step to about 92 or 93 per cent purity.

The Claude plant, costing about half as much as the Linde, commenced production some weeks later than the latter, and has also gradually increased its production and purity of product. Although up to date these are still considerably behind the performance of the Linde plant, a new still is just being installed in the Claude plant which it is hoped will materially improve both yield and purity of the product.

Due to present pipe-line limitation, coupled with heavy consumption of fuel gas at this time of year, it has been necessary for some months past for the Lone Star Gas Company to mix with the Petrolia gas some from other fields carrying less helium, so that the helium content of the gas at present being treated at Fort Worth has fallen to between 0.4 and 0.5 per cent by volume which proportionately cuts down the production of both plants.

At the time of signing the armistice the first shipment of 147,000 cu. ft. of 93 per cent helium was on the dock about to be loaded aboard ship for Europe. This at the above cited pre-war prices would represent about \$250,000,000 worth of gas.

A large part of the credit for the promptness with which this actual production was affected is due to Mr. Carter, who was tireless in his efforts in pushing matters of priority, transportation, construction, and production.

The Army and Navy have now jointly entered upon a larger production program under the immediate direction of the Navy, and have allotted some five million dollars for the purpose including the construction of a new pipe line and additional units of the Linde Plant at Fort Worth. General Squire, in an address before the American Institute of Electrical Engineers last week, stated that "Plants are under construction to give at least 50,000 cu. ft. a day at an estimated cost of not more than 10 cents per cu. ft." If present expectations of the Norton process are fulfilled, this cost may be still further greatly reduced.

The Bureau of Mines or Norton plant at Petrolia was completed as far as initial construction is concerned the middle of October, and since that time its various parts have been successively undergoing tests and adjustments of its various parts *seriatim*. The multi-tubular heat interchangers and large expansion engines, which were among the new depart-

tures in this plant, over which most anxiety was originally felt, have thus far worked out very well and now seem to be performing their allotted tasks to complete satisfaction. A good deal of difficulty was at first encountered by occasional floods of several barrels of oil and salt water coming over from the Lone Star Gas Company's gasoline extraction plant, which immediately clogged up the interchangers, making it necessary to shut down and go through the laborious process of thawing out the whole system and starting refrigeration afresh. This has now been eliminated by the installation of adequate settling chambers and traps, and tests and adjustments are proceeding upon the stills which form the last part of the equipment to be proven out. It is hoped that helium production will soon be attained, but as this plant has a rated production capacity of several times that of either of the other two, each change or adjustment in its parts requires rather more time, even aside from the fact of the entire novelty and experimental character of many of its parts.

The rest of the story including comparison of the general principles on which the three plants operate, as well as a concrete picture of the plants themselves, can best be presented by the lantern slides to which we will now turn.

BUREAU OF MINES
SAN FRANCISCO, CALIFORNIA

AN APPRECIATION OF DR. COTTRELL

By BUCKNER SPEED

Dr. Cottrell has been, to those of us who have known him for the last fifteen years, a dear friend and gay companion. The fame and recognition that have come to him for the Cottrell process are less to us than the admiration we have for his unselfish character, his constant putting of his own interests entirely in the background, his remarkable imagination, and his quick sympathy and helpfulness. On one occasion I remember his saying, at the completion of one of his large pieces of work: "Oh, I did not do much of it—I merely acted as a catalyzer to the boys who really did the work." He has truly been a catalyzer to a host of us who have had the deep delight of working with him and coming in contact with his perennially fresh and keen imagination as well as his patience in the trying times that accompany all large efforts.

This is the way the man's mind works: I recall some twelve years ago, when he was working on the precipitation of smelter smoke, I asked him for help on what seemed to be scarcely an allied problem, the freeing of California crude oil from its emulsified water. Instantly his mind worked with a snap. "Why," he said, "it's the same problem. For air put oil; for smoke particles, the minute water particles," and then his favorite form of expression: "*What will happen if we put a high electrostatic stress on the oil?*" Then in his characteristic quick manner, in a few minutes there were thrown together a beaker of oil, a spark coil, and two pieces of copper, and lo, the de-emulsification of the California oils had been solved. Within a few minutes, on a block of paraffin under the microscope there was spread out a drop of the emulsified oil, with two electric wires touching its edges. When the spark coil was put in operation the water drops were seen to arrange themselves in the field of the microscope like the iron filings between the poles of the magnet, to dance about and jiggle themselves into larger drops; and in these few minutes of experimentation the problem was solved by which millions of barrels of unmerchantable California oil were rendered fit both for refining and for fuel purposes.

It was a familiar phrase to be heard in the University of California anywhere from the botany to the physiology departments when any question of any description came up: "Oh, go over and talk to Cott about it—he doesn't know anything about the subject but he will put some idea in your head before you have

talked with him ten minutes," and this he invariably did. This is the work he is now doing in Washington and all over the country; wherever he touches an industry, there he leaves the germ of a thought that months later will come out as a manufacturing process. Such a man's work cannot well be measured by the achievements that have been credited to him.

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UNITED STATES PATENTS

Date of Application	Date of Issue	Number	TITLE
1906, Jan. 4	1907, Sept. 24	866,843	Manufacture of Sulfuric Acid
1906, Jan. 4	1907, Sept. 24	866,844	Apparatus for Separating Sulfuric Acid
1907, July 9	1908, Aug. 11	895,729	Art of Separating Suspended Particles from Gaseous Bodies
1908, July 13	1910, Jan. 11	945,917	Effecting Interchange of Electric Charges between Solid Conductors and Gases
1908, Nov. 24	1913, Apr. 29	1,060,065	Filtering Medium and Process for Making the Same
1909, Feb. 26	1912, Feb. 6	1,016,476	Purification of Gases
1909, May 20	1911, Mar. 21	987,115	Separating and Collecting Particles of One Liquid Suspended in Another Liquid
1909, May 20	1911, Mar. 21	987,116	Apparatus for Separating and Collecting Particles of One Liquid Suspended in Another Liquid
1909, Sept. 9	1915, June 15	1,143,175	Synchronous Electrical Contact-Maker
1909, Sept. 9	1912, Aug. 13	1,035,422	Apparatus for Separating and Collecting Particles from Gaseous Bodies
1909, Oct. 12	1911, Mar. 21	987,114	Process for Separating and Collecting Particles of One Liquid Suspended in Another Liquid
1910, Dec. 1	1911, Mar. 21	987,117	Separating and Collecting Particles of One Liquid Suspended in Another Liquid
1911, Nov. 6	1913, July 22	1,067,974	Method of Discharge of Electricity into Gases

FOREIGN INDUSTRIAL NEWS

By A. McMILLAN, 24 Westend Park St., Glasgow, Scotland

THE APPLICATION OF WELDING

The amount of publicity that has been given to the fact that ships are being constructed with the various parts welded together instead of being riveted as hitherto must serve to focus the attention of engineers upon the possibilities of this method of construction. Welding has for a long time been used with considerable success for the carrying out of various repairs, for the uniting of fractured parts of castings, and even for the thickening up of wasted parts, but its extension to many processes has been slow in following the obvious success which it has long achieved in the more limited field of repair work. For the construction of light tanks where absolute water or oil tightness is desired, welding can be easily used and it is worthy of notice that the process has been utilized in this direction but mainly for the uniting of parts in awkward positions where riveting would be difficult to perform. The blow-pipe yields one of the simplest means of cutting plates known to the engineer, particularly if cutting to any desired shape is required, but it must be admitted, says *Power User*, that the more laborious methods are still used in shops which will be considered up to date. It will be apparent that the field open to the application of welding processes is far from being covered by the examples quoted above.

SOURCES OF POTASH

The trade in potash, says the *Times Trade Supplement*, which is one of world-wide importance, was at the outbreak of the war, almost entirely in German hands and was considered to be one of the powerful economic levers by means of which Germany might secure from enemy countries the necessary supply of raw materials for her various industries. During the last few years, however, it has been shown that potash can be obtained in quantity from other natural products. In a paper by Mr. E. A. Ashcroft read before the Institute of Mining, London, it was stated that it was possible to manufacture from potash feldspar fused in closed receptacles with an equal weight of common salt at a temperature not exceeding 1000° C. a product consisting of finely-divided insoluble sodium feldspar and a mixture of quite neutral and freely-soluble sodium and potassium chlorides. The author maintains that, under proper conditions, this simple process is capable of industrial application and that it might be applied to the vast supplies of alunite found in South Australia where it is estimated that at Bullahdelah in New South Wales at least 200 million tons of this material are in sight in cliff form in the outcrop. It is stated that by simply calcining the alunite large quantities of fertilizer containing 16 per cent potassium sulfate could be prepared on the spot.

HARDWARE FOR BRAZIL

Although Brazil is fast approaching that state which will render the country independent of a good many of the foreign-made articles that have hitherto formed part of its imports, the various kinds of enameled ware are not among them. This class of goods made locally is very inferior and finds markets only in the far interior. The best stores do not stock such goods and, as a rule, they sell only the high-class manufactures of Great Britain and the United States, together with those of the less expensive grade from Germany. Although inferior in wearing qualities, the German article is lighter and more attractively turned out. The difference in selling price is as much as 50 per cent in some cases. The demand is most pronounced in cups, saucers, plates, jugs, basins, bowls, buckets, ewers, etc., but there is a good sale for all kinds of cooking utensils such as saucepans, ladles, fish-slices, pans, and colanders. Although, in many parts of Brazil, articles of these kinds in aluminum have been making headway, nevertheless the native demand for enameled ware is very regular. The principal ports of entry for such goods are, in order of importance: Rio de Janeiro, Bahia, Rio Grande de Sul, Perra, Manaus, and Pernambuco. The selling kinds are white inside with colored enamel outside or white throughout lined with colored band, blue or red. Blue is the more popular color. The terms for sale in the trade have been, up till now, 90 days' sight with a discount of 1½ to 2 per cent for immediate payment. In normal times Brazil takes from the United Kingdom goods to the value of \$20,000 in wrought and \$70,000 in cast iron together with an additional \$280,000 in tinplate.

LUBRICATING OILS

A memorandum recently published by the Department of Scientific and Industrial Research, London, deals with the subject of cutting lubricants and cooling liquids, and states that the mineral oils which are best suited for the first named purpose, either by themselves or in combination with oils of animal or vegetable origin are those of pale color and low viscosity ranging from 100 to 200 sec., Redwood Standard, at a temperature of 200° F. For high-speed conditions oils of lower viscosity may be used and similarly oils of higher viscosity are suitable for low-speed work. Taking the animal oils, used either alone or in combination with one another, it is found that prime lard oil is practically free from acid while tinged lard oil contains a percentage as high as 15 in some cases. The tinged oil is less costly in the first place but is more inclined to gum under severe conditions. As lard oil congeals in cold weather it should be mixed with good low-cooled mineral oil for winter use.

ANTI-GERMAN INDUSTRIAL DEVELOPMENTS IN SWITZERLAND

German papers acknowledge, says *Engineering*, that during the war the industrial developments in Switzerland have taken up a decidedly anti-German trend. Prior to the war, Germany was by far the largest purveyor of industrial products in Switzerland. German goods were to the fore in all branches and German commercial travellers visited the country in large numbers. Even before the war, a movement against the German commercial invasion had manifested itself and right-minded Swiss strongly urged their country to adopt a more independent attitude. Measures are now clamored for, which are intended to favor home industry as against foreign undertakings, and steps have also been taken which the Germans are inclined to call non-neutral. Active work is in process, it would appear, to close the Swiss markets as much as possible to Germans in favor of France and allied countries. Germany is blamed in Switzerland for illegal competition and for underselling home industry.

USES OF RAW PRODUCTS

The *Wellmarkt* directs attention to new uses of some raw products. In Holland a useful gum or paste is being made from garlic. The bulbs are pressed and the juice or fluid matter so obtained is thickened by evaporation. A good substitute for cork is said to be obtained from certain fungi which are dried and ground, mixed with cement and consolidated by pressure. In Norway, a process has been patented to enable carbide to be used for driving motors. In Denmark, a company has been floated to make briquettes from heather. These are said to have a higher heat value than peat. Experiments are also being carried out whereby chalk marl, especially that which comes from the Limburg mines, may be used as a manure.

MANCHURIAN MAGNESITE

According to *Engineer*, 126 (1918), 351, a Manchu mining company is now distributing a prospectus which states that the reserve of magnesite ore in Manchuria is estimated at 200 million tons. The quality of this ore is said to be excellent and much better than that found in North America. Fire-proof bricks made with this magnesite and sent to the Chemical Industries Exhibition held at Tokio in 1917 have been tested and found to be superior to those hitherto imported from Austria which, prior to the war, was practically the sole source of supply. The same fact is said to have come to light on testing magnesite cements. According to analyses made, the future of these productions is most promising. The tests made of the Manchurian magnesite gave the following results: magnesia, 47.13 per cent; lime, traces; oxide of iron and aluminum, 0.64 per cent; silica, 1.48 per cent; carbon dioxide and water, 50.75 per cent.

CATALYST FOR METALLIC SALTS

According to a new German patent, the mass obtained by precipitating metallic salts on an inorganic carrier is dried and mixed with the material to be treated or is triturated with an inert solvent and is then treated to expel the water and volatile acid of the salts which would otherwise act adversely to the reduction process. If the catalyst is intended for reducing fats and oils, kieselguhr, asbestos, etc., are saturated with nickel acetate, the dried mass being ground extremely fine with little oil and then heated to 150° or 200° C. in a closed apparatus, filled with stirrers, and connected to a vacuum pipe. When the water and volatile acid have been drawn off, the catalyst is rendered more active by a current of hydrogen. The product is claimed to be stable and to stand carriage.

ANNEALING ALUMINUM

The common practice employed for annealing cold-rolled sheet aluminum is to treat the metal for 18 to 30 hrs. at a temperature of about 375° C. and subsequently allow it to cool in air. The maximum softness attainable for material of commercial purity is 4 to 5 on the Shore scleroscope scale. When rolled hard the material has a Shore hardness of 13 to 15. The hardness of the annealed sheet is no measure of its ductility. The coarse-grained material obtained by an annealing of 30 hrs. at 400° C. is very weak although its hardness is only 4. When annealed at 400° C. even for short periods, the metal "blisters," an effect also produced by prolonged heating even at 350° C. The formation of these blisters, says *Engineer*, 126, 463, is dependent on the temperature and speed of pouring the original cast metal. Prolonged annealings are very harmful, rendering the metal coarse and weak. The results of tests show that there is no necessity for the common practice of annealing aluminum for 24 hrs. at 375° C., a much shorter time being sufficient.

THE LUDWIK HARDNESS TEST

In a recent paper before the Institute of Mechanical Engineers, London, Prof. W. C. Unwin dealt with what is admittedly a difficult problem—the question of hardness tests. The well-known Brinnell test is open to the objection that the hardness number derived is influenced by the magnitude of the load and the radius of the ball. This is apparently due to the fact that the indentations are dissimilar. Dr. Paul Ludwik, of Vienna, says the *Electrician*, has proposed the use of a right-angled cone as the indenting tool. The indentations in this case are always geometrically similar so that the hardness number is a much more constant quantity. Prof. Unwin presents a variety of data comparing the two methods. If a truncated cone is used one of the possible objections to the Ludwik test, *viz.*, that the point of the cone is unable to withstand constant pressure, is removed. In these circumstances, the indentations are not quite geometrically similar for different loads but are more nearly so than for the ball test, and the hardness number will be within limits independent of the load. The rational direction of standardization would seem to be to vary the load so that the volume of indentation is approximately constant. It is shown that in these circumstances the load required to produce a certain indentation can be approximately predicted. The volume of indentation is greater for a less load in the cone test than in the ball test which seems to be an advantage on the side of the former.

THE ELECTRICAL INDUSTRY IN JAPAN

A statistical report of electrical undertakings in Japan has just been issued in which it is stated that the total number of such undertakings in the country is 2,617. Of these, 1,195 depend on water for their power, 854 on steam, and 568 on gas. They are, again, composed of 472 electrical supply undertakings, 26 electric traction, 48 electric traction and supply, 1,946 isolated plants and 125 official plants. Classified by degree of electrical pressure, 1,728 are "low," 720 are "high," and 159 are "extra high." "Low" pressure means a pressure not exceeding 600 volts in the continuous circuit nor 300 volts in the alternating system. "High" pressure means a pressure beyond this low-pressure limit and not exceeding 3,500 volts.

TUNGSTEN ALLOYS

Under the German patent of G. Fuchs, tungsten alloys with the precious metals are produced indirectly from alloys with nickel, iron, or aluminum, and are claimed to have superior properties for jewelry while their resistance to acids gives them advantages for technical purposes. An alloy composed of 75 per cent gold, 10 to 15 per cent tungsten, and 10 to 15 per cent nickel can be hammered and rolled and takes a much finer polish than platinum, while one with 80 parts silver, 10 to 15 nickel, and 10 to 15 of tungsten is said to have greater strength than that prepared with gold. It is also stated to be more resistant to oxidation and takes a better polish than silver.

ADAPTING DIESELS TO TAR OILS

The Basingstoke Town Council, England, has adopted a scheme drawn up by their engineer, Mr. G. Broadhurst, providing for the fitting of Smitar's pulverizers to the Diesel engines by which a considerable economy in crude oil is expected. Instead of each engine consuming a minimum of 12 lbs. crude oil per hour, they will be started on crude oil and, after running for five minutes, changed over to tar oil. In addition to an annual saving of \$1,250, it will be possible to keep the engines running for longer periods. The present ring-type pulverizers have to be cleaned out three times per week, whereas, with the new pulverizers, this will only be necessary when the engines have run 800 hours—a net saving of 21 hours per week.

AMMONIACAL LIQUOR AS A FERTILIZER

Some very good results by using ammonia water as a fertilizer have been obtained by Dr. F. Mach at the Agricultural Institute, Baden. At the same time, great caution is advised in this use of gas water owing to its poisonous character. The water in question contained on an average 1.4 per cent of ammoniacal nitrogen and only little mineral substance, there being 1.11 per cent of dry residue and 0.008 per cent of ignition residue. But there were also present 0.24 per cent of phenols, 0.23 per cent of sulfureted hydrogen, 0.196 per cent of hydro-sulfo-cyanic acid, and traces of hydrocyanic acid. For these reasons the water must be spread over the soil and ploughed under about 2 weeks before potatoes or seeds are sown. Ammonia in itself is, moreover, not in general a sufficient fertilizer. Most crops also need potash and phosphate. If it were not for the poisons present, the gas water would be superior to liquid farmyard manure.

SUBSTITUTE VARNISHES IN DENMARK

The British *Board of Trade Journal* states that a company has been registered at Copenhagen for the production of a varnish substitute—stated to be a "Gallalit" substitute derived from fish oil. It is stated that this substitute has been tried at the State Experimental Department and has been found useful in connection with electrical insulators. Experiments show that it resists 25–35,000 volts. The factory for the manufacture of this product has been built at the Scaw in the extreme north of Denmark. Other varnishes which have been patented in foreign countries are also being made in this factory. One, it is stated, is made in all colors and has the quality of covering and drying extremely well. An excellent fish guano is extracted from the offal.

PO-YOAK OIL—A NEW DRYING OIL

A sample of Po-Yoak oil from Sierra Leone, derived from the kernels of a species of *Parinarium*, was found, on examination, to be pale yellow in color, contained a deposit of dark-colored "stearin," and had a smell resembling that of Chinese tung oil. On standing for some time in a cool place the oil became thick and pasty. Its high iodine value indicated that it belonged to the class of drying oils and could be utilized in the manufacture of paints and varnishes, though technical trials will be necessary to determine its precise value for these purposes. It is interesting to note, says the *Times Trade Supplement*, that the kernels of *Parinarium Mobola* from Liberia were introduced on the Liverpool market some 40 years ago as an oilseed.

BRITISH GULANA TIMBER

The current number of *Timehri*, a British Guiana journal, contains articles of interest on the constructional woods of that colony and on ligno-concrete. Experiments are given illustrative of 17 kinds of the 250 distinct woods in British Guiana and it is known that 13 out of the 17, when subjected to tests of the relative transverse strength, were better able to resist stress than oak, pitch pine, teak, or mahogany. Fourteen were stronger than jarrah, northern pine, or white pine, and fifteen were stronger than white fir or spruce. Mr. L. P. Hodge, who writes on ligno-concrete, draws attention to the increase in price of mild steel or iron reinforcement caused by the war—an increase which is likely to be maintained in peace, at least for some time, because of the demand for structural steel—and suggests that the greenheart grown in British Guiana will have teak only as its main competitor. With the exception of English oak, and beech, which is not available in large quantities, it is said that there are no woods so suitable for ligno-concrete as teak and greenheart.

AN INSTITUTE FOR COÖPERATIVE RESEARCH AS AN AID TO THE AMERICAN DRUG INDUSTRY

A number of interesting letters bearing upon the proposed institute for drug research were received too late for printing in the January issue of *THIS JOURNAL*. These letters are given below.

At the meeting of the Advisory Committee of the AMERICAN CHEMICAL SOCIETY on Saturday, January 11, 1919, the resolutions of the New York Section of the AMERICAN CHEMICAL SOCIETY, urging that the establishment of the institute be undertaken under the auspices of the AMERICAN CHEMICAL SOCIETY, were considered, and the president authorized to appoint a committee to report to the Advisory Committee the statement of endowment needed for salaries, buildings, equipment, and operating expenses, and an outline of policies for such an institute.

The president appointed Chas. H. Herty chairman of this committee and will appoint the other members of the committee later.—[EDITOR.]

MANUFACTURERS

WILLARD OHLIGER, Vice President, Frederick Stearns & Co., Detroit, Mich.

The plan to establish a national institute in which chemists and chemical manufacturers can obtain the services of expert workers along related lines of scientific effort to round out deficiencies or gaps in their own staffs or to carry on work that they are not equipped to do, seems logical and timely. While a number of manufacturers, pharmaceutical perhaps more especially, have the needed staff of chemists, biologists, bacteriologists, pharmacologists, and other scientific workers in their own plants, there is a larger number not so fortunately situated. The latter have at times experienced more or less difficulty in obtaining the services of capable scientific men to carry on special problems of research or even high-grade bacteriological or pharmacological testing. Some of our best scientific men in the colleges and universities either do not have the necessary time, or do not seem to care to undertake any work savoring of the commercial, evidently considering such tasks beneath the dignity of their position. It goes without saying that an institution to do the work suggested must be conducted by big men, men with a vision, not hide-bound, tolerant of new things, ideas, methods, not prejudiced, but always open to conviction.

A manufacturer or other patron of the institute should be able to have any particular phase of a problem which he has developed through his own efforts and ability worked out without necessarily throwing the whole subject open to competition. This would be but justice to the inventor or developer of an idea, method, or product. He should be protected in every way by the institute and by every worker connected with it. If he receives no such protection the result of his work and industry could shortly become the property of his competitors.

For instance, he may produce a desirable chemical according to methods of his own but experience difficulty in purifying it. I believe that it should be readily possible for him to go to the institute with this one problem and have assistance in working it out. I do not believe that the institute should be given *carte blanche* with no limitation whatever.

In the testing, both on animals and clinically, an institute could be of almost inestimable value since many of the largest manufacturers have either no facilities at all for this work, or but inadequate ones. Even those who are equipped to do all of their own work would find the institute valuable if for no other purpose than to check and verify the work already done. A favorable report by such an organization would give the manufacturer greater confidence in his own product and no argument

is necessary to demonstrate that physicians, dentists, and veterinarians would feel likewise. It would place the determination of the merits of a medicinal preparation in the hands of men who have no financial or personal interest in the article. Their verdict should then be honest, impartial, disinterested, and scientifically correct.

B. L. MURRAY, Merck & Co., Rahway, N. J.

"Having solved the details of the manufacture of some new compound where would you turn to have it tested thoroughly with respect to its use in medicine?" Thus spoke one baseball fan to another. Let me ask a counter question which has likewise proved difficult to many other fans. "Having discovered a new compound of proven(?) merit, where would you turn to have it manufactured?" The answers to both are unsatisfactory. There are men in private life, in educational institutions, and in commercial enterprises who are abundantly able to test any medicine. While they are able, they do not always have the opportunity. And there are many firms that can manufacture the new discoveries. While they, too, are able, usually they will not.

The above seems to be the situation as it is before us to-day. It is evident that a neutral go-between is needed. If we had a bureau in some organization devoted to sciences in general (National Academy of Science? American Association for Advancement of Science?) to which the research discoverer and the manufacturer discoverer could take their products for the purpose of making more suitable connections for appropriate further steps, it would seem to help. The go-between would serve primarily as a clearing house helping each client to meet his affinity. Thus to the able scientist would be presented the missing opportunity, and to the unwilling manufacturer the incontrovertible evidence of merit in the new medicine. Perhaps not much more than the above is required to meet our present needs, and I believe the plan outlined is workable, because not much money is necessary to carry it along.

As to our future needs—we ought to take up the hunt for new and better medicines with renewed vigor and on a more extensive scale. Not all the desirable ones will be found in the coal-tar products, not all in animal products, not all in any one field. Nature is vast and we shall have to search for things relatively very small. What is one crystallizable principle from the juice of a single leaf in Nature's immense warehouse? It is as nothing. It is merely cocaine! Locked in what other of Nature's cells, animal, mineral, or vegetable, shall we find the other active principles that are wearily waiting for us? There are indeed many cells, and the hunt must be both intensive and extensive.

A general movement to investigate the possibilities of new medicinal agents such as has been proposed and discussed depends for its success primarily on money. Lots of money would be required, and the returns in terms of money would be nearly invisible. Business men engaged in making their dollars bring in other dollars will hardly finance such an enterprise. Philanthropists may be found who will endow the movement. The reward would not be in dollars, but would be infinitely better. A thorough search for the philanthropist should be made. The work cannot even begin without money in plenty.

But why should we, Americans, leave to chance philanthropy a work so imposing, so important, and filled with such vast possibilities for good for our individual selves? Perhaps an endowment cannot be secured. Must we then lose out? I see no other hopeful means of accomplishing this work than

through our own efforts. Let the plain citizens furnish the money. The benefits from the work are to be theirs. This, as you see, means organization of the work under government direction. We all contribute to the expense of government work, and we all enjoy the results.

It is quite possible that there is now no department of the Government ready or suitable for the work. A new organization would be desirable any way for a new problem. It is a good time to propose a new phase of government work. We are in a transition stage. We have developed the need for a new line of work, let us provide ourselves with new tools. Think of the chemists, biologists, pharmacologists, physicians, and other scientists, needed for our work, who are at this moment in uniform! What a fine lot of candidates from which to make selections for some of this work!

The discovery, testing, and subsequent manufacture of new medicines bristles with knotty problems. This is not the time to solve them, but they may be recognized nevertheless. As to discovery, usually the result of research, it must be conceded at the outset that the field is limitless. This of itself presents a real problem. Workers may spend their lives in fruitless and disappointing search. The need for *well-directed* research is evident. Research merely in exchange for the monthly stipend is to be guarded against. Testing is a highly important part of the work. It is often research. It must, to speak but briefly, be of a nature acceptable in general to physicians, since upon the verdict of the practicing physician rests the success or failure of any medicine, new or old. The conclusions of this research must be indisputable and, of course, without prejudice. Manufacture is another problem by itself, or rather a set of problems. An entirely new money investment has to be considered. Nothing less than a reasonably good prospect of dividends from the proposed investment will interest the manufacturer. The question of patent protection will have to be considered. But I see nothing insurmountable in the manufacturing problems. Nor, indeed, in the entire question at issue.

FREDERIC FENGER, Armour & Company, Chicago, Ill.

It is the true coöperative spirit and the bringing together of the industrial and college men which bring about real progress and produce results.

A national institute for biological research conducted along coöperative lines would obviously be of great benefit to humanity.

Such an institute should be financially independent and investigations carried out on a strictly scientific basis. The strife for patent processes and products should be eliminated. Patents may be of benefit to the individual manufacturer but they are not stimulating to harmonious coöperation and at times even stand in the way of further progress.

The work accomplished should be published and all the participants given full credit in order that the honors may be fairly distributed. Such a procedure would insure the success of the undertaking.

JOHN URI LLOYD, Lloyd Brothers, Cincinnati, Ohio

With great interest have I pondered over your letter, as well as the comments of the gentlemen who contributed to the December number of the *Journal of Industrial and Engineering Chemistry*. Much have I deliberated over the subject as a whole, which I will frankly state is not new to me as concerns necessities of those who, in plant pharmacy, need the help of an institute of coöperative research.

These several years the Hygienic Laboratory, Washington, and the various governmental departments connected with medicine and chemistry have appealed to me as rendering admirable service in the work they have featured. To them the thanks of all America is due. But their activities are limited, and I have felt that in time to come an institution such as

you now contemplate must in some way be established. This will necessarily be devoted mostly to research in directions which some prefer to consider commercial. And yet, as I view the problem, commercial effort may be altruistic, and a manufacturer may be self-sacrificingly devoted to American industrial progress as a whole.

This problem, in the abstract, I more than once discussed with the late Dr. M. I. Wilbert, of Washington, suggesting to him that through such an institution a defective process might be perfected without giving to competitors the "trade secrets" of a manufacturing establishment. My idea was that, under such a condition, the manufacturer present to a committee of unquestioned integrity, in the minutest detail, the origin of such a preparation and the manner in which it was prepared, thus protecting, by the candor of the manufacturer and the unquestioned integrity of the research committee, both the manufacturer and the institute.

These discussions with Dr. Wilbert led to many radiating lines of thought, but his decision was to the effect that present trade ideals and methods, as well as the opinions held by ultra-scientific persons regarding "commercial" affiliations, rendered such as this impracticable.

In my opinion, the substance of this perplexing problem is comprehensively presented by the following extract from Dr. P. A. Levene's contribution to your December journal:

I therefore suggest the organization of an institute of chemotherapy in the broader sense of the term. The aim of the institute should be, on the one hand, to promote this branch of science, on the other, to offer the facilities to industrial institutions to solve specific problems which they may encounter.

Take now the viewpoint of the manufacturing pharmacist. The first desideratum is an authoritative publication, establishing the authenticity of the crude materials employed in making remedial plant products. This, I take it, is the province, not of an investigating institute such as is now under contemplation, but rather of the Government itself, which has at its command unquestioned talent and every opportunity for the issuing of an authoritative publication on standards. Every crude drug employed in the making of preparations used by physicians might, in this publication, be authoritatively described, both as regards origin and qualities. Every chemist and pharmacist of the country, as well as every dealer in crude drugs, would then have at his command unquestionable descriptions of materials to be handled or manipulated. All physicians, likewise, regardless of professional differences or affiliations, would recognize a common (National) drug standard, on which all could agree.

There is great need of balanced research in pharmaceutical directions. Few who have worked in plant pharmacy for any length of time will disagree with the statement that simple processes of manipulation may result in the alteration of "both their toxic and therapeutic properties—by the mode of administration or by chemical modifications." Such alterations, as well as the diverging products derived from a single plant by means of different processes of manipulation, constitute in themselves a line of mighty questionings. The great field of research, opportunity, and necessity in plant therapeutic physiological lines of the future lies, not alone in establishing direct formulas, but in the study of obscure structural rearrangements, induced by time, temperature, and atmospheric exposure.

When a manufacturer meets some such perplexing problem, and desires to avail himself of the investigating opportunities afforded by the institute, if it is established, he can present with his application specimens of the standard material from which his product is made, and specimens of the preparations, as well as full descriptions of the processes by which they are obtained, and other necessary information. If the problem is one of obscure changes, such as are coming continually before makers

of plant remedial preparations, or other research necessities, such as the observing pharmacist continually meets, the problem could, under such conditions, be considered by the institute, and handled authoritatively and unhesitatingly.

I have confined my thought, as I take it is desired, to plant products, to the study of which, in a very restricted field, my life efforts have been devoted. The problem of animal serums and vaccines is probably not remote, but here, too, we are confronted with a labyrinth of complex interreactions, which, as in plant perplexities, too often lie outside the borderland of present-day, exact chemistry.

Possibly I have inexcusably neglected in what I have said the side of return opportunity to the institute. What I have said is superficial, perhaps illogical. And yet I cannot but believe that in time to come, an institute of the character now contemplated will be an accomplished fact. And when that institute is established, no reflection will be cast upon its founders or collaborators if its chief effort lies in the direction of helpfulness to those engaged in problems of commercial importance.

CHAS. E. VANDERKLEED, Hercules Powder Co., San Diego, California

It was with much interest, and for the most part with hearty approval, that I read the editorial in the September issue of the *Journal of Industrial and Engineering Chemistry*, and the subsequent and resultant addresses delivered before the New York Section of the AMERICAN CHEMICAL SOCIETY on November 8, on the subject of a proposed institute for cooperative research as an aid to the American drug industry. One fact stands out preeminently in this discussion, and that is that there is a widespread and quite unanimous realization of a great need for an institute of this kind. Permit me to emphasize, however, that the greatest need is the one so ably set forth in the editorial, namely, a cooperative institute in which, or through which, the *real value* of newly proposed medicinal products may be determined, in so far, of course, as it is possible to determine their real value other than by collecting the investigations of a large number of independent observers. The primary object of the proposed institute should therefore be to provide a means for studying the pharmacodynamic action and, in so far as this is possible, the therapeutic value of newly proposed remedies. This does not, of course, preclude the possibility of extending the scope of the proposed work to include a study of many problems of synthesis, isolation of active principles, standardization, etc., as suggested by Dr. Abel, Dr. Loevenhart, and others, but without doubt, the paramount need is for more cooperation in trying to determine the real efficacy as well as the limitations of new products.

To-day, the manufacturer of a new medicinal product can obtain a verdict as to its usefulness for the most part only by attempting to market it. As a result, many products of little or no value are introduced solely on theoretical grounds or upon very superficial data, while on the other hand, many a product of great value may be held back perhaps for years in an effort on the part of a more conscientious manufacturer to be sure of its real value. This is not fair either to the manufacturer, the medical profession, or the public.

I would also emphasize the fact that an institute such as is proposed can never in any sense of the word take the place of the research laboratory of the individual establishment. No one of course has suggested that it could; in fact, it was pointed out in the editorial that an institution such as is proposed would tend to stimulate research within manufacturing establishments. This is as it should be; there is ample room for both. Moreover, if such an institute were the means of bringing about closer cooperation between industrial research as carried on in manufacturing establishments and pure scientific research as carried on in our universities, it would be well worth while. If we but knew, many of our ablest potential industrial chemists are working on purely academic problems in our

universities, while some of the keenest of theoretical workers are struggling with industrial problems in our manufacturing establishments. Let us have a clearing house to the end that the American drug industry may be placed and kept in the world's lead.

It has been emphasized that a large endowment is essential to the establishment of an institute for cooperative research in order that competent leaders and able assistants may be secured, and proper facilities provided, for carrying out the proposed plan. If organized and conducted by the AMERICAN CHEMICAL SOCIETY, thus insuring a high and uncompromising standard, I predict that it will be able to command the hearty support of our industrial establishments, as well as the cooperation of our educational institutions, governmental departments, and related scientific societies.

UNIVERSITIES

ALBERT C. CRAWFORD, Stanford University Medical School, San Francisco, California

For the advancement of pharmacology and for the development of pharmacologists, as well as for the rational development of the drug industry, it seems essential that most of our present laboratories be strengthened, either in equipment or in their staff, as well as by an increase in budget. Many of our laboratories need enthusiastic young men who are intellectually unafraid.

There is, however, some question whether this advancement, or better utilization of our present facilities, could not be more satisfactorily obtained by the additional establishment of a cooperative research institute.

If such an institute is established, as I hope it will be, what should be its scope? Should it confine its work to chemotherapeutic investigations, to pharmacological and chemical studies with reference to utilization of coal-tar products, to testing the activity of synthetic and of natural drugs as well as to their assaying, both chemical and biological, or should it also devote its attention to the problems of pharmacognosy, etc.?

Such an institute could have a number of purposes in view. It might aid in coordinating the work now being done in various places, *i. e.*, serve as a clearing house, and might provide funds, where needed, for investigations which seem to demand it. It might devote its attention to problems of more immediate practical importance, such as are demanded by the drug trade and which are partly handled by commercial laboratories, or, it might, if properly endowed, be an institute where qualified men could devote their whole time to research, unhampered by teaching or by executive work, and from which specialized workers could be drawn for commercial or for teaching purposes, or it might devote its energies to all these and to other subjects.

All these problems demand consideration and a central, heavily-endowed institute could aid their solution, as well as bring pharmacologists in closer touch with economic questions. It would be unwise to start such a laboratory financially hampered, as such an institute must start free from obligations and be a success from the start. This latter will largely depend upon the character of the man who is to head the institution.

If such an institute is organized with the idea that there *must* be cooperation between organic chemists, pharmacologists, physicists, and others, cooperation will be possible. In our universities such cooperation is rarely possible, because our medical schools are often at a distance from the university, and the professor of organic chemistry and the professor of pharmacology are very likely to be interested in different classes of problems and their own research and teaching usually occupy their full time.

If large funds are not available, it might be wise to start a smaller organization for the study and utilization of the coal-tar products and for chemotherapeutic investigations, but with

the idea that later, when more endowment becomes available, the scope of the work is to expand. Certainly, something must be done immediately toward utilizing the by-products of the coal-tar industry for the manufacture of synthetic drugs, not merely for the value of those already known, but for the possibilities of future synthetic products (drugs, dyes, etc.).

A theoretical objection might be raised that the establishment of many more purely research institutes would tend to dissociate research work from teaching and it is well recognized that a university teacher in science, to be a success, must be a research worker, either actively or potentially, but toward such an institute as the one planned there would probably be no such criticism and it would stimulate us to better work. Before establishing such an institute, the ethical relations between the results of its scientific work and the drug industry must be determined.

While an active, central institute is desirable, if a large endowment is available without depriving existing laboratories of funds, yet there is much which can be done for the drug industry, etc., by coordinating our present facilities. The Carnegie Institute has furnished funds for the isolation of a product now used as a drug (epinephrin) and the fact that it has endeavored to standardize our professional schools would suggest that it might also be willing to serve as a clearing house for scientific problems.

The Office of Plant Introduction is introducing from abroad economic plants of all descriptions, while the Office of Drug Cultivation is encouraging, so far as practical, the domestic cultivation of drug plants and, no doubt, directly or indirectly through these sources, vegetable drugs from various portions of the world could be obtained.

The pharmacological study of hitherto unknown drugs might be referred by a committee of the Pharmacological Society to its members for study.

The biological assaying of drugs and the determination of standards for such assays could be done by the Federal Government, and the Hygienic Laboratory has shown aptitude for such work, in fact, this laboratory now supervises the interstate commerce in sera, etc., and the fact that several members of its staff have been appointed to important positions in biological work would indicate its high character. The work of the Bureau of Standards in standardizing apparatus, etc., for the trade indicates that the Federal Government can and will do other standardizations for us and perhaps even determine for investigators whether their new products are of value. It is only necessary to persuade the proper congressional committee that the country requires extension of such work and additional money can be secured for enlarging the work of the Hygienic Laboratory or for an additional division which would be established. Provision could thus be made for routine testing without disturbing the research work. After all, should not the whole institute be organized as a *new* department, free from tradition, under the Federal Government?

Chemotherapeutic work is now attracting attention and has become an important branch of pharmacology, and it seems that the time is now ripe for the establishment of one or more professorships in this subject in our larger, centrally-placed universities and where the influence of such professors could fall on a number of students. The establishment of a few such positions by the universities would advance this science and relieve the present situation to some extent.

ARTHUR D. HIRSCHFELDER, University of Minnesota, Minneapolis,
Minnesota

The experience of the chemist who knew of no way of having his new substances tested for their physiological action finds its daily counterpart in the experience of the pharmacologist. It is quite as difficult for us pharmacologists to find chemists and manufacturers who will aid us with substances and by-products

which have the structure needed for the solution of our problems, as it is for the chemist to find a pharmacologist to investigate his substances.

Obviously, we need an institute or a foundation to correlate and facilitate the investigations of workers in all the fields which lead to the introduction of new drugs. The foundation need not and probably should not attempt to do all its work under one roof, but might, like the Sprague Foundation for Medical Research or the Fund for Therapeutic Research of the American Medical Association, accomplish its results through grants for assistants, animals, and materials to directors of laboratories throughout the country where the particular problem can best be handled. To such an institute, every chemist who is not already in touch with a competent pharmacologist should submit each of his new compounds and by-products for advice as to whether any of them might prove useful for the synthesis of a drug.

The problems which are encountered in synthetic pharmacology may be classed as (1) the study of the actions of new chemical compounds prepared for other purposes, (2) the synthesis of new or rare compounds whose chemical groups might be expected to possess certain physiological actions in the body or upon bacteria, (3) the finding of new applications for well-known substances, (4) the aiding of manufacturers in solving their technical problems.

In the first three of these a great deal might be accomplished in universities if the chemical, pharmacological, and clinical staffs would meet in frequent chemiopharmacological conferences to discuss the possibilities of substances and by-products being studied in their various departments. At the University of Minnesota for some years we have given practical work in pharmacology specially designed for students in chemistry, in order to develop chemists for places in industrial synthetic drug chemistry.

As regards manufacturing chemists, many of their needs could be met through the medium of the proposed institute, not only through the industrial fellowships that would be established but also because the expert advice of cooperating pharmacologists and physicians should be made more readily attainable. The representatives of the AMERICAN CHEMICAL SOCIETY should meet squarely with those of the Pharmacological Society and the American Medical Association to formulate a modified code of medical ethics which would facilitate cooperation between physicians, pharmacologists, and manufacturing chemists, and which, without permitting of exploitation, would permit such cooperation to be mutually profitable. Moreover, it is much more difficult to obtain a scientific clinical test for a new drug than it is to get it tried out in the laboratory. At present there are many excellent and scientifically conducted clinics in which any method of diagnosis, however difficult, will be tried out and reported at once, but in which it is extremely difficult to secure the clinical trial of a new drug which has satisfactorily passed the laboratory tests on animals. If such drugs were referred to clinics by the institute, tested for the institute, and the reports published under the auspices of the institute, this difficulty should disappear. With a proper preliminary propaganda it should be possible to secure the cooperation of many clinics to work with the institute hospital.

Much of our present difficulty in matters of drugs is psychological. Our scientific physicians are suffering largely from the lethargy of therapeutic nihilism, as well as from the fear of the charge of commercialism, contrasting as strongly with the exuberant hunger of the Germans for new synthetics as does pacifism with Prussian militarism. And so the Prussian drug enthusiasts have beaten us and carried off the prizes in the newer medicines—by a better mobilization!

Until we have our clinical proving grounds well manned by zealous clinical artillerymen, eager and proud to test the range

and power of carefully inspected and supervised American medical munitions, we shall continue to reply on the easily obtained, commercialized testimonials that have carried the German synthetics across the ocean with loud booms of applause which have reached throughout America. Whatever else we do, we must mobilize our national enthusiasm and direct the efforts of all, chemists, pharmacologists, and clinicians, to new cooperative efforts for new American drugs.

DENNIS E. JACKSON, University of Cincinnati, College of Medicine,
Cincinnati, Ohio

The suggestion of an institution for drug research is at once a matter of striking interest to all chemists, pharmacologists, pharmacists, and medical men in general. One cannot refrain from speculating on the very extensive possibilities which the successful establishment of such an institution might involve.

Concerning two points, a universal agreement may be expected from the outset, *vis.*, first, that a very large sum of money, preferably not less than \$5,000,000, will be needed to make such an institution as extensive and as effective as it ought to be; and second, that if the undertaking is properly carried out the gains for science, industry, and the welfare of humanity in general may be of the very greatest extent. Indeed, it is impossible to put a financial estimate on the results of the work which would be practically certain to come out of such an institution. For the ideal arrangement, providing fully for the discovery of new drugs, or for any desired chemical manipulation of known forms, both for industrial and medicinal purposes, and finally for the complete investigation of the pharmacological properties and the therapeutic applicability of all compounds, promising from a clinical standpoint, might readily extend untold blessings to multitudes of the future who would not otherwise be born.

As has previously been indicated by other writers in the *Journal of Industrial and Engineering Chemistry*, a wide field of activity lies open for such an institution. Perhaps the greatest problem in this direction would be how to avoid too great an expansion. Certainly the institution should establish fairly intimate relations with the best universities of the country. Possibly this might be accomplished by the granting of fellowships, and occasionally, perchance, by some system corresponding to that of the temporary exchange of professors between universities. Industrial establishments would also need to send in young men to investigate certain definite problems.

The institution should have publication facilities through at least one journal, and perhaps more. A special stimulus might be exercised on industrial and scientific organizations by the holding of conventions, etc., at the institution provided with facilities to care for such meetings. And if the institution were powerful enough it might help very materially to create an effective interest in desirable legislation.

The organization and government of such an institution presents peculiar difficulties. Differing in many new and funda-

mental respects from most other institutions, there would seem here to be an opportunity for the initiation and development of a new and more nearly ideal and effective organization than any which has heretofore been established. The thinking out and doing of a piece of research bears a striking resemblance to the writing of a poem. One must wait for an inspiration, and when, by chance, the opportunity comes, it must be seized at once. Otherwise the spirit of that discovery is in all probability gone forever, so far as that individual is concerned. The true scientific mind is an extremely sensitive affair, and it is sometimes very remarkable indeed what small things may serve to completely block one's progress along any given scientific line. And it is easily conceivable that a certain group of scientific institutions might, by some unfortunate organization, or by some hampering form of red tape, kill more science than that same group of institutions would create in any given period of time. It requires a great deal more than money to insure the development of a large and successful research institution. And if a kind providence should look with sufficient financial favor upon this undertaking so splendidly conceived, it will be interesting to see what form of organization this exceedingly happy omen for the future of science in America may bring forth.

There is a matter of peculiar academic interest involved in the nature of the manner of selection of men for the more desirable scientific positions. And it would be exceedingly important for those upon whom might devolve the function of exercising this somewhat questionable pleasure to use great care in seeing that this group of workers should be truly representative of American men of science as a whole. One is almost tempted to suspect that this work ought to be carried out entirely by men who represent solely industrial interests. In this connection there is another matter to which the writer cannot refrain from referring briefly. This concerns the appointment of "strong departmental heads." This title has a tendency to remind the writer of but a single individual, William Hohen-zollern. Every one would enthusiastically urge the selection of the best men available for all positions. And within the realm of each man's sphere he should absolutely be monarch of all he surveys. But from this vantage point he should by no means be able in any respect to "survey" every other investigator who might want to come to the institution to work in that particular field of science. In other words, no political system which centralizes in any given division all power in one scientific head, and thereby automatically eliminates every other eminent scientist in that particular line in the country, should be adopted. While these points represent but minor details, it is perhaps impossible to consider them too early in the conception of plans, the materialization of which might finally represent the highest ideals of American science; for it is quite as important a virtue to be able to spend money well as it is to accumulate it in the beginning.

SCIENTIFIC SOCIETIES

AMERICAN CHEMICAL SOCIETY ADVISORY COMMITTEE MINUTES

The Advisory Committee met at the residence of President Nichols on Saturday, January 11, 1919, at 4 o'clock, to consider the appointment of committees voted at the recent meeting of the Council and to take up other matters.

An invitation from the Buffalo Section of the AMERICAN CHEMICAL SOCIETY, requesting the Society to hold its Spring Meeting in Buffalo, was read. It was voted that the invitation of the Buffalo Section be accepted, and that the meeting begin on the morning of April 8, with the Council meeting on the afternoon of April 7.

Owing to the fact that one member of the Finance Committee is in Europe, that Dr. Arthur E. Hill will be in Washington for some months, and that the chairman of the Finance Committee needs one of the members in New York, as the rules require two members of the committee to be present when the safety deposit vault is opened, Dr. Arthur E. Hill sent in his resignation to the committee. The resignation was accepted with appreciation of Dr. Hill's many years of unselfish and devoted service on the Finance Committee, and President Nichols appointed Mr. J. E. Teeple to the position thus made vacant.

The following members were appointed delegates to the meeting of the American Institute of Mining Engineers to be

held in New York City on February 17 to 20, 1919: A. R. Ledoux, H. E. Niese, and E. P. Mathewson.

Mr. F. W. Weissmann, councilor of the AMERICAN CHEMICAL SOCIETY in the Cincinnati Section, was appointed as a representative of the AMERICAN CHEMICAL SOCIETY on the occasion of "National Society Night" of the Dayton Engineers Club, February 4.

The Secretary was instructed to write Dr. Raymond F. Bacon, director of the Mellon Institute, in reply to his letter regarding the assistance of the AMERICAN CHEMICAL SOCIETY to the War Department in settling up the question of chemical plants, and to say that the Society will be very glad to assist the War Department if the War Department sees fit to request it to do so.

The Secretary was instructed to write Senator Shafroth, sending him a copy of the resolution passed at the recent Council meeting with reference to the use of the metric system, pointing out that the chemists of the country are heartily in favor of the principle of his Bill S. 5037.

The Secretary brought before the committee the motion as printed in the Proceedings for 1919, page 3, covering the opinion of the Council with reference to the duty-free importation of American-made glassware, chemicals, and chemical apparatus for educational institutions. The President stated that the motion as recorded was according to his understanding of the situation, and the committee voted unanimously that the motion stand as recorded, pending change by the Council itself.

After careful consideration and advice from the members of the Advisory Committee, the President appointed the following committees as directed by the Council:

1—Committee to Cooperate with the Society for the Promotion of Engineering Education on Educational Problems: H. P. Talbot, R. H. McKee, S. W. Parr.

2—Committee on Publication of Compendia of Chemical Literature: Julius Stieglitz, John Johnston, E. C. Franklin, J. C. Olsen, James Kendall.

3—Committee to Consider Allocation of Federal Grants for Scientific and Industrial Research: W. R. Whitney, C. L. Alsberg, John Johnston, W. D. Bigelow, Wm. McPherson.

4—Committee to Formulate a Method of Cooperation with the National Research Council: W. D. Bancroft, Atherton Seidell, W. F. Hillebrand, F. G. Cottrell, C. L. Parsons.

5—Committee on Coordination of Chemical Work within the War Department: C. H. Herty, E. P. Kohler, H. P. Talbot, John Johnston.

6—Omnibus Committee for Spring Meeting: A. D. Little, B. C. Hesse, F. M. Dorsey, T. B. Wagner, R. F. Bacon, C. G. Derick, L. C. Drefahl.

The Advisory Committee approved the idea of calling the former publicity service of the Society the "A. C. S. News Service."

In response to the resolutions of the New York Section upon an institute for drug research, the President was authorized to appoint a committee to report to the Advisory Committee a statement of endowment needed for salaries, buildings, equipment, and operating expenses, and an outline of policies for such an institute. The President appointed Dr. Chas. H. Herty chairman of this committee, the other members to be appointed later.

The President appointed a committee of three, consisting of W. A. Hamor, A. M. Patterson, and L. C. Newell, to consider a request for the preparation of a list recommending chemical texts for libraries.

CHAS. L. PARSONS
Secretary

WASHINGTON, D. C.

THE GRASSELLI MEDAL

The Grasselli Chemical Company, of Cleveland, Ohio, has announced its intention to found a medal to be awarded by the New York Section of the Society of Chemical Industry. We print herewith the letter of announcement and the rules for the award of the medal.

To the Secretary of the New York Section
Society of Chemical Industry
52 East 41st St., New York

As an appreciation and aid toward the aims of the Society we take pleasure in notifying you:

1—That unless and until you are advised to the contrary we will annually provide a medal for the thesis presented at your meeting which shall, in the opinion of the Medal Committee, offer the most useful suggestions in applied chemistry.

2—The medal will be of gold and of suitable design, and will be known as "The Grasselli Medal."

3—The award shall be made in reasonable accordance with rules hereto, or as amended by your Executive Committee.

Asking that you kindly present this communication to your Committee and advise, if satisfactory, we remain,

Yours respectfully
THE GRASSELLI CHEMICAL COMPANY
(Signed) T. S. GRASSELLI

President

June 13, 1918

RULES FOR THE AWARD OF THE GRASSELLI MEDAL

I—The Grasselli Medal may be awarded annually for the thesis presented before the New York Section of the Society of Chemical Industry which shall, in the opinion of the Medal Committee, offer the most useful suggestions in applied chemistry.

II—The award shall be decided by a Medal Committee, and may be made to any citizen of the United States.

III—Nominations for the award may be made by any member of the New York Section of the Society, or by the Executive Committee of the New York Section.

IV—The Medal Committee shall be appointed at one of the last two meetings of the Spring season and shall be constituted as follows:

The Secretary of the New York Section of the Society of Chemical Industry.

Three chemists who are members of the Executive Committee of the New York Section of the Society of Chemical Industry to be selected by the chairman, or in his absence, by the vice chairman.

Three officers or managers of representative industries who are also members of the Society of Chemical Industry and who may or may not be graduate chemists and who shall also be selected by the Executive Committee of the New York Section of the Society of Chemical Industry.

The chairman, or in his absence, the vice chairman, shall be an ex-officio member who shall only vote when and as hereinbefore provided.

V—The Medal Committee shall meet at the call of its chairman during the period between the last Spring and the first Fall meetings of the Section and four members shall constitute a quorum, and a majority vote of those present shall be necessary to choose excepting only that in event of a tie vote the chairman of the Section shall cast the deciding vote.

VI—Immediately that it has been decided who shall receive the award, the Medal Committee shall notify the chairman of the Executive Committee of the Section, who shall thereupon decide the date of presentation and advise the winner accordingly.

VII—The presentation shall be made at one of the first two of the Fall meetings of the Section by a present or past president or other officer of the Society who shall be selected by the Executive Committee of the New York Section.

VIII—The Executive Committee of the New York Section shall have the power to amend these rules and, or, decide any questions not specifically provided in them.

ELEVENTH ANNUAL MEETING AMERICAN INSTITUTE OF CHEMICAL ENGINEERS CHICAGO, ILL., JANUARY 15-18, 1919

The meeting was called to order at 9.45 A.M. at the Congress Hotel by President G. W. Thompson, of the National Lead Company. Mr. Leonard Busby, President of the Chicago Surface Lines, welcomed the chemical engineers to Chicago.

At the business session the following officers were elected for the coming year: Arthur D. Little, President; A. W. Smith, Third Vice President; John C. Olsen, Secretary; F. W. Frierichs, Treasurer; Chas. F. McKenna, Auditor; J. V. N. Dorr, Herbert Dow, and Hugh K. Moore, Directors for three years.

The Secretary reported a membership of 306, showing an increase of 22 during the past year. Eight applications for membership had not yet been acted upon. The Treasurer reported a substantial balance on hand as well as \$1250 invested in Liberty Bonds. The membership committee reported action on 19 applications for membership, some having been rejected on account of insufficient chemical engineering experience or non-conformity with the Code of Ethics of the Institute. Prof. Withrow, chairman of the Committee on Chemical Engineering Education, reported arrangements for sending copy of Dr. Mann's report on engineering education to all members requesting same and a full report with opportunity for discussion at the Summer Meeting.

The Committee on Meetings reported invitations from Boston, Atlanta, Providence, and Cincinnati for the Summer Meeting, with the recommendation that Providence be selected. The matter was left to the Council with power.

The remainder of the day was devoted to papers and discussion on the subject of maintenance and preservation of our chemical industries. Representatives were present from many of the prominent chemical companies, and the U. S. Tariff Commission was represented by Dr. Grinnell Jones. The great interest in the topic for discussion was shown by the attendance of about 100 at the opening session Wednesday morning.

President Thompson made the opening address, taking as his subject "Chemical Industries Made Permanent." As the distinctly war industries would undoubtedly cease operation the discussion was confined to the group of peace industries. Competition is mainly to be feared from the chemical industries of Germany. It is problematical how soon the German industries will be able to recover from the disastrous effects of the war and sell their products in the world's markets in the face of the universal hatred which she has aroused.

Assuming that the competition would become serious President Thompson proposed three remedies. The Webb law would allow competitive industries to combine for export trade, pooling profits, and underselling the German industries when necessary; open price associations would enable manufacturers to supply the domestic market without ruinous competition. President Thompson's third suggestion was that the smaller manufacturers combine for economy of production and equalizing profits.

The symposium had been arranged by a special committee consisting of Maximilian Toch and L. H. Baekeland who had extended an invitation to the chemical industries of the United States to send representatives to the meeting.

Maximilian Toch read a paper on "Résumé of Conditions as They Exist at Present in the Chemical Industries," in which he showed the great importance of the war development of the chemical industries and urged government protection against German competition.

Dr. Louis Matos, representing the National Aniline and Chemical Co., emphasized the fact that in the dye industry many processes were not yet fully developed and that from 3 to 5 years would be required before reliable data on production costs could be obtained.

Mr. Robert Hilton, of the Ault and Wiborg Co., declared that it would be absolutely impossible to meet the competition of the well-established German industries unless a much higher protective tariff were enacted by Congress. Mr. Wm. H. Rollin, of the Rollin Chemical Co., held the same view with reference to the recently established barium industry.

During the general discussion which followed these papers a drastic anti-dumping law was advocated. The licensing system adopted by Great Britain was also urged as a very effective remedy. Under this system the importation of dyes is prohibited when domestic manufacturers can supply the market, and importation is permitted only to the extent required to

supply the domestic market with dyes not manufactured in the country or of which the production is not sufficient.

Dr. Grinnell Jones, chemist of the U. S. Tariff Commission, discussed the recommendations made to Congress by this Commission. The bill submitted by the Commission makes no radical changes in the present tariff law either as to rates or classification. It merely corrects technical errors in the present law by which the evident intention of Congress is nullified. Dr. Jones expressed the opinion that the Tariff Commission is not prepared to suggest any radical changes in the present tariff and that no material increase in tariff is likely until after the next presidential election. The remedy for the present predicament of the chemical industries is to be found in the reduction of manufacturing costs by the work of the chemical engineer.

Dr. Edw. Gudeman in a paper on "Reconstruction Aspects of Some Chemical Industries of the United States" urged the adoption of a very broad reconstruction program. He not only advocated protection for our newly established chemical industries but also conservation of our national resources both material and human, by improving living conditions, giving employment to discharged soldiers and sailors, universal education in English, economic equality and development of our transportation facilities.

At the conclusion of the discussion a set of resolutions which had been drafted by a committee consisting of President Thompson, Secretary Olsen, F. E. Dodge, F. M. Dorsey, Edw. Gudeman, A. H. Hooker, H. W. Kellogg, C. Bai Lihme, Louis Matos, S. W. Parr, and M. Toch were adopted. The resolutions strongly urged Congress to provide adequate tariff protection, enact an anti-dumping law and also to sell government stocks of chemicals without breaking the market. The Secretary was instructed to send a copy of the resolutions to every senator and congressman.

Thursday was spent in a visit to the large plant of the Corn Products Refining Co., at Argo, Ill. The party of 54 was divided into groups of 8 for the inspection of the plant. At the complimentary luncheon served by the company the superintendent, Mr. F. M. Sayre, explained the welfare work being carried on at the plant and the cooperative system by which labor disputes had been very satisfactorily adjusted.

At the Thursday evening session Col. Alfred H. White described the nitrogen fixation projects and plants which had been constructed by the U. S. Government. The lecture was illustrated by lantern slides of many of the plants. Prof. Julius Stieglitz spoke on the production of synthetic medicinal chemicals. The attendance at this session was about 250.

On Friday morning the following papers were read and discussed:

"Reinforced Concrete Tanks for Storing Ammonia Liquors," by F. W. Frierichs.

"Concrete as a Chemical Engineering Material," by Maximilian Toch.

"Some Wild Engineering I Have Known," by David Wesson.

"Belting for Power Transmission," by Ernest D. Wilson.

A complimentary luncheon was served by the local committee on Friday as well as on Wednesday. After luncheon, members of the Institute were taken by auto to the plant of the Lindsay Light Company where the manufacture of gas mantles was shown from the production of the nitrates of cerium and thorium from monazite sand to the finished mantle. The party then proceeded to the Underwriters Laboratories of Chicago where a great variety of physical and chemical tests are carried out on all kinds of structural material, including fire tests on finished walls.

Friday evening the subscription dinner was held at Congress Hotel. About 60 covers were laid. The first number of the after-dinner program consisted of vocal selections by Madam Myrna Sharlow, of the Chicago Grand Opera Company.

Everyone was charmed by the delightful rendering of popular songs by Madam Sharlow who was repeatedly anchored.

Mr. Arthur Lowenstein introduced Mr. Wilbur D. Nesbit as the toastmaster of the evening. The audience was kept in a roar by Mr. Nesbit's sparkling wit and humor. He introduced in his own inimitable manner the following toasts:

"Why Is a Chemical Engineer?" by L. V. Redman, chairman of the Chicago Section of the AMERICAN CHEMICAL SOCIETY.

"The Problems of the Chemist as Seen by a Layman," by Vincent Rockey, of the *Literary Digest*.

"The Tariff Commission," by Grinnell Jones.

"Chemical Horse Sense," by G. W. Thompson.

"The Future of the Institute," by J. C. Olsen.

"Some Chemical Fakes I Have Met," by David Wesson.

Saturday morning the plant of the Standard Oil Co., at Whiting, Ind., was visited.

The visiting ladies were entertained at the opera, a theatre party and by auto trips.

The local section of the AMERICAN CHEMICAL SOCIETY participated in the meeting and was well represented at all sessions.

NEW YORK CITY

J. C. OLSEN

NOTES AND CORRESPONDENCE

A. C. S. NEWS SERVICE

The work of the Publicity Committee has been transformed into the A. C. S. News Service. The Committee is continued and Mr. John Walker Harrington has been appointed by the Directors to assist by giving technical aid in the preparation of the matter issued to the press. Upon request he has prepared the following article on "Laboratory and Newspaper Shop" which explains the purposes of the News Service. It will be of direct interest to members who contemplate submitting articles.

LABORATORY AND NEWSPAPER SHOP

Mark Twain once showed to a Major the manuscript of a war story which he had just written: "Your unfamiliarity with military matters," observed that officer, "has betrayed you into some little mistakes. Still, they are picturesque ones—let them go; military men will smile at them; the rest won't detect them."

The gifted author had himself been a journalist, and if we may believe his own account, what he lacked in accuracy he made up in imagination. As an agricultural editor, he shook the confidence of his readers when he wrote that turnips should never be pulled from the tree but should be permitted to drop when frost-bitten. Since his days as a reporter the public has come to demand more exactitude, and it even has breakfast quarrels with its favorite newspapers if it detects them in error. It is no longer enough that the journals of our day should be filled with entertaining news—and some of it true.

When we read about politics we expect to have the report of an adept who knows more about it than we do; we take our Wall Street news from writers who are precise to a dot; and even the accounts of amusements must come from critics of keen observation and mature judgment. And yet to have every department of a newspaper covered by an expert would require not a mere staff, but a regiment. Some newspapers in the large cities have technical men to write on scientific matters; but departments are likely to multiply unduly, just as they did in the days of George W. Childs on the *Public Ledger* of Philadelphia, when there was a pigeon editor and a bee editor and a score or so more of such specialists—all on the same floor.

In order to have the facts concerning them reported clearly when the occasion requires, corporations, associations, and societies often retain men of newspaper training to be reporters for them, and to prepare information of their activities for the press. The Publicity Committee of the AMERICAN CHEMICAL SOCIETY was appointed when some New York newspaper men made the suggestion that the Society would be very useful to them if it offered facilities for gaining information on chemical matters. Hence the issuing of the bulletins, which have been so well received by the press of the United States.

The work of the Committee has now so expanded that it is impossible for its members to spare the time from their professional labors to develop it, and therefore I have been asked to sit in and help. The writer has spent many years in the

newspaper shops and has had some experience in the laboratory. Under the direction of Dr. Herty he will look after some of the details of issuing matter to the press.

One cannot make bricks without straw, nor issue news without facts, and therefore more than ever the Society is depending upon its members to send in bulletins of five or six hundred words about events in the chemical world or brief accounts of new phases of that science of sciences—chemistry. For such as are accepted the sum of \$5 will be paid.

What is news? Falling back on the late Mr. Webster, we are told that "news is a report of recent occurrences—information of something that has lately taken place or something before unknown—fresh tidings—recent intelligence." Except that it conveys the idea of timeliness in news, the dictionary has left us much in the dark. News must be new, but little that is new is news. News is that characteristic of a happening which has an appeal to persons beyond the circle immediately concerned. It may reach out to curiosity, to awe, to self-interest, and what that appeal may be is rather to be felt than described. It is often a subtle quality defying cold analysis, and being a quality, news judgments may differ. For example, Charles A. Dana once said that if a dog bit a man, it was not news, but if a man bit a dog—such was news. The next day the *New York Sun* had on its first page a column account of a prominent man having been bitten by a dog, and for several days thereafter the details concerning this occurrence were duly reported. The unusual is only one of the elements of news. Thus even such a past master as the late Charles A. Dana could not construct an infallible news formula. News, as does electricity, defies absolute definition; and yet it is a definite commodity.

The trained newspaper man knows news; he senses it; he feels it. He has that gift "the nose for news" sharpened by experience, and developed by enthusiasm and constant contact with all classes of his fellowmen. Every man has a nose for news, for that matter, but sometimes the organ is rudimentary. Probably there is no one reading this article but knows some skilled newsgatherer of the daily press. Stop and consider his method! The man who garners exclusive news (the "beats" and the "scoops" of the newspaper shop) makes a business of building up among acquaintances the ability to detect the news element. That is how he makes himself invaluable to his newspaper. He is teaching men to consider their own activities from the point of view of the outsider. The average man, however, is too close to his work to sense fully its public relation.

In the words of Julian Ralph, one of the best all-round newspaper men this country has ever produced, the journalist sees everything with the eyes of the infant. Did you ever see an old reporter? The newspaper man keeps young by making even his own task a perpetual re-discovery of its relations to the general public.

Hence one who is meditating a bulletin should not write it in his laboratory, but rather in his home or his club, where he may feel the lay influences. Let him try it first on a newspaper

friend, or if none is available, waylay some other innocent bystander, and see if he can get in his eye the kindling gleam of interest. Avoid involved technical terms. The language of the laboratory is often as unintelligible to the public as is the quaint lingo of the newspaper shop which reporters talk but never write. In general, the broader and wider the application of the "story," to use the newspaper parlance, the better news it is. One element of news, however, is action or the suggestion of action. A scholarly paper on vitamins, as the night wears on in the newspaper shop, is likely to be crowded out by an elopement. There is more interest in a Gretna Green clergyman, than in a "chemical parson." Potash is fully dealt with in books of reference, but give a scientist the Perkin Medal for devising ways to extract that element and beat Germany, and potash looms in the news and we are reporting an important news event.

If chemistry would see its activities adequately reported, let it do as most other interests do in this world—meet the newspaper half way. Emerson said that if a man but make mousetraps good enough, the world will beat a track to his door. Perhaps so, but it is just as well when a section of the Society is holding an important meeting to send the city editors of the newspapers a timely notice, and to furnish a clear abstract of the speeches or lectures hours in advance. If some special apparatus is being shown, a press view in the afternoon, long before the evening meeting, will greatly aid the reporters in getting a clear idea of the matter. Just as the opera house provides facilities for the critics at the last dress rehearsal, and so gives them the chance of writing their accounts at leisure, and then of going around on the evening of the performance to confirm their suspicions, so the minds of the newspaper men should be well prepared.

If the chemist is writing matter for the lay press, he may well bear in mind that his account or story should be an invert product. In the days of straphangers, the average news article is like a pyramid built in the air, base up. The man of science, inclined to begin with the creation of the world, and carefully laying a solid foundation, builds his article in the form of the tapering pyramid of Cheops. These are days of headline and rapid-fire writing. The reporter often writes under stress. Having a hair-trigger mind, it is not surprising that at times it goes off at half cock. His conclusions are always picturesque, albeit they may bring a twinkle to the eye of the savant. Get acquainted and help him get his facts straight.

The chemist and the reporter get along famously when they come to know each other. Both are of the analytical turn of mind, both natural-born seekers after causes and truths. The journalist knows that the chemist is not a pallid crank with steel-bowed spectacles and scraggly whiskers; let the chemist eliminate the idea that the average newspaper man is like the stage reporter, a creature of loud-pedal garments and cheek of triple brass, and the rapprochement is already accomplished. Every profession or calling is wrongly judged by its extreme types. From the reporter, the chemist may learn to keep in closer touch with humanity at large; from the chemist, the newspaper man may derive not only workable accuracy but a precision which will meet every requirement in these days when the public is looking to the daily press for information on which it can rely to guide it in its business affairs, and when mere diversion is becoming more and more incidental.

Such are the general principles on which the Society, in response to the coöperation and interest of leading newspapers of the United States, inaugurated on January first the A. C. S. NEWS SERVICE, with the sole object of issuing live and dependable news of the progress of chemistry, worded in non-technical language as far as this can be done in harmony with scientific accuracy. The SERVICE will not be shy in using the language of chemistry, but it will bear in mind that often between the man of science and the public, and sometimes be-

tween members of the same profession, there is a great gulf fixed, known as nomenclature.

Science in its literary expression has been dominated for many years by the niggling and meticulous style of Teuton textbook makers. Many articles on technical subjects contain few direct statements and those are overlaid with qualifications. The reporter is forced by his training to tell the gist of the "biggest story" in an introduction occupying an inch of type. Then the vital fact must be proclaimed in a "step ladder" headline of thirty-two letters or spaces, or, better still, of sixteen. He attempts to get as near as possible to the method of the first war correspondent, the late J. Caesar, who reported the conquest of Gaul in three words.

It is a common impression among technical men that science cannot be explained to the layman. As long as one's mind is made up that a thing cannot be done, there is little likelihood of its being done. Modern chemistry, however, has discarded the caul of mystery bequeathed by its mother, alchemy, and year by year its face is more clearly seen by the people. The great facts of science can be told in the simplest speech.

As timeliness is the primal element of news, let the item which presents itself as news be sent at once. When a revision of matter is requested or more facts are desired a prompt reply will enable the SERVICE to put out material which is of interest to the public as of even date. Let the New York office have information and abstracts concerning papers which may have a national news interest as far in advance of the meetings of Sections as possible, so that it may be distributed subject to release in the newspapers of the country the morning following.

Certain Sections of our Society have already established close relations with the daily press which have proved to be of mutual advantage. The chemist may be able to give quickly just what the newspaper may need in an emergency. It is suggested that all members assist newspapers in expanding our regular bulletins, should editors find them available as a basis for more extended or special articles.

Chemistry from year to year will have its outlook and its public relations better understood, for the journalist is always the idealist, ready and willing to help any worthy endeavor in the interest of his fellowmen. That news is always good news which makes for enlightenment and progress.

JOHN WALKER HARRINGTON

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Numerous requests have been received for copies of bulletins which would indicate in a general way the character and make-up of articles which are desired. In answer to such inquiries there is reproduced below a bulletin on gas warfare which has been printed by a very large number of newspapers.

REVEALS SECRETS OF GAS DEFENSE

LIFTING OF VEIL OF CENSORSHIP PERMITS CHEMICAL WARFARE SERVICE TO TELL HITHERTO UNKNOWN DETAILS OF ITS PROGRAM FOR THE DEFEAT OF THE HUN

Details of the enormous preparations which had been made in this country to overwhelm the German armies with poison gas were made public yesterday by the New York Section of the AMERICAN CHEMICAL SOCIETY under the auspices of which a conference of chemical organizations was recently held at the Chemists' Club, New York City. It is the belief of military authorities, and engineering chemists as well, that the knowledge that there existed such facilities for the manufacture of deadly vapors and protective devices against them was an important factor in the petition of Germany for an armistice.

Colonel Bradley Dewey, commanding officer of the Gas Defense, stated that in May 1917 the production of gas masks was started by a group of five volunteers. In eight weeks they had shipped 20,000 masks far inferior to the present type. There had been produced up to the time the Huns laid down their arms five million masks, three million extra canisters, one-half million horse masks, and a large quantity of mustard gas suits, gloves, ointments, and antidotes. The production of gas masks when hostilities ceased had reached 40,000 a day. The 1919 model, which the Colonel exhibited, represents a revolution in design and overcomes all the discomforts of the

earlier patterns, while efficiency is ten-fold increased. The officer expressed regret that all the men at the front could not have had the latest type before the signing of the armistice.

Colonel William H. Walker, the commanding officer of the Edgewood Arsenal, and a prominent member of the Society, summarized the achievements of the gas offensive program of the Government. "We had," he stated, "on November 11 of this year all the facilities for producing mustard gas at the rate of 100 tons a day, to say nothing of our resources for deluging our enemies with chlorine, phosgene, chlorpicrin, and toxic vapors previously unknown to them."

Colonel Walker showed that the errors of extended investigations seeking new and improved processes which caused so much delay in quantity output in some other lines of war activities could not be charged against the chemists. From the outset, he declared, well-known and efficient toxic gases were selected for manufacture in effective quantities, while simultaneously a corps of expert research workers sought for improved methods and products. As a result, there was never a day when the production of materials did not exceed the ability to utilize it. In fact, large quantities were shipped overseas in bulk, because other departments were failing in their delivery of containers. Following the discovery of improved processes of manufacture, more factory units were built, but meanwhile production by the old methods continued until the new plants were ready for operation.

In appreciative words, Colonel Walker paid tribute to the patriotic spirit in which the chemists of the country, for the most part enlisted men, had braved the dangers of the poisonous gas plants, far from the glamour of the real battlefields, and in many cases had made the supreme sacrifice.

He also told of the cooperation which he had received from the private chemical companies throughout the country, and as a part return for their helpfulness, offered to supply their research laboratories with any quantities of his poisonous materials for experimental purposes.

If gas warfare is to hold a permanent place in war programs, the American chemist is prepared.

THE TRAINING OF THE CHEMIST

Editor of the Journal of Industrial and Engineering Chemistry:

Every one who is engaged in the work of training chemists welcomes Mr. Church's frank article in the December number of *THIS JOURNAL* on "A Manufacturer's Experience with Graduate Chemical Engineers," and wishes that such helpful suggestions might be more frequently made. That kind of criticism from employers, definite, clearly stated, and friendly, has a positive educational value to young men in the process of training, and is accepted as wise counsel by those who are responsible for that training and who want to know what the manufacturer desires in the chemist he employs. It would not be at all out of place for the *JOURNAL* to add to its long list of helpful features an "Educational Column," inviting frequent contributions not only from employers but from teachers as well, in which the former would state their criticisms and desires regardless of how radical they may be or how subversive of existing methods and courses, and the latter would suggest ways in which the training processes could be altered to make possible the attainment of the end sought.

Better still, the Society at large, which has a vital interest in everything that concerns the state of the chemist and chemistry in America, could well have a small, permanent committee on education, whose function should be not only to discuss and criticize curricula and methods, but also to act as a clearing house for suggestions regarding the training of the chemist both from the point of view of the manufacturer and employer, and of the teacher and university. Such a committee, on which a large industry, a leading university, and a small college might be represented, could collect criticisms and suggestions from both sides, and from time to time publish a digest of all of them in the *JOURNAL*, with recommendations.

Some such scheme was undertaken a few years ago¹ by a Committee of the American Institute of Chemical Engineers on Chemical Engineering Education. The enlightening report of that committee brought about some desirable changes in the

curricula of a good many institutions where chemists were in training. The new and unplanned-for conditions brought about by the war call for another like intensive study of the present situation in chemical education. Is not such a study well worth the attention of a committee of the AMERICAN CHEMICAL SOCIETY?

While Mr. Church is stating his ideas on the subject in such a helpful way, and other employers are doubtless echoing the criticisms, it is worth while for a teacher to call attention to difficulties of which every teacher is aware who is trying to meet the ideals he has in the training of the chemist; for it must be remembered that the manufacturer and the teacher are not very far apart in their ideas of what such training should produce. Every teacher of chemists knows for instance that there is a serious loss of time, both for the employing company and the young chemist, when the latter begins his work. Every teacher knows that for a period varying from three months to a year after the school experience, the employing company is itself a teacher, in some cases supplementing, in some cases correcting, what the young man has learned in his college or university. Every teacher feels responsible for this loss of time and overlapping of effort, while at the same time he knows that in part at least the causes are beyond his control. One of those causes is worth emphatic and repeated statement until it is definitely removed.

Most of the criticisms of the training a chemist receives in the college or technical school or university come to this: the graduate lacks judgment and imagination. That is no news to the men who have trained him. They have struggled to get better results, but granting that the young man has these qualities latent within him when he comes into the institution, the mechanical character of his preparation, and the accepted method of laboratory instruction in chemistry in the early years of the course, as exemplified in most textbooks on the subject, constitute a severe handicap. It is difficult for anyone who has never taught to realize how much the college student uses his memory and how little he uses his reasoning power—how mechanical his work is. If he has had chemistry, or physics, or science work of any kind in his preparatory school, the directions for such work are given him in minutest detail by his laboratory manual or his instructor. His judgment has not been called into action. Perhaps that is the method that must be used with students of preparatory school age. When that student, so trained, comes to college, the struggle begins between him and his new set of teachers to break this mental habit of expecting and following detailed directions. For a couple of years, in some cases for the entire four years of the course, the teacher does most of the struggling.

The teacher is not greatly aided in the struggle to develop judgment and imagination by most of the modern, and in other respects excellent, laboratory manuals in chemistry. Any good book of that character, either in general chemistry, or analytical chemistry, or organic chemistry, affords abundant illustration of what is here complained of. Directions are given in such detail that the young man does not dare to be independent, is almost afraid to take his finger off the particular line of printing in his manual of directions which he is following lest he do something in a different way—a way that might give just as good a chemical result and a much more valuable mental result. Many a student is lost in the chemical laboratory when he gets a few feet away from his textbook. The question always in his mind is, "What shall I do next?" and if his instructor or textbook is not conveniently near, he feels chemically utterly forsaken. The freshman who wanted to know whether gunpowder would deflagrate on charcoal before a blowpipe, and tried it, is more promising as an embryo chemist than the other freshman who was given a 250 cc. glass balloon with the simple direction to get the weight of 22.4 liters of carbon dioxide at standard conditions of temperature and pressure, who got the weight of

the balloon and gas, and then appealed to his instructor with "What shall I do now?" The last-named young man had had a year of preparatory school chemistry and several months in a college laboratory. Experience of many years in teaching and personal inspection of conditions in the chemical laboratories of most of the well-known institutions in this country lead one to believe that dependence and a general helplessness are far too common among students.

In reply to the above criticism of textbooks and methods, it will be urged that that particular plan of instruction is necessary to save the time of the student, to lead him by the shortest route to the result he ought to get. The prefaces of some chemistry books state frankly that the plan of the book is designed to save time, and to reduce to a minimum the amount of instruction required from the instructor. As if time were the most important consideration! As if only books and men can teach! Have mistakes lost all their power of teaching?

If the student has not the time to make mistakes, has he not the right to demand that that privilege be given him?

This is the gist of the whole matter, and the suggestion from an employer that the course of training for chemists be continued for five years, or six years, meets hearty favorable response from every teacher of chemistry. The teacher knows that the present four years (thirty-six months) is inadequate time in which to accomplish what he agrees with the employer is the end to be attained, namely, the development of the judgment and the imagination. Into these thirty-six months are now crowded courses in language, mathematics, physics, electricity, logic, history, economics, and many of the branches of chemical science. The result is likely to be an accumulation of information rather than a deepening of mental processes. The student uses his memory ("crams" is the college students' expressive word), passes examinations, but does not get a great deal of opportunity to use his judgment and his imagination. More time for the course would remove much of this mechanical character of the training.

How can an extension of the time given to training be brought about?

The larger universities can adopt an independent policy in the matter and organize their courses as they judge is best for the cause. Some have already done so, and have made engineering courses, including that of chemical engineering, of graduate character. But such action on the part of one college, regardless of sister institutions, would be disastrous to it. Competition among these institutions is too keen, parents and boys are too impatient to bring to an end the so-called "educational" portion of a boy's training. No one college can require five or six years for an engineering course if other colleges give a course in less time, and if industries take on young men who have had only four years of training.

Here is where the AMERICAN CHEMICAL SOCIETY and similar organizations can do a great work in advancing the cause of chemical education in America. Such societies can take a positive, definite action favoring five or six years as the minimum period for the training of the chemist. They can communicate such action to the presidents of all the institutions in the country, where chemists are being trained. Later, after giving sufficient opportunity for making changes, the Society could classify educational institutions in accordance with the length of time given to chemical training, make public such classification and stamp with its approval the institutions which have extended their courses. The Society would thus be doing for chemical education in America what the Carnegie Foundation for the Advancement of Teaching did, with such far-reaching and altogether beneficial results, for medical education in this country.

Industries themselves have it within their power to become a very effective help in bringing about this desirable extension of

time. If the great concerns which employ chemists would refuse to accept any who had not had five or six years of training, the educational institutions would respond by providing the training called for.

Does this read like a call for help? Frankly it is such, just as Mr. Church's criticism of the graduate in chemistry is a call for help. His call is addressed to educational institutions. This call is addressed to the AMERICAN CHEMICAL SOCIETY and to industry. Is a committee of the Society to study and report on the situation entirely out of the question? Cannot industrial organizations and universities and colleges get together in some definite way? Cannot these forces unite to bring about what everybody knows is a needed reform?

UNION COLLEGE
SCHENECTADY, N. Y.
January 2, 1919

EDWARD ELLERY

A LETTER FROM BELGIUM

To the President of the American Chemical Society:

The Belgian laboratories were formerly accustomed to being supplied, till 1914, with apparatus and products coming from Germany.

As you can understand, there is here in Belgium a general wish to prevent all trade with that country, and to provide ourselves in America, England, and France.

Would you be so kind as to invite the chemical trade firms of the United States to send us catalogues, information, and addresses, so that we should be able henceforth to send our orders to your country?

With many thanks, yours very truly,

(Signed) A. J. J. VANDERALDE

Director

LABORATOIRE DE LA VILLE DE GAND
RUE DE LA BIBLIOTHEQUE
GHENT, BELGIUM, December 11, 1918

RAMSAY MEMORIAL FUND IN AMERICA

Contributions to the Ramsay Memorial Fund in the United States now amount to \$3000. It is the desire of the American Committee of the Ramsay Memorial Fund to make the fund an expression of the esteem for Sir William Ramsay in this country. Many have expressed a wish to contribute, but have held back on account of their inability to send in a sum commensurate with their esteem. This has been due to the numerous calls upon all for the past two years. Small sums, from one to five dollars, will be welcomed by the committee, which is anxious to make the expression of appreciation as widespread as possible. Contributions may be sent to Prof. Charles Baskerville, Chairman, College of the City of New York, or Mr. W. J. Matheson, Treasurer, 21 Burling Slip, New York City.

SOME APPLICATIONS OF PHYSICAL CHEMISTRY IN THE COAL-TAR INDUSTRY—CORRECTION

In the article printed under the above title [THIS JOURNAL, 10 (1918), 1016] the following change should be made:

Page 1019, table, 5th col., last figure—"0.1047" should read "0.01047."

WILBERT J. HUFF

AN ANAEROBIC CULTURE VOLUMETER—CORRECTION

In my article under the above title [THIS JOURNAL, 10 (1918), 624] the following correction should be made:

Page 625, 2nd col., third line from the end of the article, "stimulates" should read "simulates."

ZAE NORTHRUP

WASHINGTON LETTER.....	74

By PAUL WOOTON, Union Trust Building, Washington, D. C.

Industrial miracles are being performed in the conversion to a peace basis of chemical plants established for war purposes. This is the opinion of a high official here who is in close touch with that feature of reconstruction. Despite the ingenuity being displayed in finding peace uses for these plants, there are some establishments which are not adaptable to such conversion. As a consequence their value has depreciated tremendously with the passing of the war's necessities. In one case, a plant which cost \$100,000,000 was offered for sale for \$6,000,000.

The Government has something like \$300,000,000 invested in chemical plants. In the near future, the Government expects to offer an opportunity for negotiations looking to the sale of some of these establishments. The policy in this connection, however, has not been worked out finally. It practically has been decided, however, to put on the market the platinum which was being held for use in the government acid factories. A small reserve of the metal may be retained, but suggestions that large stocks be carried are not meeting with favor.

A matter which is exciting much comment on Capitol Hill is the reopening of the Muscle Shoals controversy by Representative Longworth. Mr. Longworth, during the debate on the River and Harbor bill, found occasion to fire what is termed the first gun in the most determined effort that has yet been made to bring out the whole situation. In November, Mr. Longworth wrote the Secretary of War as follows:

I have just read a clipping from the *Nashville Tennessean* of last Monday, stating that work on the Muscle Shoals dam has been ordered to be resumed. I should be glad to be advised as to whether this statement is true, and if so, first, how much is it estimated that the entire cost of the dam will be; second, does the estimated cost of the dam include power plant; and if not what is its estimated cost; third, if the total cost of the project shall exceed the amount heretofore appropriated out of the so-called nitrate fund, is it contemplated to draw on some other fund or to ask Congress for an additional appropriation; fourth, how long is it estimated that it will take to complete the project; fifth, is it expected that the power to be furnished by the project will be continuous throughout the year, or is it expected that at certain seasons there will be either no power developed or less than at other seasons; sixth, is it expected that all power so developed shall be used in connection with the nitrate plant recently erected at Muscle Shoals, or is it expected that a portion of it will be used by other plants, and if so, what plants?

To the above letter, Benedict Crowell, the Assistant Secretary of War, six weeks later made the following reply:

Acknowledging the receipt of your letter of the 14th ultimo requesting certain information regarding the dam at Muscle Shoals, Tennessee River. I have the honor to state that on November 9 information was received from the chairman of the War Industries Board that restrictions could now be withdrawn from this construction, and the district engineer was at once notified to resume work on the project.

Referring to the specific questions propounded in your letter, the following information is submitted:

1. The total cost of the project was estimated in October 1917 to be \$14,534,000, based upon then prevailing wages and prices of material. On February 23, 1918, because of the lowering of the cost of cement to the Government, the estimate was reduced to \$14,000,000.

2. This estimate includes the dam, locks, and flume rights, and the power house with hydroelectric machinery capable of generating about 120,000 horse power. The power-house substructure will be constructed so as to provide for placing additional units in the future, if desired, in order to utilize the noncontinuous or secondary power in connection with steam-generating units already installed at Nitrate Plant No. 2.

3. If the amount available from the appropriation of Section 124 of the National Defense Act should prove insufficient to complete the project, it will be supplemented by reimbursing the appropriation for expenditures already made from that fund which might, with equal propriety, have been made from other funds at the disposal of the bureau. Such reimbursement will be deferred until the necessity therefor actually arises.

4. It is estimated that about three years will be required for the completion of the project.

5. Of the power to be furnished by the project, it is estimated that approximately 72,000 horse power will be continuous throughout the year. In all but the driest years it is to be expected that approximately 100,000 horse power can be developed continuously.

6. The most economical development of power at Dam No. 2 requires the ultimate installation of generating capacity largely in excess of the requirements of Nitrate Plants Nos. 1 and 2, in order that advantage may be taken of the large amount of secondary power available at the dam. It is probable, however, that the initial installation will not be greater than required for the operation of the nitrate plants and that no surplus power will be available for use by other plants.

In the course of his remarks, Mr. Longworth revealed that he had propounded, in addition, fifty other questions. He estimates that more than \$100,000,000 have been expended and points out that not an ounce of nitrates has yet been produced. He characterizes the expenditure as waste and says that not an ounce of nitrates ever will be produced for governmental purposes. In answer to a question as to the one private corporation, which Mr. Longworth alleges to be the beneficiary of this great expenditure, he made this answer:

The Air Nitrate Corporation, a corporation with \$1,000 capital, divided into 10 shares, controlled by the president and directors of the American Cyanamid Co., which was formed to relieve the American Cyanamid Co. from any liability on the construction of this plant. They have received \$1,000,000 in cash for supervision. They have not put up a single cent; they have assumed no liabilities; and now the Government is expending \$14,000,000 to produce power to make fertilizer for this company.

Their royalties will amount to somewhere about \$2,000,000 a year, and they assume no liability or risk whatever. Now, forsooth, we are going to build for them—the American people are going to build for them—a dam to operate their plant for their own profit. It is stated in the body of the letter just read that the power to be generated at this dam will be sufficient to supply only this one plant. Did you ever hear of a monopoly more complete?

With regard to what he expects to do in the future, Mr. Longworth said:

I hope to be able before long in one discourse to lay before the House fully and frankly and without mincing words the result of my investigation into this whole nitrate proposition. Therefore, I do not care now to make any specific answer to the question of the gentleman from Illinois. I will postpone it until I receive full information. I will say that if the information is not forthcoming, specific and accurate, I intend to move that an investigation be had by Congress of this entire nitrate proposition, and the two abandoned Ohio plants as well as this Muscle Shoals monstrosity corporation and its aiders and abettors, particularly of the activities of the Air Nitrates.

During January, the War Trade Board removed the import restrictions on most of the war minerals and abandoned the supervision over the distribution of most of the imported raw materials. In announcing the removal of control, the War Trade Board issued a statement complimenting the various trade associations through which the control had been exercised. In this connection, the statement said:

This control of the War Trade Board over the distribution of raw materials imported into this country has been exercised through various associations in the trade dealing in such raw materials.

Among the commodities thus controlled were many upon which our success in the war depended. At the time of our entrance into the war the sources of many of these raw materials were controlled by the Allies. As a result there were certain restrictions upon their importation into the United States. In order to prevent hoarding and speculation and to insure the application of commodities to essential purposes, the War Trade Board undertook to regulate their distribution in this country, and thereby to procure to the Allies a release of restrictions over their exportation.

This work was accomplished through associations in the various trades, some already existing, some formed for the purpose. The War Trade Board required either that the controlled commodities be consigned to associations, or issued import licenses on the condition that bills of lading be indorsed to the associations. The shipments were then released by the associations only upon guarantees being furnished against their re-exportation, against their sale into enemy hands, or against their use for speculative purposes.

The War Trade Board has at all times maintained a close contact with these associations, it has been intimately acquainted with all import shipments, and the Board has directed their activities and prescribed the regulations under which they operated. These government regulations, in fact, have been carried out largely through the cooperation of the trade associations involved, and is one of the notable examples of the patriotism displayed by American business men during the war crisis.

In addition to the metals and the better known commodities, the export and import restrictions have been lifted on vegetable oils, flaxseed, castor beans, castor oil, tanning materials, and many other commodities.

Officials here are convinced that no great difficulty will be found by privately owned sulfuric acid plants in placing a normal output. The fear expressed in some quarters that there is to be considerable "withering" of the industry is not justified by bird's-eye view of the industry, which is obtainable by the Government's sulfuric acid specialists.

The absorption of Army chemists by the industries did not proceed as rapidly during the past month as was expected. On the other hand, chemists were released from the service in larger numbers than had been anticipated, with the result that there is a surplus of chemists at this time. This condition is regarded as temporary. The Chemical Warfare Service is keeping a record of positions and of men released who desire employment. Every effort is being made to be helpful to the chemists who have contributed so importantly toward the success of the service.

The Chemical Warfare Service still has work for a good many men. It will require several months to complete the research being made for the Navy. Others are required to make reports and get the records into shape so as to make them available and valuable for reference.

Reasons for continuing the Chemical Warfare Service as a permanent branch of the War Department were presented to the House Committee on Appropriations by Gen. Wm. L. Sibert. In part, he said:

An organization of this kind would have as its biggest element a research branch, the function of which branch would be to keep abreast of the times in all of the chemical appliances or substances necessary or useful in war and, if the use of gas is continued or authorized, the training of troops in the use of gas masks and things of that sort. That would be a part of its functions, but whether gas is used or not there are other chemical substances, such as smokes, that have a tactical use in warfare and the use of which is growing. I refer to the making of screens behind which troops can advance. We would also have a proving ground force in connection with

our research force to try out appliances that were developed either in our own laboratories or found abroad.

A total of \$100,827,611.32 was expended by the Navy Department for chemicals and explosives during 1918, according to the report of the chief of the Bureau of Supplies and Accounts. Some of the expenditures were as follows: linseed oil, \$228,743; castor oil, \$160,340; ammonium picrate, \$2,904,000; chemicals for gas shells, \$327,000; anhydrous ammonia, \$86,748.26; chloride of ammonia, \$57,020.70; calcium carbide, \$28,745; carbon tetrachloride, \$45,100; hydrogen gas, \$22,460; oxygen gas, \$29,898; glycerin, \$208,807; nitrating cotton, \$394,980; platinum and iridium, \$149,868; soda ash, \$16,593; mercury, \$3,569.892. Acids were used as follows:

Carbolic.....	250,000 pounds	\$ 97,500.00
Hydrochloric.....	205,800 pounds	6,159.00
Hydrofluoric.....	117,200 pounds	13,177.50
Nitric.....	55,638 pounds	8,857.77
Oxalic.....	200 pounds	97.50
Sulfuric.....		
Fuming.....	35,100 tons	1,666,700.00
60° Baumé.....	1,156,780 pounds	19,076.00
66° Baumé.....	28,900 tons	804,160.00
60° Baumé.....	17,200 tons	311,400.00

Applications for the use of enemy-owned or controlled dye patents are being filed with the Federal Trade Commission in increasing number.

Following its first applications for twelve dye patent licenses, E. I. du Pont de Nemours & Company, Wilmington, Del., has filed with the Commission applications covering 148 additional patents on dyes, processes for making them, or otherwise related to their manufacture.

At the same time, the Arma Engineering Company, N. Y. C., asked for licenses to use eleven patents covering manufacture of navigation instruments; the Phenarsenyl Distributing Company, N. Y. C., applied for two medical licenses; the Takamine Laboratory, Inc., N. Y. C., applied for a license covering manufacture of "C,C-Dialkyl-Barbituric Acid;" and the receivers of the Camden Iron Works applied for a license to use a "Hydraulic Press" patent.

The Commission is considering the merits of the applications.

INDUSTRIAL NOTES

The H. K. Mulford Company has purchased the Metropolitan Building, Broad and Wallace Streets, Philadelphia. The price paid for the building, which is 10 stories high, occupying a lot 160 by 400 ft., according to report was \$1,200,000. The entire building will be devoted to the manufacture of pharmaceutical preparations. The floor area is 40,000 sq. ft. on each of its 10 floors, equivalent to 9 acres.

The American Castor Oil Co., Colcord Building, Oklahoma City, Okla., recently organized with a capital of \$100,000, is planning for the construction of a new plant to cost about \$50,000. It is proposed to install machinery to provide for a capacity of about 10 tons every 24 hours.

Director Clarke, of the New York State Museum, made an intensive study of the graphite deposits in the Adirondacks in the summer of 1917 and published a report. Harold E. Alling, of the museum's staff, who was given the field work upon which the report was based, made a thorough personal investigation of 19 out of 24 known deposits of graphite in the Champlain counties, some of which have been worked for 40 years profitably, while others have been failures, and to his observation has added exhaustive study of all literature and geological research and discussion. The bulletin comprises 150 pages.

The Gulf Reduction Co., Pensacola, Fla., has filed articles of incorporation with a capital of \$200,000 to engage in the manufacture of dyestuffs, etc. C. G. Rives, Jr., is president; L. Lavedan, of Camp Walton, Fla., vice president; and William Fisher, Pensacola, secretary-treasurer.

A plan to establish a medicinal plant garden in the forest preserves has been laid before the preserve commissioners of Cook County, Illinois, by Prof. Edward N. Gathercoal, instructor of pharmacognosy of the University of Illinois. Such a garden, the professor says, would tend to relieve the shortage of drugs.

Plans have been filed by the General Chemical Company for the construction of a new two-story plant at Laurel Hill, Long Island. The cost of the structure will be \$35,000. It will replace the office building and laboratory recently destroyed by fire with a loss of \$10,000.

The Salt Lake Potash Co., of Salt Lake City, Utah, has applied to the state engineer for the use of water from Great Salt Lake, to be used between March 1 and September 1 of each year, in "the production of salt and other valuable mineral products" which the waters contain. The plans of the company contemplate a large project. About 3,500 acres will be used for evaporating. Further details have not yet been announced.

The County Syndicate Aktiebolag has petitioned the Swedish government for permission to make 5,000,000 liters (1,321,000 gal.) of alcoholic spirit from white moss, of which there are enormous quantities available. The quality of such alcohol is said to be very good, and it costs less per liter than spirit made from grain or potatoes, and can easily be denatured. The petition proposes that the alcohol be manufactured under official supervision and that the government be taken in as partner.

Extensive deposits of high-grade bauxite in British Guiana were reported in 1897 and 1910. The British government required that any company working these deposits must be under its control, this requirement being met by an American company after long negotiations. The first cargoes were recently mined and shipped from the colony. Further deposits have been located in French and Dutch Guiana and it is believed that this strip of South America contains the most extensive deposits of aluminum ore accessible to ocean transportation.

A discovery of French chemists is that by coating the interior of containers with aluminum paint the accumulation of deposits which come from hard water may be prevented.

Importation of crude salt-peter during the first eight months of last year amounted to 4,900,032 lbs., against 7,529,180 lbs. in the same time the preceding year, and 9,258,084 lbs. in the corresponding period two years previous.

The picric acid plant now in course of construction in North Brunswick, Ca., will be completed, according to Washington reports, and will be used to manufacture dyestuffs, fertilizer, and other by-products of the process of picric acid manufacture

LIST OF APPLICATIONS MADE TO THE FEDERAL TRADE COMMISSION FOR LICENSES UNDER ENEMY CONTROLLED PATENTS PURSUANT TO THE "TRADING WITH THE ENEMY ACT"

YEAR	PAT. NO.	PATENTER	ASSIGNEE	PATENT	APPLICANT
1914	1,116,398	Paul Ehrlich and Alfred Bertheim, Frankfurt - on - the-Main, Germany	Farbwerke vorm. Meister, Lucius & Brüning, Höchst-on-the-Main, Germany	Dihydrochlorid of diamini-dioxyarsenobenzene.	Phenarsenyl Distributing Company of New York, Inc., 154 Nassau St., New York City
1911	986,148	Paul Ehrlich and Alfred Bertheim, Frankfurt - on - the-Main, Germany	Farbwerke vorm. Meister, Lucius & Brüning, Höchst-on-the-Main, Germany	Derivative of oxyarylarsonic acids and process of making same	Phenarsenyl Distributing Company of New York, Inc., 154 Nassau St., New York City
1914	1,099,108	Adolf Winther, August Leopold Laska, Arthur Zitscher, Felix Kunert, and Edwin Acker, Offenbach - on - the-Main, Germany	Chemische Fabrik Griesheim-Elektron, Frankfurt - on - the-Main, Germany	Producing ice colors	E. I. du Pont de Nemours & Co., Wilmington, Del.
1914	1,121,026	August Leopold Laska and Arthur Zitscher, Offenbach-on-the-Main, Germany	Chemische Fabrik Griesheim-Elektron, Frankfurt - on - the-Main, Germany	Azo dyes from the arylamids of 2,3-oxyanaphthoic acid and process of making them	E. I. du Pont de Nemours & Co., Wilmington, Del.
1914	1,122,564	Arthur Zitscher, Felix Kunert, and Edwin Acker, Offenbach-on-the-Main, Germany	Chemische Fabrik Griesheim-Elektron, Frankfurt - on - the-Main, Germany	Condensation products from the arylamids of 2,3-oxyanaphthoic acid and formaldehyde and azo dyestuffs therefrom and process of making same	E. I. du Pont de Nemours & Co., Wilmington, Del.
1909	910,889	Robert Wimmer, Ludwigshafen-on-the-Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Stable indigo-white and process of making same	E. I. du Pont de Nemours & Co., Wilmington, Del.
1912	1,027,836	Wilhelm Gauss, Ludwigshafen-on-the-Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Reducing indigo coloring matters	E. I. du Pont de Nemours & Co., Wilmington, Del.
1912	1,036,241	Henry Stalay, Arthur Holt, Ludwigshafen - on - the-Rhine, and Otto Schmidt, Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen - on-the-Rhine, Germany	Aromatic ammonium compounds and process of making same	E. I. du Pont de Nemours & Co., Wilmington, Del.
1914	1,106,970	Karl Reinking and Armand Julius Stiegelmann, Ludwigshafen-on-the-Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Compounds of leuco vat dyes with aralkyl compounds and process of making same	E. I. du Pont de Nemours & Co., Wilmington, Del.
1903	733,280	Karl Schirmacher, Soden, Germany	Farbwerke vorm. Meister, Lucius & Brüning, Höchst-on-the-Main, Germany	Red azo dye and process of making same	Central Dyestuff & Chemical Company, Newark, N. J.
1914	Copyright Registration No. 10,633 Class A 1 C	Franz Siemenroth, Berlin, Germany		Die Organischen Geschmacksstoffe, von Dr. Georg Cohn	The John Crerar Library, Chicago, Ill.
1903	739,579	René Bohn, Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen - on-the-Rhine, Germany	Blue coloring matter	E. I. du Pont de Nemours & Co., Wilmington, Del.
1906	828,778	Roland H. Scholl, Karlsruhe, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Compound of the anthraquinone series and process of making same	E. I. du Pont de Nemours & Co., Wilmington, Del.
1907	845,129	Roland H. Scholl, Karlsruhe, and Max A. Kunz, Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen - on-the-Rhine, Germany	Process of preparing anthraquinone compounds	E. I. du Pont de Nemours & Co., Wilmington, Del.
1907	856,811	Roland H. Scholl, Karlsruhe, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen - on-the-Rhine, Germany	Dye of the anthraquinone series and process of making same	E. I. du Pont de Nemours & Co., Wilmington, Del.
1908	876,810	Max A. Kunz, Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen - on-the-Rhine, Germany	Anthracene dye and process of making same	E. I. du Pont de Nemours & Co., Wilmington, Del.
1911	1,003,124	Otto Rohm, Darmstadt, Germany		Process of bating hides	E. C. Klipstein & Sons Co., 644 Greenwich St., New York City

Synthetic olive oil, placed on the market recently, has met with favor and has been endorsed by the U. S. Conditioning and Testing Co. It is similar to a pure, technical olive oil, its saponification and iodine values being identical with those of olive oil.

The manufacture of "engalith" has been undertaken recently in England by three companies. This is the same substance as the composition known as "galalith" in Germany which is an excellent substitute for celluloid although it cannot be used for very thin articles. It is produced in rods, tubes, and sheets, and in sixty different colors, and is used for a great variety of articles such as buttons, combs, beads, carriage and motor fittings, etc.

Experiments in making paper with sawdust have been carried out successfully in Aberdeen, Scotland, and have aroused considerable interest in Great Britain. These experiments were begun because of the increasing scarcity of wood pulp, which had to be imported, and the consequent shortage of paper. Wood flour, made by grinding sawdust, has been used for several years in a number of manufactures, but its possibilities for making paper had not been investigated. Paper is now being made containing 35 per cent sawdust, 30 per cent waste paper, and 35 per cent imported wood pulp, and is reported to be entirely satisfactory for newspapers.

The imports of arsenic for the first 11 months in 1918 were 5,048 short tons, 3,480 tons of which came from Mexico, 1,566 tons from Canada, and the rest from England and Australia. The total imports for the year will be about 5,600 tons. There was also imported \$19,838 worth of sheep dip containing arsenic, but no Paris green or London purple.

The Government has made arrangements to get sufficient nitrate of soda to supply farmers with the amounts they require for fertilizer during 1919. The price will be \$81 per short ton, free on board cars at the loading point or port. In addition, the farmer will be obliged to pay the freight charges to unloading point and incidental expenses that he incurs in connection with the delivery of the nitrate. Early in the year application blanks will be sent to county agents and local committees. The distribution will be made under the direction of the Bureau of Markets under the Food Control Act. The Department of Agriculture has made a survey of supplies of nitrate and the indications are that there will be sufficient to meet reasonable requirements during the coming year.

Experts of the War Trade Board are now in Alsace to make arrangements for ships which have heretofore returned from France in ballast, after carrying over supplies for the Army, to load potash for the United States. According to Edward N. Hurley, chairman of the U. S. Shipping Board, the United States requires between 500,000 and 600,000 tons of potash, and he said he believed the Alsatian deposits would fully meet the requirements.

The Aniline Dyes and Chemicals, Inc., Cedar and Washington Streets, New York City, has applied to have its capital stock increased from \$800,000 to \$1,000,000. It is stated that the increased capital is to be used in a general expansion of the business of the company.

The Flint Varnish and Color Works, Toronto, are establishing a research laboratory in connection with their plant. The work is being organized by Mr. H. F. Blake, of Flint, Mich., as chief chemist.

The Will Corporation, of Rochester, N. Y., announces the purchase of the stock of chemical apparatus, bacteriological apparatus, chemical reagents, and other laboratory supplies owned by the Bausch & Lomb Optical Co., of Rochester. The Will Corporation formerly operated a research and industrial laboratory, but will now make a specialty of laboratory apparatus, and has taken over the force heretofore connected with this branch of the Bausch & Lomb Optical Company.

Twenty companies for the manufacture and distribution of drugs, chemicals, and dyes were organized during December, their aggregate authorized capitalization being \$6,145,000, according to figures compiled by the *Journal of Commerce*. This figure represents an increase as compared with \$3,870,000 in November and appears as the largest total for any month since March 1918. The indicated investment for the 12 months of last year is \$73,403,000, as compared with \$146,160,000 in 1917 and \$99,244,000 in 1916. The aggregate authorized capital of new drug and chemical companies formed since the beginning of the war in August 1914, to the end of 1918, is shown to be \$401,210,000. The names of the companies with capitalization of \$50,000 and over, which were incorporated in December, are: Ambrine Laboratories, Inc., N. Y., \$250,000; American Remedies Co., Del., \$300,000; American Potash and Fertilizer Co., N. J., \$600,000; Aspirin Company of America, N. J., \$125,000; Allen Pharmacal Co., N. J., \$100,000; du Pont Chemical Co., Del., \$3,600,000; H. & H. Medical Specialty Co., N. Y., \$50,000; Koppers Products Co., Del., \$50,000; K. T. C. Chemical Corporation, N. Y., \$50,000; Kinsey Chemical Co., N. J., \$100,000; Laboratory Products Co., N. Y., \$250,000; Laxcarin Products Co., Del., \$100,000; Nono Laboratories Co., W. Va., \$100,000; Panvar Co., Del., \$100,000; Pacific Herb Products Co., Wash., \$50,000; Pittsfield Chemical Co., Pa., \$140,000; Spanish American Druggist Corporation, N. Y., \$100,000; Standard Chemical Works, Pa., \$100,000; Victory Drug & Chemical Corporation, N. Y., \$100,000; Washington Dye and Chemical Co., N. Y., \$150,000.

The Monsanto Chemical Works, of St. Louis, Mo., have purchased the four story and basement brick and stone building at 12 Platt Street, New York City. The building is near the present offices and headquarters which the company maintain at 1 Platt Street and over which A. C. Robertson has presided as New York manager for a number of years. It is the expectation of the Monsanto Chemical Works to occupy its new premises on or about May 1. The Monsanto Company intends to use the building as a permanent New York office, and will make some improvements.

Balfour Guthrie & Co., of San Francisco, Cal., have erected a warehouse at Lindsay, Cal., in the heart of the Northern California citrus district, and will deal in insecticides. Chemicals will be shipped in tank cars and distributed from there. The business will be in charge of Mr. Paul R. Jones.

The Standard Oil Company of California has developed an improved process of refining lubricants which it is expected will be adopted by all other Standard Companies. The new refining agent used is known as Death Valley clay, the deposit being located in Death Valley. The clay is said to have five times the effectiveness of fuller's earth, now in general use. This company controls a large deposit and has expended about \$250,000 in surface improvements. It has equipped its plant at El Secunda, Cal., for the use of the new process and will shortly make the needed changes at its Richmond, Cal., plant.

The United States Civil Service Commission announces an open competitive examination for assistant curator, for men only, on February 5 and 6, 1919. A vacancy in the Department of Geology, National Museum, Washington, D. C., at \$1,800 a year, and future vacancies requiring similar qualifications, at this or higher or lower entrance salaries, will be filled from this examination, unless it is found in the interest of the service to fill any vacancy by reinstatement, transfer, or promotion. It is desired to secure men thoroughly conversant with the most recent methods, and qualified to undertake independent, original investigation in mineralogy and petrology.

A report from Salt Lake City dated December 26, said: "With an authorized capitalization of \$11,000,000, articles of incorporation for the Liberty Potash Company have been drafted and made ready for official recording with the secretary of the State of Utah. One million dollars of the capital stock has been set apart as preferred, and is held almost entirely by men prominent in commercial affairs of Utah and Wyoming. The remaining stock is common. The Liberty Potash Company has been formed for the purpose of producing potash from mineral deposits in the leucite hills of Wyoming, where a mineral known as wyomingite occurs in immense quantities at Superior, near Green River, Wyoming.

The U. S. Copper Products Corporation, Cleveland, O., expects to manufacture brass and copper tubing and their new mill is now under construction on West 73rd Street, south of Denison Avenue, Cleveland. It will be a thoroughly modern type of mill for the production of seamless tubing, electric furnaces being used for melting. This company is incorporated for a million and a half and expects to expend on its first unit approximately \$600,000.

The Canadian Council for Scientific and Industrial Research have under consideration plans involving the erection of a \$500,000 central laboratory building to house some fifty laboratories. It is planned to make this building the heart of a great central industrial research institute, similar in function to the Bureau of Standards at Washington and the Mellon Institute at Pittsburgh. It is hoped that the scheme, which is considered essential to the future industrial development of the Dominion and the ability of the country to compete on an equal basis with the other industrial nations of the world, will provide modern scientific equipment for the investigation of Canada's raw materials. It will serve as a national laboratory for the fixing of standards of all kinds, for the testing of materials, and for the devising of methods of utilizing by-products of industry at present wasted.

With a view to ascertaining the location and resources of all laboratories in the United States capable of being used in industrial research work, Mr. Alfred D. Flinn, secretary of the Engineering Foundation, is seeking all available information regarding them on behalf of the joint committee of the Engineering and National Research Council on Promotion of Industrial Research. Readers having laboratories not already listed by the Engineering Foundation are asked as a patriotic duty to communicate with Mr. Flinn at 33 West 39th St., New York City.

The capital stock of the Scottish Canadian Magnesite Co., Ltd., Hull, Que., has been increased from \$600,000 to \$1,000,000.

France has formed a combine, with a capital of 40,000,000 francs, for the manufacture of all chemicals. It has already a factory capable of producing 2,000 tons of indigo annually, and is independent of Germany for chemical and dye products.

A Canadian Laboratory Supply Co., Ltd., with headquarters at Toronto, has been recently organized to meet the needs of Canadian research and industrial laboratories. The executive officers are Mr. F. G. McKay, president; Mr. J. H. Wilson, vice president and general manager; and H. B. Hall, secretary-treasurer.

The Southern Cottrell Precipitation Company has been organized at Chattanooga by W. G. Waldo, Morrow Chamberlain, P. J. Kruesi, and others, to operate in the central southern states for recovering by-products. It is reported that the first installation will be made at a furnace at Rockdale, Tenn.

A company known as the Malmundersokung has recently been formed in Helsingfors to study Finland's mineral deposits, known but unexploited, and to make a complete survey for new deposits. The majority of shares in this company has been taken by Finland's Industrial Bureau and the Krupp Company of Essen.

The Bureau of Standards has published a "Metric Manual for Soldiers," the aim of which is to give to the American soldiers the grasp of the metric system which will enable them to think and work in metric units. As recommended, no tables of equivalents need be memorized. Brief tables and vocabulary are given for reference. The units are described by actual examples likely to be encountered in military work.

Spain has called for bids on concessions to work the Catalonia potash beds. Consul-General Hurst cabled from Barcelona, under date of December 25, that the Spanish government has published detailed conditions for bids on concessions to work the potash beds of Catalonia, which will be received from Spanish and foreign companies or parties until February 14 at Instituto Geologico de Espana al Madrid.

The end of hostilities is making no difference in the research plant for fixation of atmospheric nitrogen which has been established at the Arlington Farms Laboratory. This is really the test plant for the big plants established at Sheffield, Ala., at a cost of more than a hundred million dollars. The work at the Arlington Laboratory is on synthetic ammonia and is being done by the Bureau of Ordnance which took over the experiments started by Frederick W. Brown, in charge of fertilizer investigations for the Bureau of Soils, U. S. Department of Agriculture.

The Warren Chemical Co., of Newark, has been incorporated under the laws of New Jersey with a capital of \$100,000. Incorporators are John Burstein, Benjamin Burstein, Samuel C. Burstein, of Newark.

PERSONAL NOTES

Einar Vang Grano, chemical engineer and assistant sales manager of the Krebs Pigment and Chemical Company, passed away at his residence in Leonia, N. J., on December 30, 1918, after a brief illness.

Mr. Grano was born in Denmark thirty-five years ago and was graduated with the degree of chemical engineer from the Copenhagen Polytechnic Institute. He began his career in this country in 1906 as research chemist with the Krebs Company of Newport, Delaware, and in recognition of his exceptional abilities was soon made general manager. He remained in this position until 1912, when he entered the selling department to broaden his knowledge of the commercial field.

Mr. Grano's pleasing personality and brilliancy won him a host of loyal friends in both technical and commercial lines, who will ever remember his sterling qualities. He was generally looked upon as one of the leading lithopone experts in this country.

Mr. Grano is survived by his wife and three children. He was a member of the Masonic Order (Tuscan Lodge, Englewood, N. J.), the American Chemical Society, and the Drug and Chemical Club, of New York City.

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Dr. M. O. Forster, F. R. S., has been appointed by the Salters' Company to be the first director of the newly established Salters' Institute of Industrial Chemistry.

Mr. Harry L. Cole, who has been in the Aviation Service while on leave from the State College of Washington, resumed his academic duties in the college on January 15, as instructor in the department of chemistry.

Sir Herbert Jackson has been appointed director of the British Scientific Instrument Research Association. He has resigned from the Daniell professorship of chemistry, King's College, London.

Lieutenant Colonel Frank P. Underhill, commanding officer of the Yale Chemical Warfare Unit, has recently returned from France, where he went to introduce a cure for men gassed at the front. This new method was adopted.

Dr. Lafayette B. Mendel, professor of physiological chemistry at Yale, is attending the meetings of the Inter-Allied Food Commission in Europe.

Dr. H. E. Howe, of A. D. Little, Inc., Cambridge, Mass., has been commissioned Major in the Reserve Corps of the U. S. Army.

Mr. Harold S. Booth holds the du Pont Fellowship in chemistry in Cornell for 1918-1919. He formerly held the Sage Fellowship in chemistry there.

Dr. H. N. Holmes, of the chemistry department at Oberlin College, has been released from part work in order to carry out research for the National Research Council, having been appointed a member of a National Committee of four on colloids.

Captain Paul J. Hanzlik, Medical Corps, U. S. A., chief of the Dermatological Unit, Chemical Warfare Service, Camp Leach, American University, has returned to his position of assistant professor of pharmacology, School of Medicine, Western Reserve University.

At a joint meeting of the Franklin Institute and the Philadelphia Section of the AMERICAN CHEMICAL SOCIETY on December 5, Provost Smith delivered a lecture on "Chemistry in Old Philadelphia." In this lecture the work of twelve pioneers in chemistry was considered.

Captain Gerald L. Wendt, C. W. S., is resuming his duties as assistant professor of chemistry at the University of Chicago, and as a member of the editorial board of the Bulletin of the Chicago Section of the AMERICAN CHEMICAL SOCIETY, having been discharged from the Service on December 1.

Carl N. Austin, who went from the Sears-Roebuck laboratories with a commission as First Lieutenant in Gas Defense, has recently been appointed director of the First Corps Gas School located at Gondrecourt, Meuse, France.

Lieut. John P. Trickey, a member of the Chicago Section, A. C. S., has been promoted to a Captaincy in the Chemical Warfare Service, and is on duty in France.

Prof. Fred W. Ashton has been granted a leave of absence by the University of the Philippines and has taken over new duties as carbonization supervisor with the Chemical Warfare Service at Manila, P. I.

Mr. Eugene F. Cayo, of the Chemical Warfare Service, has resumed his former position as manufacturing chemist with the Stewart and Holmes Drug Co., Seattle, Wash.

The Inter-Allied Scientific Conference, after its meeting in London under the auspices of the Royal Society, adjourned to Paris, where it continued at the end of November its meeting under the auspices of the Academy of Sciences. The American delegates are: Dr. H. A. Bumstead, Colonel J. J. Carty, Professor W. F. Durand, Dr. Simon Flexner, Dr. George E. Hale, and Professor A. A. Noyes.

Mr. Seth S. Walker, formerly associate chemist of the Florida Agricultural Experiment Station and more recently chemist to the Florida Fruit Products Company, is now soil chemist for the Louisiana Agricultural Experiment Station at Baton Rouge.

Mr. J. J. McKee, until recently New York manager of C. A. Dunham Co., Marshalltown, Ia., has severed his connections with that company to take up work with the Machinery Utilities Co., 501 Fifth Avenue, New York City.

Dr. Harold C. Chapin, formerly with the National Carbon Company in Cleveland, has resigned to become associate professor of chemistry at Lafayette College, Easton, Pa.

Ascher F. Shupp, Ph.D., has resigned his position as research chemist on dyestuffs for E. I. du Pont de Nemours and Company, and is now working on an industrial fellowship at the Mellon Institute.

Mr. C. T. Ho is now chemist with the Antoine Chiris Co., Delaware, N. J., having resigned his position as chemist with the Althouse Chemical Co., Reading, Pa.

Mr. W. D. Bonner, in addition to being professor of chemistry at the University of Utah, is acting as consulting chemist to the U. S. Bureau of Mines and is in charge of laboratory investigation on oil shales.

Mr. C. C. O'Loughlin, formerly of the Braun-Knecht-Heimann Co., San Francisco, Cal., is now associated with the Sales Department of the Hoskins Manufacturing Co., Detroit, Mich.

Mr. O. L. Berger, who was superintendent for the Nekoosa-Edwards Paper Co., Port Edwards, Wis., is vice president of the Fiber Making Processes, Inc., having charge of the division for chemical pulp and by-products.

Dr. H. C. Trimble, who recently received the Ph.D. degree from the University of Chicago, has returned to the University of North Dakota as assistant professor of organic chemistry.

Mr. W. J. Crozier (Ph.D., Harvard, 1915), formerly resident naturalist to the Bermuda Biological Station for Research (Harvard), has been appointed assistant professor in physiology at the College of Medicine, University of Illinois, Chicago, Ill.

Mr. N. Spevakov has resigned the position of chemist at the P. B. Brigham Hospital, Boston, to take that of chemist with The Digestive Ferments Co., Detroit, Mich.

Mr. O. S. Groner, formerly professor of chemistry at Ottawa University, Ottawa, Kan., has taken up the same kind of work with the Transylvania College, Lexington, Ky.

Mr. L. A. Pappenhagen has resigned his position as chemist for the National Transit Company, of Oil City, Pa., and has accepted an instructorship in chemistry at Ohio Wesleyan University, located at Delaware, Ohio.

Mr. S. S. Wong, formerly of Wiley & Co., Baltimore, Md., is now chemist in the Northampton Coke Plant of the Bethlehem Steel Company.

Dr. W. R. Bloor, formerly assistant professor of biological chemistry at the Harvard Medical School, Boston, Mass., has been appointed professor of biochemistry and head of the division of biochemistry and pharmacology at the University of California, Berkeley, Cal.

Mr. Henry C. Thornton, formerly assistant chemist of the Interboro Rapid Transit Company in New York, and later in the employ of the American Smelting and Refining Company, Perth Amboy, N. J., is at present employed as chemist with the Duquesne Reduction Co., Pittsburgh, Pa.

Mr. J. A. DeCew, formerly with Process Engineers Limited, of Montreal, Canada, is now located in New York City in charge of Process Engineers, Inc., a New York company formed to take over the business in the United States of the Montreal company. He has associated with him Mr. A. W. Nickerson, who recently was released from the Chemical Warfare Service.

Prof. Hal W. Moseley has been promoted to associate professor of chemistry in Tulane University, New Orleans, La.

Mr. F. Xavier M. Lehmann, formerly manager of the Boston office and in charge of the Boston laboratory of the American Aniline Products, Inc., is now in charge of the technical department of the same firm, located in New York.

Former Lieutenant Colonel Allerton S. Cushman, having received his honorable discharge from the Ordnance Department, U. S. A., where he has served for the past eighteen months, has returned to his former professional activities as head of the Institute of Industrial Research, Washington, D. C. Messrs. Henry A. Gardner, George W. Coggeshall, and H. C. Fuller, who have also resigned from various branches of war service in which they were engaged, have also returned to their work in the Institute of Industrial Research.

Prof. E. O. Heuse, formerly instructor in physical chemistry at the University of Illinois, and later professor of chemistry at Monmouth College, Monmouth, Ill., is now professor of chemistry and head of the department at Southern Methodist University, Dallas, Texas.

Mr. Wayne H. Carter, formerly chemist with the Air Nitrates Corporation at Cartersville, Ala., is now employed as instructor in quantitative analysis at Lehigh University, South Bethlehem, Pa.

Mr. F. W. Bunyan is now chief chemist of the Noble Electric Steel Co., Heroult, Cal.

Mr. W. H. Keen, formerly general manager of the Chemica Products Co., Washington, D. C., and metallurgical superintendent of the Washington Steel and Ordnance Co., Washington, D. C., is now factory manager of the U. S. Copper Products Corporation, Cleveland, Ohio.

Mr. K. B. Thomas has resigned his position as superintendent of the sulfuric acid department of the Calumet and Arizona Mining Company to accept a position as superintendent of the Standard Chemical and Oil Co., Troy, Ala.

Mr. C. S. McKellogg, Corporal in the Chemical Warfare Service, stationed at American University, has been furloughed to the University of Mississippi as assistant professor of chemistry, where he is to have charge of the work in organic and physiological chemistry.

Mr. A. A. Heller, treasurer and general manager of the International Oxygen Company, has given up his active managerial duties. Mr. Eugene Schoen has been appointed general manager for the company. Mr. Heller, as treasurer, continues in charge of the financial departments of the business.

Mr. Joseph Otis Peirce, formerly chief chemist for the Aspro Metallurgical Company of Pittsburgh, is now research chemist in the chemical division of the Procter and Gamble Company, at Ivorydale, Ohio.

Mr. W. Boyd Campbell, for the past several years assistant superintendent at the Forest Products Laboratory, McGill University, Montreal, is now in charge of the chemical engineering work of the Process Engineers Limited, Montreal.

GOVERNMENT PUBLICATIONS

By R. S. McBRIDE, Bureau of Standards, Washington

NOTICE—Publications for which price is indicated can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. Other publications can usually be supplied from the Bureau or Department from which they originate. Commerce Reports are received by all large libraries and may be consulted there, or single numbers can be secured by application to the Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington. The regular subscription rate for these Commerce Reports mailed daily is \$2.50 per year, payable in advance, to the Superintendent of Documents.

GEOLOGICAL SURVEY

Stone in 1916. G. F. LOUGHLIN. Separate from Mineral Resources of the United States, 1916, Part II. 88 pp. Published November 25, 1918.

The Economic Limits to Domestic Independence in Minerals. G. O. SMITH. Separate from Mineral Resources of the United States, 1917, Part I. 6 pp. Published December 28, 1918.

International Control of Minerals. C. K. LEITH. Separate from Mineral Resources of the United States, 1917, Part I. 10 pp. Published December 31, 1918.

Structure and Oil and Gas Resources of the Osage Reservation, Oklahoma. D. E. WINCHESTER, K. C. HEALD AND OTHERS. Bulletin 686-G. 15 pp.

Artesian Waters in the Vicinity of the Black Hills, South Dakota. N. H. DARTON. Water-Supply Paper 428. 64 pp. This paper contains numerous chemical analyses.

Thirty-Ninth Annual Report of the Director of the United States Geological Survey. 163 pp.

Geology of Northeastern Montana. A. J. COLLIER. Professional Paper 120-B. Shorter contributions to General Geology, 1918. 23 pp. Published December 12, 1918.

A Contribution to the Geology of Northeastern Texas and Southern Oklahoma. L. W. STEPHENSON. Professional Paper 120-H. Shorter contributions to General Geology, 1918. 35 pp. Published November 22, 1918.

Shorter Contributions to General Geology, 1917. D. WHITE. Professional Paper 108. 241 pp. This paper contains twelve short reports not of direct chemical interest.

BUREAU OF MINES

The Fusibility of Coal Ash and the Determination of the Softening Temperature. A. C. FIELDNER, A. E. HALL AND A. L. FIELD. Bulletin 129. 146 pp. Paper, 20 cents. Published May 1918.

The present publication reviews the literature on the subject and gives in detail the effect of various oxidizing, reducing, and neutral atmospheres such as are found in various parts of the fuel bed on the softening temperature of ash when molded in the form of Seger cones. As a result of this study a practical method of determining fusibility has been developed whereby the ash is caused to soften and form slags in which the iron exists in approximately the same state of oxidation as the iron in fuel-bed clinkers.

Although it is believed that this method will indicate the probable clinkering characteristics of a coal better than any fusion tests heretofore described, the bureau does not recommend the general use of this method in coal specifications until it is justified by actual trial in furnace tests of different coals. As no fusibility test of a well-mixed sample of the average ash of a coal takes into account the physical distribution of the impurities in the coal as burned, much additional investigation is needed to establish the exact relation of these laboratory fusibility tests to clinker formation. In order to correlate this proposed test of minimum softening temperature with clinker formation, the Bureau is now making clinkering tests in a specially designed experimental furnace, in which different coals having ashes that differ in fusibility are burned under similar and known conditions of combustion. The results of this investigation will be published in a subsequent report. In the meantime it is hoped that other investigators will obtain similar correlation data.

The Diesel Engine; Its Fuels and Its Uses. H. HAAS. Bulletin 156. 133 pp. Paper, 25 cents. Published June 1918. In this report the author discusses recent developments in the design and construction of the Diesel engine, the fuels suitable for burning in it, and the uses to which it is particularly adaptable.

Miners' Safety and Health Almanac for 1919. R. C. WILLIAMS. Miners' Circular 24. 48 pp. Price, 5 cents. Published December 1918.

Melting Brass in a Rocking Electric Furnace. H. W. GILLET AND A. E. RHOADE. Bulletin 171. 131 pp. Paper, 20 cents. Published July 1918.

The object of this paper is to set forth in detail the possibilities and limitations of a rocking electric brass furnace. The general problem of electric brass furnaces is discussed and various types of furnaces are compared only so far as is necessary for the purpose of this report. Information on such other furnaces as have found commercial use is obtainable from the makers of the various furnaces. Reference to some of the more important articles in scientific and technical publications, dealing with the general subject of electric brass melting and with the performances of various specific types of furnaces, is made herein in order that interested persons may pursue the subject further.

Rock Quarrying for Cement Manufacture. O. BOWLES. Bulletin 160. 160 pp. Paper, 25 cents. Published June 1918.

Innovations in the Metallurgy of Lead. D. A. LYON AND O. C. RALSTON. Bulletin 157. 176 pp. Paper, 20 cents. Published July 1918. "The data reported in this bulletin are largely the results of experiments conducted by the Salt Lake City station of the Bureau of Mines in cooperation with the department of metallurgical research of the University of Utah."

Sulfur Dioxide Method for Determining Copper Minerals in Partly Oxidized Ores. C. E. VAN BARNEVELD AND E. S. LEAVER. Technical Paper 198. 14 pp. Price, 5 cents. Published October 1918.

Methods of Shutting off Water in Oil and Gas Wells. F. B. TOUGH. Bulletin 163. 122 pp. Price, 30 cents. Published October 1918.

Eighth Annual Report by the Director of the Bureau of Mines. 124 pp. Price, 10 cents. Published December 1918.

BUREAU OF STEAM ENGINEERING

Description of Navy Standard Boiler, Water-Testing Outfit, and Instructions for Use. Revised edition, 1918. 11 pp.

FUEL ADMINISTRATION

Conservation by Correct Use of Natural Gas for Cooking. Unnumbered publication of the Bureau of Oil Conservation. Reprint of Ohio State University Bulletin 28 entitled "Effect of Gas Pressure on Natural Gas Cooking Operations in the Home." 20 pp.

Standardization of Petroleum Specifications' Committee. Oil Division Bulletin 1. This is the first report of this committee which has been printed. 10 pp.

BUREAU OF STANDARDS

Influence of Quality of Gas and Other Factors on the Efficiency of Gas-Mantle Lamps. R. S. MCBRIDE, W. A. DUNKLEY, E. C. CRITTENDEN, AND A. H. TAYLOR. Technologic Paper 110. 49 pp. Paper, 15 cents. Published October 25, 1918.

With uniform gas quality and with good conditions of service in other particulars the usefulness for mantle lighting of lean water gas of the qualities studied compared with rich water gas is slightly higher for some types of lamps than in proportion to the total heating values. Comparing lean coal gas and lean water gas of the qualities tested, the coal gas is slightly less useful, and this difference is about the same as the difference between the two qualities of water gas. Hence, it may be concluded that the usefulness of a uniform quality of coal gas of 550 to 575 B. t. u. per cu. ft. as compared with a uniform supply of richer water gas, *e. g.*, one meeting a 22-candlepower requirement, is substantially in proportion to the heating values of the two gases. However, greater fluctuations in B. t. u. per cu. ft., slightly greater difficulties in adjustment, and the other factors met in commercial use of lamps make the higher

quality gas somewhat less desirable per heat unit for general use than either of the two kinds of lean gas.

Measurements on the Index of Refraction of Air for Wave Lengths from 2218 Å to 9000 Å. W. F. MEGGERS AND C. G. PETERS. Scientific Paper 327. 44 pp. Paper, 10 cents. Published October 31, 1918.

Testing of Textile Materials. Circular 41. 3rd Edition. This edition supersedes the 2nd edition under the title of "Testing and Properties of Textile Materials." 15 pp. Published September 20, 1918.

Spectroradiometric Investigation of the Transmission of Various Substances. W. W. COBLENTZ, W. B. EMERSON, M. B. LONG. Scientific Paper 325. 24 pp. Paper, 5 cents. Issued August 8, 1918. "This paper gives the spectral transmission of various substances, especially colored fluorite, light filters, and colored glasses. Some of the substances provide a simple means for obtaining narrow spectral bands of radiant energy of high intensity and large area, without the employment of a spectroscope. By properly combining them one can obtain a screen having a narrow band of high transmission at 0.38, 0.5, 0.55, 0.7, 0.8, 1, and 2.2 μ . The data on glasses are also useful in giving information as to their applicability for protecting the eyes from injurious radiations."

Electrical Oscillations in Antennas and Inductance Coils. J. M. MILLER. Scientific Paper 326. 20 pp. Paper, 5 cents. Issued October 23, 1918.

Variance of Measuring Instruments and Its Relation to Accuracy and Sensitivity. F. J. SCHLINK. Scientific Paper 328. 24 pp. Paper, 5 cents. Issued September 30, 1918.

Metric Manual for Soldiers. Miscellaneous Publications 21-16 pp. The soldier's primer of the metric system—an international decimal system of weights and measures adopted as the legal standard by France and thirty-three other nations and in world-wide use.

Compressive Strength of Large Brick Piers. J. G. BRAGG. Technologic Paper 111. 39 pp. Paper, 10 cents. Issued September 20, 1918.

New Baumé Scale for Sugar Solutions. F. J. BATES AND H. W. BEARCE. Technologic Paper 115. 11 pp. Issued October 30, 1918.

Measurements of Wave Lengths in the Spectrum of Neon. K. BURNS, W. F. MEGGERS, AND P. W. MERRILL. Scientific Paper 329. 11 pp. Price, 5 cents. Published November 12, 1918.

The Decrease in Ultraviolet and Total Radiation with Usage of Quartz Mercury Vapor Lamps. W. W. COBLENTZ, M. B. LONG, AND H. KAHLER. Scientific Paper 330. 20 pp. Paper, 5 cents. Published November 12, 1918.

Toluol Recovery. R. S. MCBRIDE, C. E. REINICKER, AND W. A. DUNKLEY. Technologic Paper 117. 60 pp. Paper, 10 cents. Published December 19, 1918. So that it might be fully informed as to the technical problems involved in these questions the Bureau sent its representatives to visit a considerable number of toluol-recovery plants. As a result of these inspections and after numerous conferences there was issued October 15, 1917, the preliminary report entitled "Recovery of Light Oil and Refining of Toluol." Large demand for this preliminary issue soon exhausted the supply of this pamphlet and a new edition was therefore necessary. In the meantime, however, another publication from the Bureau entitled "Toluol Recovery and Standards for Gas Service" had been put out in a number of technical and trade publications. In connection with the revision of the first report it is desired to combine these two articles and some additional material which the Bureau has prepared in a single publication; the present paper is the result. In Part II of this paper are given a description of toluol-

plant construction and methods of operation, a discussion of the various results which can be obtained, and a brief outline of the cost of carrying out this recovery. Part III is a discussion of the relation of toluol recovery to standards for gas service. Part IV gives a typical form of contract which the Ordnance Department has made with various companies for the operation of toluol-recovery plants in connection with city gas works.

DEPARTMENT OF AGRICULTURE

Highway Cost Keeping. J. J. TOBIN AND A. R. LOSH. Department Bulletin 660. 52 pp. Paper, 10 cents. Published September 12, 1918.

The Chemical Analysis of Wheat-Flour Substitutes and of the Breads Made Therefrom. J. A. LE CLERC AND H. L. WESSLING. Department Bulletin 701. 12 pp. Paper, 5 cents. Published September 20, 1918. This bulletin gives the results of the analysis of more than 30-part substitutes for wheat flour and the bread made from them.

Digestibility of Protein Supplied by Soy-Bean and Peanut Press-Cake Flours. A. D. HOLMES. Department Bulletin 717. 28 pp. Paper, 5 cents. Published September 25, 1918. This bulletin records studies of the digestibility of protein supplied by soy-bean and peanut press-cake flours. It is primarily of interest to students and investigators of food problems.

A Method for Preparing a Commercial Grade of Calcium Arsenate. J. K. HAYWOOD AND C. M. SMITH. Department Bulletin 750. 10 pp. Paper, 5 cents. Published October 5, 1918. This paper is of interest to manufacturers of insecticides and fungicides.

Analysis of Experimental Work with Ground Raw Rock Phosphate as a Fertilizer. W. H. WAGGAMAN AND C. R. WAGNER. Department Bulletin 699. 119 pp. Paper, 10 cents. Published October 16, 1918.

A Preliminary Study of the Bleaching of Oats with Sulfur Dioxide. G. H. BASTON. Department Bulletin 725. 11 pp. Paper, 5 cents. Published October 22, 1918. This bulletin consists of the results of laboratory experiments with oats before and after bleaching and is of interest to chemists generally.

Articles from the Journal of Agricultural Research

Resistance of Seeds to Desiccation. G. T. HARRINGTON AND W. CROCKER. 14, 525-532 (September 16).

An Improved Method for Recovering Trypanosomes from the Blood of Rats for Antigen Purposes in Connection with Complement Fixation. F. H. REYNOLDS AND H. W. SCHOENING. 14, 573-576 (September 23).

Condition of Fertilizer Potash Residues in Hagerstown Silty Loam Soil. W. FREAR AND E. S. ERB. 15, 59-81 (October 14, 1918).

Chemistry of Sweet-Clover Silage in Comparison with Alfalfa Silage. C. O. SWANSON AND E. L. TAGUE. 15, 113-132 (October 14, 1918).

Effect of Hydrocyanic-Acid Gas under Vacuum Conditions on Subterranean Larvae. E. R. SASSER AND H. L. SANFORD. 15, 133-136 (October 21, 1918).

Catalase and Oxidase Content of Seeds in Relation to Their Dormancy, Age, Vitality, and Respiration. W. CROCKER AND G. T. HARRINGTON. 15, 137-174 (October 21, 1918).

Plasticity of Biologic Forms of *Puccinia graminis*. E. C. STAKMAN, F. J. PIEMEISEL, AND M. N. LEVINE. 15, 221-249 (October 28, 1918).

Experiments in Field Technic in Plot Tests. A. C. ARNY AND H. K. HAYES. 15, 251-262 (October 28, 1918).

Net Energy Values of Alfalfa Hay and of Starch. H. P. ARMSBY AND J. A. FRIES. 15, 269-286 (November 4, 1918).

Soil Factors Affecting the Toxicity of Alkali. F. S. HARRIS AND D. W. PITTMAN. 15, 287-319 (November 4, 1918).

Soil Acidity as Affected by Moisture Conditions of the Soil. S. D. CONNER. 15, 321-329 (November 11, 1918).

Determining the Absolute Salt Content of Soils by Means of the Freezing-Point Method. G. J. BOUYOUKOS AND M. M. MCCOOL. 15, 331-336 (November 11, 1918).

BUREAU OF FOREIGN AND DOMESTIC COMMERCE

Industrial Standards. The following pamphlets of the Industrial Standards Series issued by this Bureau are Spanish-English editions of specifications approved by the American Society for Testing Materials or other organizations, which have been prepared for circulation recently.

2—Standard specifications for carbon steel rails. Revised 1914. 27 pp. 5 cents.

5—Standard specifications for medium-carbon steel splice bars. Revised 1914. 15 pp., 2 text figs. 5 cents.

6—Standard specifications for high-carbon steel splice bars. Revised 1914. 15 pp., 2 text figs. 5 cents.

7—Standard specifications for structural steel for bridges. Revised 1916. 21 pp., 4 text figs. 5 cents.

9—Standard specifications for structural steel for locomotives. Revised 1916. 19 pp., 2 text figs. 5 cents.

10—Standard specifications for carbon steel bars for railway springs. Revised 1916. 13 pp. 5 cents.

11—Standard specifications for carbon steel and alloy steel forgings. Revised 1918. 25 pp., 2 text figs. 5 cents.

12—Standard specifications for quenched and tempered carbon-steel axles, shafts, and other forgings for locomotives and cars. Revised 1918. 25 pp., 2 text figs. 5 cents.

13—Standard specifications for carbon steel forgings for locomotives. Revised 1916. 19 pp., 2 text figs. 5 cents.

BOOK REVIEWS

A Study of Engineering Education. By CHARLES RIBORG MANN. xi + 130 pp. Bulletin 11. The Carnegie Foundation for the Advancement of Teaching 1918.¹

The Carnegie Foundation for the Advancement of Teaching has just issued a generous pamphlet in large octavo, on "A Study of Engineering Education," by Professor Charles Riborg Mann, of the Department of Physics at the Massachusetts Institute of Technology. Naturally, this report is mainly concerned with a discussion of engineering as related to what are usually recognized as the old staple branches of the science, both theoretical and practical; but, inasmuch as we, as chemists, are represented on the basic committee by two organizations,

"The American Chemical Society" and "The American Institute of Chemical Engineers," and also inasmuch as several of the points noted in this remarkable survey are directly connected with both the teaching and the application of chemistry—therefore, it follows that we, as chemists, are more than casually interested in the report and its later developments.

One of the most interesting points registered is that the qualities of the successful engineer are noted in repeated allusion and reference, and, in reply to a questionnaire noting the following six groups of qualities, namely, character, judgment, efficiency, understanding of men, knowledge, and technique—out of seven thousand engineers replying, 94.5 per cent place character at the head of the list and technique at the bottom.

¹ Reprinted from *The Crucible*, published monthly by the Pittsburgh Section of the American Chemical Society, 1 (1918), 61.

There are many other notable additions to our information and instances of emphasis on well-known principles, such as the well-known guide of learning a thing through its use, as is well illustrated by the common "part-time" method of mingling instruction with shop practice and observation.

One who would gather all that this report has of value must study the report itself; but there is one matter, which comes out, by suggestion and perhaps neglect, rather than by actual formulation and emphasis thereon, and that is the peculiar practical psychology of the research element in the actual history of our average American chemical student. In other words, how shall we learn and teach the trick of finding, formulating, and answering real research problems?

One of the greatest of chemical teachers of all time, the former head of the first real chemical research department in an American university (and of whom the writer was a former student), used to bewail the fact that, up to the time of his statement, only 5 per cent of his graduates showed marked ability as original research workers. This statement, presumably entirely correct from the old-fashioned standpoint, used to cause the writer much food for thought. Questions such as the following would arise:

Did the teaching element in the teacher so overshadow the research element that the student simply reflected the unconscious tendency of the teacher? Was this great teacher himself naturally hampered by the lack of a real understanding of the research quality? Or was the fault to be found in the peculiar conditions and limitations of the American student and chemical explorer? Certainly, the relative mediocrity of the American student, as compared with the foreign student's productivity in most lines of pure research has, till recently, been too obvious to call for further comment.

But there must be some further answer and some rebuttal to the criticism of the universal inferiority of the American research student. Perhaps it can be found by a frank confession from all; so here goes for a starter.

It was the experience of the writer that he barely caught the research idea while he was taking the training for his doctorate; and certainly, he did not do much to expand that sorrowful 5 per cent. That was the sum and substance of my experience when teaching in a western State University, where the burdens of teaching and administration proved a sore limitation on any fair chance at research, though I did have a chance to turn out some fine men from among my students. Otherwise, some literary chemical work remains as almost the sole positive result of fifteen years of hard work; but later, when the writer found himself harnessed in the school of "Hard Knocks," then the special practical problem invariably suggested its appropriate answer, and the research quality seemed to develop.

I have heard a similar confession from many a colleague in the recent chemical opportunity which has come over us like a flood—from the broader work of such industrial miracles as this grand Mellon Institute—from the needs and emergencies and opportunities of this great world war.

The main fact seems to be, that the American mind is suited to grapple with any problem as soon as it puts on the overalls.

That suggests that, as a nation, we may still be in the colonistic condition, where "necessity is the mother of invention."

It may mean that we are specially fitted to cope with the practical, as the means of solving both the practical and the theoretical. Assuredly it does not mean that the inventive American chemist is the inferior of any race or nation of chemists, although it is quite possible that we still have something to learn of the value and strength of more intensive concentration, and also of the immense power of thoroughness, and it must mean that when we shall have begun to get some of the more immediate practical problems settled, we will attack the more remote and theoretical work, which must always remain as

part and parcel of the general task of using all the resources of Nature for the good of man.

And, speaking of engineering education in general—and of examinations in particular—here is a story which I picked up, years ago, and which is not entirely apochryphal; it is worth pondering over. It happened, once upon a time, that two young chemists in Munich, at Baeyer's laboratory, had the effrontery to work out the proof of the correct structure of the rosaniline dyes. They showed that it was the methyl side chain of the toluidine that became the real type nucleus of the rosaniline and pararosaniline compounds. That was at the time when the great August Hofmann of Berlin was trying to force the facts to fit his mistaken theory that there was a triple-ammonia-nucleus at the center of the rosaniline compounds. Now these two successful young chemists were no other than Emil and Otto Fischer, and they became at once well-known chemists; but it so happened that Emil Fischer was still a "privat-docent," not a "Herr Doctor."

So, one day in the spring, Baeyer suggested to this bright, but conceited, young Emil Fischer, that he ought to stop his investigation for a while, and brush up his general chemistry to be able to take his Doctor's examination. Herr Emil Fischer consented to take the examination, but he made the mistake of supposing that just because he had done a piece of good work he was all ready for his trial. And so Emil Fischer let things slide along. Some days before the examination Herr Professor Baeyer is said to have retired from the world to the penetralia of his private library, where the same Professor Baeyer did glean and gather many facts on the history of the development of chemistry which would serve as sharp tests for the candidate. And so it happened that when the examination came on, at the very first question from Herr Professor Baeyer, the renowned young chemist, Herr Emil Fischer, was startled by meeting something to which he had to reply, "Ich weiss es nich," and it is said that for two hours this same, cruel, said Professor Baeyer kept this same brilliant, young chemist, the Herr Emil Fischer, replying, "I do not know."

Of course, any good chemist might conceivably work up a set of questions that might conceivably flunk any other chemist; and that suggests some of the rights and wrongs of the "examination system."

But after Professor Baeyer had gotten his favorite star pupil down where he wanted him, with all the starch taken out of him, he gave him some reasonable questions, and allowed Fischer to make a really brilliant examination.

The story is still old University gossip among those who know; and it is worth while, for it suggests questions which every young American chemist will wish to think out for himself. What is a real examination? What is the test of real success? What is real success—in theory and practice?

CHAS. S. PALMER

The Chemical Analysis of Iron. By ANDREW ALEXANDER BLAIR. 8th Ed. 318 pp. J. B. Lippincott Co., Philadelphia, 1918. Price, \$5.00.

There must come a time in the life of every book which has passed through a number of editions when the author must decide as to whether some of the material contained in it should or should not be relegated to the historical museum or carried on as dead. In these times of scarcity of paper it seems that the author has lost a valuable opportunity to prune out-obsolete material, or at least to star for the benefit of the uninitiated, the useful methods.

In these days why should anyone be interested in Bunsen's method of rapid filtration in which is pictured a hand pump for producing diminished pressure? Who among practical workers is interested in the determination of carbon in steel by combustion with lead chromate and potassium chlorate, when he can

use a direct combustion method and get accurate results in one-tenth of the time? Many such examples might be cited. The book has been the standard for so long a time and there is so much good in it that it seems a pity not in some way to have made some distinction between modern and out-of-date methods. This edition differs from the previous one in the improvement of the methods for the analysis of alloy steels.

HENRY FAY

High Explosives: A Practical Treatise. By CAPT. E. DEW. S. COLVER, Dr. Met., F.C.S., Attaché British Ministry of Munitions. 8vo., 830 pp. D. Van Nostrand Co., New York, 1918. Price, \$20.00 net.

This compendious volume contains a mass of information collected from numerous sources which will prove of value to chemists interested in the manufacture, handling, and testing of explosives, their raw materials and intermediates. It is much to be regretted that this volume could not have been in the hands of American chemists a year or two earlier at a time when any possible guidance in the rapidly expanding explosive industry was so woefully needed. The author's aim has been to fill a marked gap in English technical literature on the subject of high explosives and he has to a very considerable extent succeeded in carrying out his purpose. A work of this nature undertaken in time of war is very seriously handicapped as the author points out in his preface, by the necessity of preventing the transmission of information to the enemy. The reviewer might point out at this place that even during times of peace, the ever-present potentiality of war has acted as a bar to explosives experts publishing information, to quote modern diplomatic language, "in a spirit of complete candor." In fact it is possible to go further and state that many publications on military explosives have been issued on purpose to mislead and deceive. Of any such tendency the volume under discussion is obviously free. The reviewer takes occasion to suggest that as the recent great war was fought with an enemy who had made himself specially proficient in the chemistry and technology of high explosives the rigorous suppression of the early exchange of technical information between experts of the allied cause resulted in a far greater handicap to the Allies than it did to Germany and Austria. It would seem desirable hereafter that the American and the International Societies for Testing Materials should add to their activities the standardization and testing of at least the well-known types of military explosives. Had this been done during past years many serious mistakes would have been avoided and probably many deaths by accident among munition workers prevented.

The volume under review appears to be particularly valuable for its treatment of the subject of the nitro-aromatic high explosives. For reasons discussed above, the best and most recent experience in methods of manufacture and handling are not given. The same criticism may be permitted with respect to that most important of all initiators, fulminate of mercury, the modern and safe methods of manufacture being touched but lightly, if not made conspicuous by their absence. In short, the work is one which will be used as a reference book by every explosives chemist but will not be used as a sure guide to all that is known in its field.

The volume of 830 pages with four appendices and index, printed on heavy paper on account of its numerous illustrations, is too ponderous and much of the subject matter could have been eliminated or relegated to a separate volume to the advantage of the work as a book of ready reference. Appendix I, giving an extensive review of patents dealing with nitro compounds, mainly German, might well have been omitted, as German patent specifications dealing with such subjects are generally more misinforming than enlightening.

Chapter VIII on American and Russian petroleum should have been omitted; it is out of place in the volume and dis-

poses of American petroleum as though it were a standard substance of definite composition which is described as, "A thick oil comparatively easily separated by distillation into the various paraffin hydrocarbons of which it is composed." Such superficial treatment of a big and complex subject could be looked upon only as padding to an already too ponderous volume, even if the general subject of petroleum and its products had not been already summarized in Chapter II.

So compendious a work on a subject so little standardized taxes the ability of the reviewer but it may be fairly stated that it would be impossible to prepare a volume dealing with this field of knowledge which would not at many points yield itself to criticism. As a whole the book is an addition to the growing family of works on high explosives, close acquaintance with which should be cultivated with discretion by the student and investigator in this dangerous though fascinating field.

ALLERTON S. CUSHMAN

The Manufacture of Sulfate of Ammonia and Crude Ammonia.

By GASCOIGNE T. CALVERT. 153 pp. Illustrated. Second Edition. Benn Bros., Ltd., London, 1917. Price, \$3.00 net.

This book is essentially a description of plant apparatus prevailing in British practice for making sulfate of ammonia from crude gas liquor. Various types of stills and saturators are described and illustrated, a brief account is given of the Claus process for recovery of sulfur from the waste gases and of methods of laboratory testing applying to ammonia manufacture. One brief chapter is devoted to operation, another to cost of manufacture (starting from crude gas liquor and acid), and a third to a description of a single, nearly obsolete, method for the manufacture of concentrated ammoniacal liquor.

The book is inadequate to meet the requirements of those readers desiring enlightenment on modern methods of ammonium sulfate recovery direct from coke oven or other coal gas, and on the elaborate modern processes for concentrating and purifying ammoniacal liquor. There is a disappointing lack of any exposition of the principles underlying successful and economical operation and the recovery of high-grade, well-crystallized sulfate.

The typography and illustrations are good, and the descriptions of plant apparatus will prove valuable to users of this class of equipment.

HORACE C. PORTER

The Zinc Industry. By ERNEST A. SMITH. 223 pp. Longmans, Green & Company, New York, 1918. Price, \$3.50.

This little book can be recommended as an excellent introduction to the zinc industry. Although written from the British standpoint and particularly for the benefit of the British reader, it is nevertheless a well-balanced volume and treats the zinc industry of the world in a fairly comprehensive manner. As the author states in his preface, there has been comparatively little written in England about the zinc industry and its world development since the classical work of Dr. John Percy which appeared in 1861, and the present work of Mr. Smith must be reviewed in the light of this fact. In other words, a Zinc Primer is more timely under these conditions than an exhaustive treatise would be. As the title of the book indicates, the treatment is of the industry as a whole and does not unduly emphasize the technology of zinc extraction, although the technical side is well covered from a general point of view.

To the zinc metallurgist and specialist, this book brings nothing new; as a matter of fact, it contains much that is out of date, and considerably more, when the author goes into details, which reveals his unfamiliarity with first-hand information. Nevertheless the book is a good one for any zinc man to read, since it gives the broad outlook on the industry which the expert often fails to grasp in his intense application to his own particular sector.

FRANK G. BREYER

The Manufacture of Intermediate Products for Dyes. By JOHN CANNELL CAIN. x + 263 pp. 25 Illustrations. Macmillan and Company, Ltd., London and New York, 1918. Price, \$3.50.

The author has chosen the intermediate products treated in this volume from "The Dyestuff Census of the United States," supplemented by his extensive experience; and this selection seems to be very complete for this class of chemicals.

The book gives abstracts from the literature pertaining to the manufacture of intermediates, and the aim of the author has been to present the literature of intermediates in a sufficiently complete form so that the chemist interested would be able to base his work on the description given in the work without any general reference to the original literature. This is true in many instances, and undoubtedly industrial laboratory work could be undertaken based on the information given. Where the literature or the author's personal experience makes available technical procedure, the author has given this fully.

The book will be of great interest to anyone engaged in the manufacture of intermediates or of dyestuffs. It does not give processes that can be immediately installed in the shop but it does give a practical starting point. Chemists who do not have at their command a very extensive library will find Dr. Cain's book invaluable.

The author has given systematically the chief dyes for which the intermediate in question is used and this phase of the work will appeal especially to students of the dyestuff industry. There are also recorded "essential scientific data such as melting points, boiling points, densities, solubilities, etc. The pure chemistry of the subject has been left alone as it is readily available."

In only a few cases are there given cuts or diagrams of apparatus, for, as the author remarks, such cuts of apparatus or diagrams can be obtained readily from the advertising sections of the various technical periodicals.

The book is a timely and decidedly worth-while contribution to the dyestuff industry.

R. NORRIS SHREVE

Annual Chemical Directory of the United States. Edited by B. F. LOVELACE, Consulting Editor, and CHARLES G. THOMAS, Managing Editor. Williams and Wilkins Co., Baltimore, Md. Price, \$5.00.

The editor in his foreword to the Chemical Directory states, "We endeavor to list every chemical substance under its proper name, giving also the commonly used terms with cross references."

If this is the editor's intention he certainly has badly applied it in the case of bleaching powder, also known as chloride of lime and calcium hypochlorite.

In the case of the heading "Chloride of Lime" it is cross-indexed back to calcium hypochlorite and bleach; while the headings "Bleach and Calcium Hypochlorite" have no cross references whatsoever. This is a most bewildering situation, for the observer unfamiliar with the chemical terms would assume that bleach was not chloride of lime, while chloride of lime was bleach; and the same would be the case with calcium hypochlorite—he might assume that chloride of lime was calcium hypochlorite, while calcium hypochlorite was not chloride of lime.

Under each of these headings there are listed different dealers and manufacturers, from which the only conclusion that can be drawn is that the editor himself lacks familiarity with chemical nomenclature. There are other similar cases, but this one cited is the most startling.

It would seem that an improvement might be made in the listing of analytical and consulting chemists, as well as chemical engineers. Assume that a manufacturer desires some specific information which he feels certain could be supplied him by some consulting chemist or chemical engineer. He would go to the Chemical Directory and expect to find some means by which out of the hundreds of names he could pick out the man, or the men, who would be most liable to be able to supply him with the desired information. As the chemical engineers and consulting chemists are tabulated at the present time, he gets only a list of names which he might just as well get out of a telephone directory; and only through gossip can he obtain information as to the desirability of a special firm or a special engineer. It would seem that some means of cross-indexing the engineers under their specialties could be accomplished.

The chapters "Societies and Associations" and "Publications—Technical and Scientific Journals" are sadly incomplete. In a most casual observation it is noticed that many of the most important European societies and publications are not mentioned in either of these chapters. They form undoubtedly a good beginning, but to be of real value should be very thoroughly revised and increased. This could be accomplished in the country without spending much time, excepting that required for a visit to the Congressional Library in Washington.

On the whole, the Annual Chemical Directory of the United States is a valuable asset at this time to any library, since it gives an analytical cross-section of the status of chemistry in the United States at present.

JOHN W. BECKMAN

NEW PUBLICATIONS

By CLARA M. GUPPY, Librarian Mellon Institute of Industrial Research, Pittsburgh

Chemical Industry: La Réorganisation de l'Industrie Chimique en France. EUGÈNE and PAUL GRANDMOUGIN. 277 pp. Price, 12 fr. 50. H. Dunod et E. Pinat, Paris.

Chemistry: Industrial and Manufacturing Chemistry. Part 2. Inorganic. GEOFFREY MARTIN. 2nd Ed. 498 pp. Price, 28s. Crosby, Lockwood & Son, London.

Chemistry: Practical Chemistry for Intermediate Classes. H. B. DUNNICLIFF. 8vo. 289 pp. Price, 5s. The Macmillan Co., London.

Chemistry of Synthetic Drugs. PERCY MAY. 2nd Ed. Revised and enlarged. 8vo. 250 pp. Price, \$3.50. Longmans, Green & Co., New York.

Electrolysis: Applications of Electrolysis in Chemical Industry. A. J. HALR. 8vo. 157 pp. Price, \$2.50. Longmans, Green & Co., New York.

Gas and Gas Making. Growth, Method, and Prospects of the Gas Industry. W. H. Y. WEBBER. 8vo. 143 pp. Price, 2s. 6d. Pitman, London.

Glassblowing: Le Soufflage du Verre dans les Laboratoires Scientifiques et Industriels. HENRI VIOREUX. 248 pp. Price, 12 fr. H. Dunod et E. Pinat, Paris.

Industry and Humanity: A Study in the Principles Underlying Industrial Reconstruction. W. L. M. KING. 8vo. 552 pp. Price, \$3.00. Houghton, Mifflin Co., Boston.

Ingots and Ingot Moulds. A. W. BREAMLEY and HARRY BREAMLEY. 8vo. 218 pp. Price, \$5.50. Longmans, Green & Co., New York.

Iron: l'Industrie du Fer. LOUIS FERRASSON. Price, 4 fr. 50. Payot et Cie, Paris.

Metallography and Heat Treatment of Iron and Steel. ALBERT SAUVAGE. 2nd Ed. 4to. 486 pp. Price, \$6.00. Sauveur and Boylston, Cambridge, Mass.

Mineral Industry 1917. G. A. ROUSH. 8vo. 928 pp. Price, \$10.00. McGraw-Hill Book Co., New York.

Science: Introduction to the Study of Science. W. P. SMITH and E. G. JEWETT. 12mo. 620 pp. Price, \$1.40. The Macmillan Co., New York.

Spectroscopy. E. C. C. BALY. 8vo. 701 pp. Price, 12s. 6d. Longmans, Green & Co., London.

Welding: A Practical Manual of Autogenous Welding (Oxy-Acetylene). R. GRANJON and P. ROSEMBURG. Translated by D. Richardson. 7th Ed. 8vo. 266 pp. Price, 5s. Charles Griffin & Co., London.

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- Aluminum: Its Use in the Motor Industry in England.** E. C. HILL. *The Metal Industry*, Vol. 16 (1918), No. 12, pp. 543-546.
- Aluminum: Manufacturing Processes Used in Europe.** O. NISSN. *Chemical and Metallurgical Engineering*, Vol. 19 (1918), No. 12, pp. 804-815.
- Cement: Influence of Gypsum on the Blast Furnace Slags in the Manufacture of Cement.** EUPHIME BERESLAVSKY. *Chemical and Metallurgical Engineering*, Vol. 20 (1919), No. 1, pp. 25-28.
- Chlorine: Commercial Uses of Chlorine.** V. R. KOKATNUR. *Canadian Chemical Journal*, Vol. 2 (1918), No. 12, pp. 305-308.
- Chrome Industry: Brief on the Status of the Chrome Industry.** COURTNEY DE KALB. *Mining and Scientific Press*, Vol. 118 (1919), No. 1, pp. 13-17.
- Chromic Oxide: Method of Chromic Oxide Determination.** Government Chemists Claim that New Method Permits Rapid Handling of Ore Samples Submitted for Analysis. W. C. RIDDELL and ESTHER KITTERBOG. *The Chemical Engineer*, Vol. 26 (1918), No. 12, pp. 457-458.
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- Explosives: High Explosive Shells and Shrapnel; Description of How Shells are Heat-Treated.** Physical and Chemical Requirements Given. J. M. HALL. *The American Drop Forger*, Vol. 4 (1918), No. 12, pp. 500-504.
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- Steel: Modern Methods of Making Steel.** F. B. LOUNSBERRY. *The American Drop Forger*, Vol. 4 (1918), No. 10, pp. 404-407.
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- Stellite and High-Speed Steel Compared.** G. B. W. *The Iron Age*, Vol. 102 (1918), No. 26, pp. 1584-1585.
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- Sulfur Dioxide: Simple Method for Determining Sulfur Dioxide.** G. W. JONES, J. H. CAPPS, and S. H. KATZ. *Mining and Scientific Press*, Vol. 117 (1918), No. 13, pp. 415-418.
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- Zirconium Content in Ores and Alloys.** J. D. FERGUSON. *Engineering and Mining Journal*, Vol. 106 (1918), No. 18, pp. 793-794.

MARKET REPORT—JANUARY, 1919

WHOLESALE PRICES PREVAILING IN THE NEW YORK MARKET ON JANUARY 15, 1919

INORGANIC CHEMICALS

Acetate of Lime, Basis 80%.....	100 Lbs.	3.00	@	3.10
Alum, ammonia, lump.....	100 Lbs.			7.00
Aluminum Sulfate, (iron free).....	Lb.	4.50	@	4.75
Ammonium Carbonate, domestic.....	Lb.		nominal	
Ammonium Chloride, white.....	Lb.	19	@	20
Aqua Ammonia, 26°, drums.....	Lb.	8 1/2	@	10 1/2
Arsenic, white.....	Lb.	10	@	15
Barium Chloride.....	Ton	70.00	@	80.00
Barium Nitrate.....	Lb.	12	@	14
Barytes, prime white, foreign.....	Ton	30.00	@	35.00
Bleaching Powder, 35 per cent.....	Lb.	2	@	3 1/4
Blue Vitriol.....	Lb.	9	@	9 1/4
Borax, crystals, in bags.....	Lb.	7 1/4	@	10 1/4
Boric Acid, powdered crystals.....	Lb.	7 1/4	@	8 1/4
Bromine, crude, domestic.....	Long Ton	28.00	@	35.00
Bromine, technical, bulk.....	Lb.	75	@	
Calcium Chloride, lump, 70 to 75% fused.....	Ton	20.00	@	22.00
Caustic Soda, 76 per cent.....	100 Lbs.	3.25	@	3.50
Chalk, light precipitated.....	Lb.	4 1/4	@	5
China Clay, imported.....	Ton	20.00	@	30.00
China Clay, imported.....	Ton	8.00	@	15.00
Fuller's Earth, foreign, powdered.....	Ton		nominal	
Fuller's Earth, domestic.....	Ton	20.00	@	30.00
Glauber's Salt, in bbls.....	100 Lbs.	2.10	@	3.00
Green Vitriol, bulk.....	100 Lbs.	2.00	@	2.25
Hydrochloric Acid, commercial, C. P.....	Lb.	8	@	8 1/4
Iodine, resublimed.....	Lb.	4.25	@	4.30
Lead Acetate, white crystals.....	Lb.	17	@	18
Lead Nitrate, C. P.....	Lb.		85	
Litharge, American.....	Lb.	14	@	15
Lithium Carbonate.....	Lb.		1.50	
Magnesium Carbonate, U. S. P.....	Lb.	25	@	30
Magnesite, "Calcined".....	Ton	60.00	@	65.00
Nitric Acid, 40°.....	Lb.		7 1/4	
Nitric Acid, 42°.....	Lb.		8 1/4	
Phosphoric Acid, 48/50%.....	Lb.	35	@	40
Phosphorus, yellow.....	Lb.	1.10	@	1.15
Plaster of Paris.....	Bbl.	2.00	@	2.50
Potassium Bichromate.....	Lb.	38 1/4	@	
Potassium Bromide, granular.....	Lb.	1.25	@	1.30
Potassium Carbonate, calcined, 80 @ 85%.....	Lb.	28	@	
Potassium Chlorate, crystals, spot.....	Lb.	40	@	41
Potassium Cyanide, bulk, 98-99 per cent.....	Lb.		nominal	
Potassium Hydroxide, 88 @ 92%.....	Lb.	60	@	70
Potassium Iodide, bulk.....	Lb.	3.75	@	4.00
Potassium Nitrate.....	Lb.	27	@	30
Potassium Permanganate, bulk, U. S. P.....	Lb.	1.40	@	1.60
Quicksilver, flask.....	75 Lbs.	110.00	@	
Red Lead, American, dry.....	100 Lbs.	11.25	@	11.50
Salt Cake, glass makers'.....	Ton	17.50	@	22.00
Silver Nitrate.....	Oz.	63 1/4	@	65
Soapstone, in bags.....	Ton	10.00	@	12.50
Soda Ash, 58%, in bags.....	100 Lbs.	1.90	@	2.00
Sodium Acetate, broken lump.....	Lb.	20	@	21
Sodium Bicarbonate, domestic.....	100 Lbs.	2.90	@	3.15
Sodium Bichromate.....	Lb.	17 1/2	@	18 1/2
Sodium Chlorate.....	Lb.	25	@	25 1/2
Sodium Cyanide.....	Lb.	30	@	32
Sodium Fluoride, commercial.....	Lb.	17	@	18
Sodium Hyposulfite.....	100 Lbs.	2.60	@	3.60
Sodium Nitrate, 95 per cent, spot.....	100 Lbs.	4.42 1/2	@	5.00
Sodium Silicate, liquid, 40° Bé.....	Lb.	2	@	2 1/2
Sodium Sulfide, 60%, fused in bbls.....	Lb.	5 1/4	@	6
Sodium Bisulfite, powdered.....	Lb.	6	@	8
Strontium Nitrate.....	Lb.	25	@	30
Sulfur.....	100 Lbs.	2.25	@	4.60
Sulfuric Acid, cleam 66° Bé.....	Ton		25.00	
Sulfuric Acid, oleum (fuming).....	Ton		25.00	
Talc, American, white.....	Lb.		15.00	
Terra Alba, America, No. 1.....	100 Lbs.		1.17 1/2	
Tin Bichloride, 50°.....	Lb.	28	@	30
Tin Oxide.....	Oz.	90	@	1.00
White Lead, American, dry.....	Lb.	10	@	10 1/2
Zinc Carbonate.....	Lb.	18	@	20
Zinc Chloride, commercial.....	Lb.	15	@	15 1/2

ORGANIC CHEMICALS

Acetanilid, C. P., in bbls.....	Lb.	58	@	60
Acetic Acid, 56 per cent, in bbls.....	100 Lbs.	9.30	@	9.55
Acetic Acid, glacial, 99 1/2%.....	100 Lbs.	19.50	@	19.70
Aconite, drums.....			25 1/4	@
Alcohol, denatured, 180 proof.....	Gal.	68	@	69

Alcohol, sugar cane, 188 proof.....	Gal.	4.90	●	4.95
Alcohol, wood, 95 per cent, refined.....	Gal.	9 11/16	●	92
Amyl Acetate.....	Gal.	4.20	●	4.50
Aniline Oil, drums extra.....	Lb.	27	●	28
Benzoic Acid, ex-toluol.....	Lb.	2.00	●	2.25
Benzene, pure.....	Gal.	22	●	22 1/2
Camphor, refined in bulk, bbls.....	Lb.	1.24 1/2	●	1.25
Carbolic Acid, U. S. P., crystals, drums.....	Lb.	25	●	35
Carbon Bisulfide.....	Lb.	19 1/2	●	10
Carbon Tetrachloride, drums, 100 gals.....	Lb.	63	●	76
Chloroform.....	Lb.		1.25	
Citric Acid, domestic, crystals.....	Lb.			
Cresote, beechwood.....	Lb.	2.00	●	2.10
Cresol, U. S. P.....	Lb.	18	●	20
Dextrine, corn (carloads, bags).....	Lb.	8	●	9
Dextrine, imported potato.....	Lb.		nominal	
Ether, U. S. P. 1900.....	Lb.	27	●	30
Formaldehyde, 40 per cent.....	Lb.	21 1/2	●	22
Glycerin, dynamite, drums extra.....	Lb.	17	●	18
Oxalic Acid, in casks.....	Lb.	36	●	38
Pyrogallie Acid, resublimed, bulk.....	Lb.	3.25	●	3.50
Salicylic Acid, U. S. P.....	Lb.	77	●	80
Starch, corn (carloads, bags) pearl.....	100 Lbs.	6.00	●	7.00
Starch, potato, Japanese.....	Lb.	13	●	14
Starch, rice.....	Lb.	12 1/2	●	13
Starch, sago flour.....	Lb.	9 1/4	●	10 1/4
Starch, wheat.....	Lb.		nominal	
Tannic Acid, commercial.....	Lb.	65	●	80
Tartaric Acid, crystals.....	Lb.	85	●	87

OILS, WAXES, ETC.

Beeswax, pure, white.....	Lb.	63	●	65
Black Mineral Oil, 29 gravity.....	Gal.	24	●	25
Castor Oil, No. 3.....	Lb.	25	●	27
Ceresin, yellow.....	Lb.	17	●	15
Corn Oil, crude.....	100 Lbs.	16.75	●	17.7
Cottonseed Oil, crude, f. o. b. mill.....	Lb.	17 1/2	●	—
Cottonseed Oil, p. s. y.....	100 Lbs.		nominal	
Menhaden Oil, crude (southern).....	Gal.	1.10	@	1.15
Neat's-foot Oil, 20°.....	Gal.	2.90	@	3.00
Paraffin, crude, 118 to 120 m. p.....	Lb.	13	@	
Paraffin Oil, high viscosity.....	Gal.	40	@	41
Rosin, "F" Grade, 280 lbs.....	Bbl.	15.10	@	15.20
Rosin Oil, first run.....	Gal.	75	@	76
Shellac, T. N.....	Lb.	67	@	68
Spermaceti, cake.....	Lb.	31	@	33
Sperm Oil, bleached winter, 38°.....	Gal.	2.23	@	2.25
Spindle Oil, No. 200.....	Gal.	38	@	40
Stearic Acid, double-pressed.....	Lb.	24	@	25
Tallow, acidless.....	Gal.	1.62	@	1.65
Tar Oil, distilled.....	Gal.	36	@	38
Turpentine, spirits of.....	Gal.	79	@	80

METALS

Aluminum, No. 1, ingots.....	Lb.	33	@	34
Antimony, ordinary.....	Lb.	7 1/4	@	8
Bismuth, N. Y.....	Lb.	3.50	@	3.65
Copper, electrolytic.....	Lb.	23	@	
Copper, lake.....	Lb.	20	@	23
Lead, N. Y.....	Lb.	5.75	@	6.00
Nickel, electrolytic.....	Lb.	55	@	56
Platinum, refined, soft.....	Oz.		nominal	
Silver.....	Oz.		1.01 1/2	
Tin, Straits.....	Oz.		nominal	
Tungsten (Wol).....	Per Unit	15.00	@	20.00
Zinc, N. Y.....	100 Lbs.	9.40	@	9.60

FERTILIZER MATERIALS

Ammonium Sulfate.....	100 Lbs.	4.90	@	5.00
Blood, dried, f. o. b. New York.....	Unit	7.25	@	7.30
Bone, 3 and 50, ground, raw.....	Ton	37.00	@	37.50
Calcium Cyanamide.....	Unit of Ammonia		nominal	
Calcium Nitrate, Norwegian.....	100 Lbs.		—	
Castor Meal.....	Unit		—	
Fish Scrap, domestic, dried, f. o. b. works.....	Unit	7.75	and	20c
Phosphate, acid, 16 per cent.....	Ton	17.00	@	18.00
Phosphate Rock, f. o. b. mine.....	Ton		nominal	
Florida land pebble, 68 per cent.....	Ton	5.00	@	6.00
Tennessee, 78-80 per cent.....	Ton	7.00	@	8.00
Potassium "muriate," basis 80 per cent.....	Ton	300.00	@	320.00
Pyrites, furnace size, imported.....	Unit		nominal	
Tankage, high-grade, f. o. b. Chicago.....	Unit	7.35	@	7.50

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EDITORIALS

FROM AN "ADOPTED" ONE

On paper bearing a broad margin of black, indicative of the irreparable loss of a father, there came recently the following charming, childlike letter. This little link in the chain of international attachment was received by a member of the AMERICAN CHEMICAL SOCIETY who had quickly answered the appeal of the American Ouvroir Funds by "adopting" the orphaned son of a French engineer.

MON CHER PARRAIN:

Maman m'a dit que j'avais un parrain en Amérique. Je voudrais bien vous connaître mais c'est bien loin, l'Amérique. Quand je serai grand je pourrai peut-être aller vous voir. Je vais à l'école. Je travaille bien. Je tâcherai que vous soyez content de moi. Je vous embrasse de tout mon cœur.

Votre petit filleul

MARCEL PIERRON

23 Janvier, 1919
4 rue Gallicni
Asnières, Sienne

Interest is actively increasing in the work of the organization which is placing in our hands in such a dignified and comprehensive manner information concerning these little ones. From the February number of *The Catalyst* it is learned that the Delaware Section has already raised \$2000 for this purpose and that the Philadelphia Section is likewise engaged in raising a goodly sum.

Let the good work go on!

THE SOLDIER, THE SAILOR, AND THE CHEMIST

An amazing thing about the early months of our participation in the war was the slowness with which high officials of the War and Navy Departments waked to the importance of chemistry in a conflict such as was then raging in Europe. It was not by the strictly war-making departments that the first stimulus to chemistry organization and chemical research was given, but by the Interior Department, through its Bureau of Mines.

In view of the comprehensive and vigorous way in which the service of the chemist was later utilized by both the War and Navy Departments, the question naturally arises: Why were they so tardy in grasping the significance of chemistry in this great undertaking? Doubtless the reasons are many, but we believe one of the most fundamental to be the attenuated character of the chemistry atmosphere at West Point and Annapolis.

This statement contains no reflection whatever upon the able instructors in chemistry at either of the great institutions for the training of our land and sea officers. These institutions cannot be expected to turn out military or naval chemists, even if there were such things; such instruction as is given must be elementary and more or less superficial, because of the limited time available for the subject. This side of the question gives no worry, for civilian assistance from men with the highest chemical training may always be relied upon when the pinch of war comes.

It is, however, extremely desirable that every student at West Point and at Annapolis should receive a clear picture of the chemical industries of this country as a whole, their interrelations, and their function in the transformation of raw material into the supplies which support a modern army and navy. Then, too, they should be given from time to time a general view of the trend of chemical research on lines bearing directly upon military and naval problems. General surveys of this character, to be most effective, should be given by the recognized leaders in the chemical industries and in chemical research.

We would like to suggest, therefore, that the Secretary of War and the Secretary of the Navy request the President of the AMERICAN CHEMICAL SOCIETY to appoint a committee which will give annually, at West Point and at Annapolis, five or six general lectures. The leading chemists of this country would consider it a patriotic privilege to participate in the undertaking, and our future generals and admirals would set out upon their careers with a clearer grasp and a more sympathetic understanding of that science from which war-making can never be divorced.

ARE YOUR NEEDS TAKEN CARE OF?

In this issue, page 257, there is printed a general schedule of classification of government statistics of imports and exports, followed by schedules of special interest to every producer of finished products and to every consumer of imported raw material in the chemical industries. These schedules have been prepared under the supervision of Mr. G. B. Roorbach of the U. S. Shipping Board (not of the Department of Commerce, as erroneously stated in our last issue).

To those who may wonder why so much space is devoted to the publication of this material, we would say that we consider this one of the most important contributions which has ever reached this office. Why?

Government statistics of interest to the chemical industries have always been lamentably weak. The information has been thrown into basket clauses in a way useless to one trying to develop a business intelligently. It has generally been an awful job to upset the normal practices of humdrum departmental matters in Washington. This time, however, someone has seen the light, and action has sprung from within. The various government divisions, hitherto working independently, each under its own system of classification, have realized the efficiency of a uniform system, and that the industries are entitled to far more detailed information than has previously been furnished. The published material represents a joint effort.

Another party to full cooperation is lacking, the individual manufacturer. You are now invited by Mr. Roorbach to join in the project. You know in detail exactly the kind of statistical matter you would like

the Government to publish regularly and promptly for your information. Look over these lists and see whether the items you are interested in are included. If not, write Mr. Roorbach, and *write him promptly*, for the final form of the system must be quickly determined if instructions are to reach all foreign consuls in time for the necessary changes to be made in official procedure, and for the new system to become effective with the beginning of the next fiscal year.

THE WOMAN CHEMIST HAS COME TO STAY

War brought woman into industrial chemistry. The draft of the men of the laboratories into war service made necessary her increased employment. Many were the misgivings, but these have proved groundless. Evidence from all sides warrants the statement that in this comparatively new line she has abundantly made good. Perhaps the most interesting testimony is offered by Mr. William M. Brady, chief chemist of the Illinois Steel Company, in a statement published in the February number of *The Chicago Chemical Bulletin*.

Speaking of the women in his laboratory, Mr. Brady says:

They learned the work as quickly as any men of like training could have learned it. * * * They were and are careful, conscientious, reliable workers in the field of industrial chemistry, taking their turns at night work cheerfully, and so far as I can learn, contentedly.

As to capacity for work, Mr. Brady does not deal in generalities but gives convincing figures:

During the month of July there were employed on iron and steel work, thirty-one men and seven women. Total number of determinations made in July on iron and steel, 68,798—made by women, 10,741, or 15.6 per cent of the total. Per cent of women employed, 18.5—not quite their share; they were learning the work.

During the month of October there were thirty-six men and an average of six and a half women employed on iron and steel work, three women leaving during the month, two to go back to school, one securing a better position. This to explain the one-half woman. Total number of determinations made in October on iron and steel, 66,956; made by women, 10,721, or 16 per cent of the total. Percentage of women employed, 15.3. From this it is readily seen that as soon as the women learned the work, they carried their share of the work. During the hot weather of last summer, when to sleep, for those working at night, was almost impossible, the percentage of women off duty was less than the men.

The percentage of women off duty on account of sickness is not greater than the men. In fact it has not equaled the men in our particular case, several of our men being on extended sick leave.

Requests for days off duty by women are not excessive, and are not more than those of men.

In conclusion he pays the following tribute to his woman chemists:

They have added tone to our laboratory by their pleasing personalities. They have proved beyond a doubt that they can do and will do at any hour of the day or night, careful, conscientious, reliable chemical work. They have passed the crucial test of service. They have been weighed in the chemical balance and not found wanting.

Such testimony means only one thing: The woman chemist has come to stay. This of course increases the present oversupply of chemists, and adds another point to the argument in last month's editorial, "Back to the Colleges and Universities." Read page 255 of this issue.

"AM I MY BROTHER'S KEEPER?"

When an accident of an unusual and unexpected character occurs in a laboratory, particularly a university laboratory, the details are frequently written up for publication in the journals, so that fellow-chemists, working with the same substance or under the same set of conditions, may profit by the unfortunate experience. The same cannot be said of accidents in industrial plants. Here a shroud of secrecy seems to be the rule. It is a phase of that same unfortunate psychology which has proved so detrimental to the industry in many other matters.

This subject was discussed at length and from every angle at the February meeting of the Advisory Committee, and it was the unanimous opinion of the Committee that full publicity regarding details of accidents in the chemical industries is extremely desirable. For this reason a section of *THIS JOURNAL* will be set aside for the prompt publication of such matter whenever it can be legitimately obtained. Communications on this subject are urgently requested.

If the life of one workman is saved through this publicity, the reward will be ample.

NEEDED REFORMS IN THE PATENT OFFICE

Patent matters are to the fore nowadays: not in matters of litigation but in careful study of the system. For some time past a committee of the National Research Council has been thoroughly investigating the matter from every standpoint, with the sympathetic desire to accomplish changes which will bring the office into more perfect accord with present conditions and insure its yielding that full measure of usefulness which its founders hoped. The report of the committee is published on page 250 of this issue to enable general participation in the further discussion of the subject, and it is asked that all suggestions be forwarded direct to the acting chairman of the committee.

As a further contribution to this subject there is printed on page 237 of this issue the forceful address of Mr. Thomas Ewing, former Commissioner of Patents, on "The Needs of the U. S. Patent Office," before the War Emergency Reconstruction Conference at Atlantic City last December. Because of his many years of successful conduct of the office of Patent Commissioner, Mr. Ewing speaks from an intimate knowledge of the situation, and, being no longer connected with the office, with an engaging frankness and earnestness which carry conviction.

Mr. Ewing pleads for the pressure of well-informed public opinion to be brought to bear upon Congress in order to secure the needed reforms. To develop such pressure it will first be necessary to convince the public that the most efficient working of the Patent Office is one which directly benefits each and every citizen. On this subject we stated in 1916 at Seattle, during the course of a presidential address:

The value of the patent system as a national asset lies not only in the constant additions to daily welfare, but also in the eventual public ownership of the new ideas underlying these

contributions, for the life of a patent is only seventeen years, during which time expenditure both of brain and of funds is necessary to bring the idea to its highest practical development; then the idea legally becomes the property of the nation for unrestrained use. * * * * * If these general considerations ever find full lodgment in the public mind, there will be no difficulty in securing such congressional action as will perfect the patent system and legal procedures incident thereto, thus enabling it to serve fully those high ends for which it was designed.

Perhaps the best method for bringing this home to the general public would be the publication of popular articles showing how the general welfare has been served, not only through the fostering of the inventive spirit among certain creative individuals, but also through successful development of products and processes which as originally patented would have been of little value, but under patent protection were successfully developed and became at the end of the seventeen-year period available to the public in perfected state and at largely reduced cost.

That the pressure of public opinion should be brought to bear upon Congress for remedial patent legislation is well illustrated by certain existing legislation under which those with whom we are at war are given definite advantage over our Allies. Under the Act of August 17, 1916, a nine months' extension for filing, paying fees, etc., was granted those unable on account of the war to take action within the period now fixed by law, and operated further to relieve from defaults which occurred after August 1, 1914, and before January 1, 1918, apparently assuming that the war would be well over before the latter date. This act specifically excluded enemies from the benefits of the legislation.

A few months later the Trading with the Enemy Act was passed, under which:

Any such enemy, or ally of enemy, who is unable during war, or *within six months thereafter*, on account of conditions arising out of war, to file any such application, or to pay any official fee, or to take any action required by law within the period prescribed by law, may be granted an extension of nine months beyond the expiration of said period, provided the nation of which the said applicant is a citizen, subject, or corporation shall extend substantially similar privileges to citizens and corporations of the United States.

To correct the injustice in time allowance in the two acts, bills were introduced in both the House and the Senate to grant the nine months' extension where default occurred *within six months after the close of the war*, instead of before January 1, 1918, thus giving to our Allies the same privileges our enemies enjoy. Up to the present time, however, practically a year after the introduction of the bills and with the end of the war in sight, the measure has not become law.

This failure to correct defective legislation affects not only our Allies but also our own citizens who have been unable owing to war conditions to file applications, pay fees, etc., in foreign countries within the period fixed by the laws of those countries, for their right to an extension depends upon the rights we accord to the citizens of foreign countries.

Surely Congress does not desire to give special privileges in these matters to our enemies, but the lack of legislation has brought about just that a result.

NOTES

A new development of the A. C. S. News Service—the Associated Press is beginning to send out over its wires abstracts of the Weekly Bulletins. Mr. John W. Harrington moves quietly but effectively. Find a subject which has a real news punch and try your hand.

In planning for demobilization England failed to include the chemical among the "pivotal" industries. Does this mean that England is slipping backward, that her public men are already forgetting the lesson of the war? It is to be hoped not, in view of the fine service rendered by the English chemists during the war.

Professor J. R. Withrow calls attention on page 253 of this issue to a matter which soon may affect every laboratory. Measures for enforcement of prohibition legislation are now being drafted in many states. Those in charge of such legislation can have no desire to inflict any hardship upon the work of the chemist, but it is up to us to point out the need for alcohol as a chemical reagent and the necessity of distilling apparatus in laboratory operations.

If these matters are properly presented in advance of legislation many vexing situations will be avoided.

One of the pleasures of a strict rule is the privilege of breaking it every now and then. Our practice is against the use of the name of any commercial firm in this editorial section, but we do wish to express to Lord and Taylor, of New York City, appreciation of their policy in placing beside displays of beautifully dyed silks, large placards bearing the words:

DYED WITH AMERICAN DYES

If such coöperation were general among department stores the carefully cultivated propaganda of the last three years would be of no avail.

One of the most interesting developments of the ante-peace period has just been announced, by which some three thousand enemy-owned patents will become in perpetuity available to American chemical interests. As a result of negotiations with the Alien Property Custodian the American Dyes Institute has just accomplished the formation of a company to be known as the Chemical Foundation, Inc. This new organization, in which many American chemical interests are represented, will purchase from the Custodian all enemy-owned patents, trade marks, etc., not hitherto disposed of. The Foundation will, in turn, grant non-exclusive licenses to any American citizen, or corporation in which 75 per cent of the stock is owned by American citizens.

The charter provides that all profits over and above a small fixed return to the holders of stock shall be devoted to the advancement of the interest of chemistry and the allied sciences in the useful arts and manufactures in the United States.

CONTRIBUTIONS FROM THE CHEMICAL WARFARE SERVICE, U. S. A.

PRODUCTION OF GAS DEFENSE EQUIPMENT FOR THE ARMY

ANOTHER CREDITABLE CHAPTER OF AMERICAN MANU- FACTURING ACHIEVEMENT DURING THE WAR

By BRADLEY DEWEY, Colonel, Chemical Warfare Service, U. S. A.

Received January 29, 1919

At the time of America's entrance into the war in April 1917, almost no information had come to this country about gas warfare or the requirements of gas defense equipment. In fact, it had been the policy of the allied nations, as soon as the possibilities of gas warfare were realized, to surround the whole subject with considerable secrecy, as it had been decided that inasmuch as the Germans had initiated the use of deadly gases, it was desirable to undertake immediate plans to retaliate in kind and, if possible, with even greater and more deadly effect.

The only persons who had given the matter any study were Colonel (then Major) L. P. Williamson, Medical Corps, U. S.

Army, who was stationed at the Army War College in Washington, in 1917, and Lieutenant Commander Marks of the Navy. Throughout the European war Colonel Williamson had studied every available document regarding gas warfare. Beyond the knowledge which he possessed, we had little or nothing; such an article as a gas mask had never been produced in this country. During the twenty months of our participation in the war, there grew up an organization which completed over five and one-quarter million gas masks, together with vast quantities of other defense material for the use of our armies. This accomplishment, the result of unstinted effort on the part of a loyal personnel and the most excellent coöperation of the varied manufacturing interests of the country, deserves place in the annals of America's accomplishments in the world war.

It will be well at this point to give a picture of a complete gas mask together with its more important requirements.

The gas mask, so-called, is a device to protect the eyes and



FIG. 1—TYPES OF GAS MASKS USED BY AMERICAN, ALLIED AND GERMAN ARMIES

Sitting left to right—1. German gas mask. 2. Russian gas mask. 3. Italian gas mask. 4. British mask for motor truck drivers. 5. British aeroplane respirator. 6. Experimental mask with metal facepiece. Designed by Major Connel, of Medical Corps, American Army.

Middle Row—7. First emergency method put into practice after initial gas attack in April 1915. Colonel Goodwin, of Medical Dept., British Army, devised this mask. 8. British "P. H." helmet—emergency type first used in summer of 1915. 9. British "box respirator," standard type used by British Army. 10. French M-2 mask, original French type used until spring of 1918. 11. Original French artillery mask designed by Tissot. 12. French "A. R. S." mask, last type used by French Army.

Top Row—13. Original American Navy mask. 14. American Navy mask, final type. 15. American "box respirator," a type used by U. S. Army throughout the war, the improved design developed at Gas Defense Plant to simplify manufacture. 16. American A. T. mask, all rubber mask in limited production at end of war. 17. American K. T. mask, sewed fabric mask in limited production at end of war. 18. American "Model 1919" mask, improved type ready for production when armistice was signed. This mask embodied the good features of 17 and 18 and was extremely simple to manufacture.

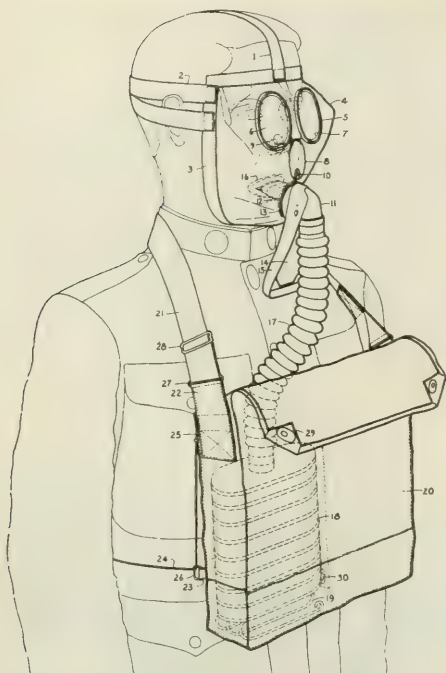


FIG. 2—DIAGRAMMATIC CROSS SECTION OF THE GAS MASK

- | | | |
|----------------|-----------------------|----------------------------|
| 1—Cotton tape | 11—Die casting | 21—Shoulder strap |
| 2—Elastic tape | 12—Die casting nut | 22—Large Loop chape |
| 3—Binder | 13—Die casting washer | 23—Small Loop chape |
| 4—Facepiece | 14—Flutter valve | 24—Body cord |
| 5—Eye cup | 15—Flutter guard | 25—Eyelet |
| 6—Lens | 16—Mouthpiece | 26—Small loop |
| 7—Lens washer | 17—Hose | 27—Large loop |
| 8—Nose spring | 18—Canister | 28—Center bar slide |
| 9—Nose pad | 19—Spring | 29—"Lift the Dot" fastener |
| 10—Nose rivet | 20—Knapsack | 30—Grommet |

lungs from harmful chemicals used in warfare. The first chemical used by the Germans was chlorine, followed by phosgene, a much more poisonous gas; then came xylyl bromide and similar lachrymators (tear producers); later diphosgene (trichloromethyl chloroformate) and chlorpicrin, both lethal and lachrymatory; later still diphenylchlorarsine, which in the form of a particulate cloud caused extreme irritation of the throat and lungs; and finally, mustard gas, which seriously affected the eyes, skin, and lungs. These represent the principal types of materials used, but gas warfare was not confined to the use of these alone; many substances of widely different chemical properties were used before the end of the war. It is evident, then, that the mask, or, as it is more correctly known, the respirator, must remove all traces of gas or smoke from the air before the air reaches the eyes, nose, or mouth. The respirator, which was manufactured in large quantity and which was furnished to our Army, copied in principle but not in details the "Small Box Respirator" used by the British. Its principal features were:

1—A canister of metal containing both neutralizing and absorptive chemicals and a smoke filter. The air to be breathed passes in through an inlet check valve and through chemicals and smoke filter.

2—A flexible rubber hose through which the purified air passes from the canister to the facepiece.

3—A facepiece effectively covering the eyes, cheeks, lower forehead, nose, mouth, and chin, provided with eyepieces permitting vision and a harness to hold the facepiece in place when wearing the mask.

4—An exhalation valve which affords easy discharge of exhaled air and at the same time instantly closes upon inspiration.

5—A knapsack slung from the neck or shoulder, in which the mask and canister are carried.

In the box respirator type manufactured, the inhaled air passing through the canister and hose went directly into the mouth through a rubber mouthpiece, which in this manner offered protection to the lungs in the event of the failure of the fit of the facepiece or of damage to the facepiece. At the same time the mask was provided with a spring and rubber device which closed off the air passage through the nose and compelled breathing entirely through the mouth.

It is also worth while to enumerate a few of the principal requirements to be fulfilled by a respirator.

1—It must successfully remove all gas fumes or smokes from the air to which a soldier is exposed, and must do this for the maximum of time for which the soldier is liable to be on duty.

2—It must be reasonably comfortable to the wearer.

3—The fit of the facepiece around the face must be a perfect gas-tight joint.

4—The material of the facepiece must be substantially impermeable to all noxious gases.

5—The eyepieces must be strong and provide for good vision.

6—The complete equipment must have durability, for all personal equipment of a soldier in the field receives extremely hard usage.

7—The resistance to flow of air through the various parts must be kept at a low figure in order that the fighting efficiency of the individual may not be too much reduced.

8—It must be of minimum weight and bulk.

The points mentioned indicate but few of the severe requirements which had to be met during the course of production. All of them were not apparent in the early days, but became of importance and had to be met as the war progressed.

At the end of May 1917, when the need for furnishing General Pershing's first division of regulars with masks arose, Colonel Williamson attacked the problem with whole-hearted enthusiasm.

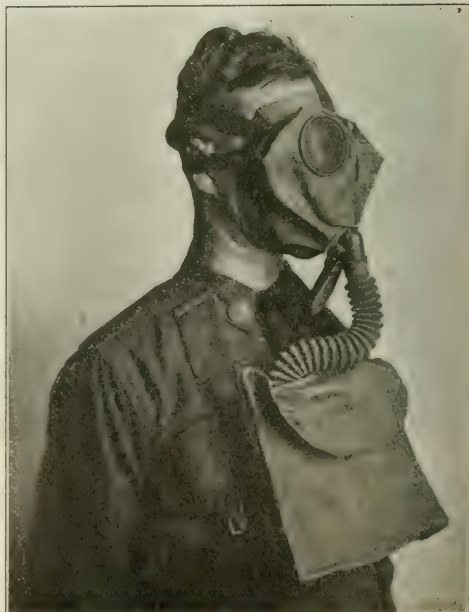


FIG. 3—AMERICAN GAS MASK OF "BOX RESPIRATOR" TYPE USED BY THE U. S. ARMY THROUGHOUT THE WAR

Early in 1917, Mr. Van H. Manning, of the Bureau of Mines, with a wonderfully coöperative spirit and great foresight, had called the attention of the War Department to the Bureau's facilities for conducting gas investigation. Consequently Colonel Williamson hurried to Mr. G. A. Burrell, who was in charge of war gas investigations for the Bureau of Mines, and impressed him with the seriousness of the problem. Mr. Burrell called upon the writer to undertake the task of furnishing 25,000 masks within three weeks time.

It was hardly realized that the lack of existing technical data and experience would make the accomplishment of such a production impossible in so short a time. Arrangements were immediately made with the B. F. Goodrich Company, of Akron, Ohio, who had been working with Lieutenant Commander Marks of the Navy, for the making of the mask and the various rubber parts involved. At the same time, arrangements were made for complete assembly and the production of the canister at the American Can Company. In addition to this, special charcoal and soda-lime granules for the absorption of the gases had to be prepared.¹

At the end of two months, twenty thousand of these masks had been produced and shipped. These first masks, measured by comparison with our later product and the product in England which was the result of over a year's experience close to the front, were far from satisfactory. In addition, the experience gained in the struggle to obtain this production emphasized the magnitude of the problem. Consequently, when, on the last of July, the Army itself took up the manufacture of gas masks, it was with a more complete realization of the seriousness of the task.

EARLY ORGANIZATION AND PRODUCTION

In July 1917, when the order for the first twenty-five thousand had been completed and the Surgeon General confirmed the arrangements which had been made for the production of 1,100,000 masks during the next year, there was authorized to take care of this production program, a personnel of one Major, two Captains and ten Lieutenants.

The period during July and August was taken up in securing the allotted personnel and in determining some fundamental points of design. This was accompanied by production arrangements for parts of 320,000 masks, metal part arrangements for the entire 1,100,000 masks, and assembly arrangements for the same quantity. The spirit of coöperation and desire to serve the Government was early evident, as was shown by the attitude of the B. F. Goodrich Company in giving technical and cost information to the Goodyear Tire and Rubber Company and the United States Rubber Company, in order that they might intelligently bid on a project in which no one but the B. F. Goodrich Company had any experience. This was a distinct departure from practice in competitive industry.

By the end of August it was clearly realized that the personnel provided was not adequate to meet the many tasks which were arising. Though an increased personnel was authorized, the way was not made entirely easy for those producing gas masks, as no end of army red tape and obstacles had to be overcome in actually securing the personnel. While arrangements had been made with the Hero Manufacturing Company, of Philadelphia, in July for the assembly of the required schedule of masks, and operations were actually started in August, it was December before the personnel of an organization even partially adequate to carry on the various problems of supply and design could be secured.

The period of September to December may be characterized as a struggle to secure adequate personnel of trained men, to overcome old-time obstacles existing in army purchase procedure, to determine important points of design, to correct

faults pointed out by the overseas organization, then growing in spite of difficulties, and to work out with the various contractors, suitable methods of manufacture.

Early in October, Major H. W. Dudley, Royal Engineers, came to the States from England, assigned as an adviser by the British Government. Major Dudley brought with him a wealth of invaluable experience on the technical side of manufacturing masks. Coupled with intimate contact with the development of the British manufacture, Major Dudley had had sufficient contact with field conditions to bring to us a well-balanced judgment on various questions. He told of the importance of wrinkles in the band, through which gases leaked; of the importance of doping thread holes with gelatine to keep

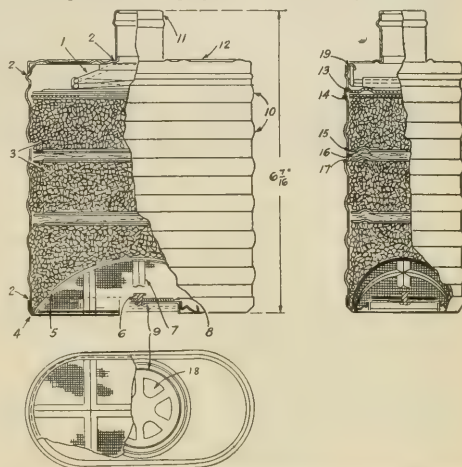


FIG. 4.—CROSS SECTION OF THE GAS MASK CANISTER SHOWING DETAILS OF FILLING

- 1—Heavy spring to prevent filling from rattling
- 2—Solder joints
- 3—Chemical fillings
- 4—Bottom of canister
- 5—Copper screen
- 6—Check valve stud
- 7—Spider to support screen
- 8—Rubber check valve
- 9—Removable plug
- 10—Bulging ribs
- 11—Nozzle for expansion hose
- 12—Can top
- 13—Heavy screen to hold filling in place
- 14—Cloth to catch fine particles
- 15—Light wire screen
- 16—Cotton baffle
- 17—Air intake holes
- 19—Lips to hold spring

the gas from being carried through by the thread; of the importance of having mouth bushings inside of the mouthpiece so that the soldiers in the excitement and surprise of a gas attack would not bite the mouthpiece and cut off their own breath. He told of the crawling up of gas along the inside seam of the canister and the necessity for doping it as a prevention. He told of the necessity of testing the canister chemicals for hardness and of eliminating all dust. He informed us of the necessity of testing all die castings to make sure that they did not leak, and the testing of fabrics for permeability to the various gases.

A few months showed us that these were not minor points but that every one was vital and that they were but samples of the innumerable points which came up day by day.

After making a study of the facilities which were available, Major Dudley made some definite recommendations which had an important bearing on our whole program.

- 1—Correction of granule¹ process to bring in line with British practice.
- 2—The institution of gas-chamber testing of masks and canisters.

¹ The granules were one of the constituents of the filling of the canister

¹ The manufacture of these chemicals is to be considered in a subsequent article.

3—Emphasis of necessity for minimum bulk and weight of respirator.

4—Strongly advising a better centralization of facilities devoted to gas-mask production.

It was also during this time that the manufacturers' rubber committee was organized, composed of the following:

Dr. W. C. Geer, B. F. Goodrich Company, *Chairman*
 Dr. Theodore Whittelsey, United States Rubber Company
 Mr. C. R. Johnson, Goodyear Tire & Rubber Company
 Mr. William Stephens, Goodyear Tire & Rubber Company (vice Mr. Johnson who entered the Gas Defense Service, January 1918)

This committee rendered valuable service in carrying on experimental work in connection with the development of the various rubber parts, mask fabric, and masks, and in giving advice in the writing of specifications. This committee later became officially a committee of the rubber industry and was known as the Gas Defense Division of the War Service Committee of the Rubber Industry of the U. S. A. It continued to give service of the same kind up to the signing of the armistice.

Up to the first of January there had been manufactured at the Hero Manufacturing Company 117,000 respirators, but they were not considered to be of sufficiently good quality to be sent overseas and were used in our training camps. However, the organization had developed to such an extent in January that a drive was made to produce 75,000 masks suitable for shipment overseas. The production was speeded up, transportation of parts was carefully traced throughout the country, and, when the country's transportation broke down, even long-distance hauling by motor trucks was employed in order to insure that the assembly plants were provided with material. During this month, 54,000 masks were produced satisfactory for overseas shipment and from this period on, production steadily increased until in April there was a production of 363,000 from this plant.

FINAL ORGANIZATION

The continued expansion of the army program during the early months of 1918 resulted in a consequent increase in program and personnel for the Gas Defense Service, until at the signing of the armistice there were in the organization 274 officers, 2353 enlisted men, and 13,000 civilians. There existed at various points in the country over 80 organized detachments of the Gas Defense Division. An estimate of the number of employees engaged in contractors' plants providing materials for the Gas Defense Division was 25,700. In July the various activities which had sprung up as a result of the use of gas by the Germans had been consolidated into one service known as the Chemical Warfare Service under Major General William L. Sibert, and our organization had become the Gas Defense Division of the Chemical Warfare Service. In order to secure better contact with various producing facilities, headquarters were located at 44th Street, New York City. The organization finally developed was as follows:

STAFF

Col. Bradley Dewey, Officer in Charge
 Lt. Col. A. L. Besse, Assistant Officer in Charge
 Lt. Col. Chas. Almy, Jr., Assistant to Officer in Charge
 Maj. F. A. Dewey, Special Assistant
 Maj. P. V. Hollenbeck, Quartermaster
 Capt. A. B. Comstock, Legal Adviser

GAS DEFENSE PLANT

Mr. R. R. Richardson, Manager
 Lt. Col. P. L. Cooney, Assistant

HERO MANUFACTURING COMPANY, ASSEMBLY PLANT

Capt. H. P. Scott, Jr., In charge
 Capt. R. M. Graham, Inspection
 Capt. P. M. Wiswall, Assembly
 Lt. W. C. Northrop, Accounting

PROCUREMENT SECTION

Mr. Robert Skemp, In charge
 Major T. H. Barth, Assistant

Maj. A. C. Dickinson
 Maj. P. R. Llewellyn
 Maj. Wilwyn Herbert
 Capt. J. S. Wolf
 Capt. K. B. Blake
 Capt. Leonard Macomber
 Capt. W. DeV. Kay
 Capt. R. V. Puß
 Capt. E. C. Herman
 Capt. E. P. Pierce
 1st Lt. R. B. Kempton

TECHNICAL SECTION

Maj. C. R. Johnson, In charge
 Maj. Waldemar Kops, Assistant

FIELD TESTING SECTION

Capt. K. Atterbury, In charge
 Capt. Paul B. Moulton, Assistant

CHEMICAL MANUFACTURING

Maj. J. C. Woodruff, In charge
 Maj. I. W. Wilson, Assistant

COMPTROLLING

Maj. H. P. Schuit, In charge
 Capt. Prior Sinclair, Assistant
 1st Lt. P. B. Prentice, Cost Accounting

OFFICE ADMINISTRATION

Maj. M. L. Emerson, In charge
 Capt. R. E. Taylor, Adjutant

Some of the larger detachments were:

ASTORIA CHEMICAL PLANT, manufacturing carbon and granules under Maj. I. W. Wilson. There was also located at Astoria a chemical development laboratory under Maj. T. L. Wheeler.

AKRON DETACHMENT, rubber parts (including all rubber companies west of the Alleghenies), Capt. L. B. Dana, Officer in Charge, Capt. W. H. Coburn and 1st Lt. H. D. Fitzgerald, assistants.

NEW BRITAIN DETACHMENT, metal parts.

Capt. M. G. Vincent, Officer in Charge

PROVIDENCE DETACHMENT, fabrics and metal parts.

1st Lt. A. W. Keller, Officer in Charge

SAN FRANCISCO DETACHMENT, carbon.

Capt. W. E. Brophy, Officer in Charge

CLEVELAND DETACHMENT, carbon.

1st Lt. E. J. Noble, Officer in Charge

HORSE MASK FACTORY

Capt. W. S. McKinney, Officer in Charge

GAS DEFENSE PLANT

Early experience showed the necessity for extreme care in the manufacture and inspection of all gas defense articles, and by November 1917 it was evident that the ordinary commercial organization was not adapted to carry on the manufacture of this new and important article on the scale necessitated by the new army program. Consequently, after consultation with many representative leaders such as Associate Justice Brandeis, Everett Moss, Harry L. Dennison, Harry Kendall, Howard H. Cooley, and Sidney Hillman, it was deemed advisable to establish a strictly government-owned and controlled organization to handle the additional output of gas masks.

The appropriation made by Congress for the purchase of gas masks could be construed to cover the manufacture of the masks in a government factory. Consequently, on November 20, 1917, the Secretary of War authorized the establishment of a government-operated plant under the direction of the Officer in Charge, Field Supply Section, Gas Defense Service of the Medical Corps, which became the Gas Defense Division of the Chemical Warfare Service when the latter was organized.

On December 5, 1917, Mr. R. R. Richardson, of Chicago, was appointed general manager of the new Gas Defense Plant, at a salary of one dollar a year. Mr. Richardson was at that time head of the Chicago Carton Company. Following this appointment and a conference in Washington on the general requirements of the situation, Mr. Richardson enlisted the

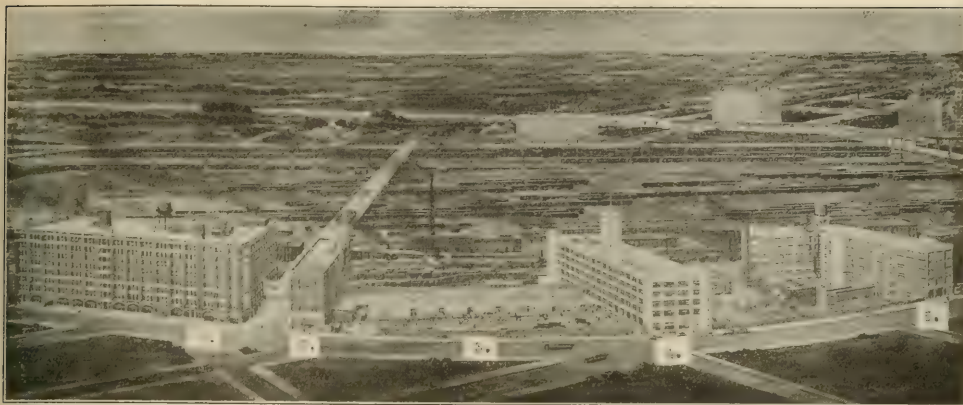


FIG. 5—GENERAL VIEW OF GAS DEFENSE PLANT

1—Ford Building 2—Goodyear Building 3—Warehouse 4—Stewart Building 5—National Casket Building

services of Mr. P. L. Coonley (now Lieutenant Colonel), of Chicago, vice president of the Link Belt Company.

With the chief executive heads appointed, steps were taken to secure proper executive personnel to carry on the work of the plant. Experienced officials were drawn from New York, Boston, Chicago, and other manufacturing centers. These men were either known personally to the chief executive and his assistant or else highly recommended to them by well-known business men.

In the latter part of November 1917 a lease was secured on the Stewart Building, Jackson and Second Avenues, Long Island City, to house the operations of the plant. The building was new and well lighted and had excellent transportation facilities. This building, 5 stories in height and with a total floor space of 175,000 sq. ft., represented the central manufacturing unit of the Gas Defense throughout its entire history. The actual operation at the plant may be said to have commenced during the week of December 24, 1917, when the first sewing machines were installed. On January 1, 1918, ten sewing machine operators who had had experience in the garment trade in New York City were employed to start operations. With these as a nucleus, a school for training of operators was started and carried on until the latter part of March, when a sufficient number of operators were available to act as instructors in the plant.

The organization of the Gas Defense Plant consisted of eleven main divisions as follows: Operating, Inspection, Personnel, Planning, Advisory, Controlling, General Office, Protection, Supply, Check Inspection and Salvage, Control Inspection.

At the signing of the armistice the following occupied the managements of the various divisions:

OPERATING DIVISION
Mr. E. L. Flory, of Chicago, Ill., In charge
Mr. E. J. Mulholland and Major L. E. Cover, Assistants

INSPECTION DIVISION
Maj. R. T. Smith, of Pittsburgh, Pa., In charge
Mr. H. S. Doty and Capt. T. H. Henecage, Assistants

PERSONNEL DIVISION
Mr. Jesse Briegel, of Chicago, Ill., In charge
Mr. E. J. Kilduff and Mr. P. O. Badger, Assistants

PLANNING DIVISION
Mr. F. C. Wales, of Boston, Mass., In charge
2nd Lt. C. H. Adamson and Master Engineer R. C. Erb, Assistants

ADVISORY DIVISION
Mr. G. D. McKibbin, of Chicago, Ill., In charge
2nd Lt. G. White, Assistant

CONTROLLING DIVISION
Mr. W. B. Harris, of East Orange, N. J., In charge
Mr. H. J. Goodyear and Mr. C. W. Patten, Assistants

GENERAL OFFICE DIVISION
Mr. G. J. Quinn, of Boston, Mass., In charge
Mr. E. J. Ruegg, Assistant

PROTECTION DIVISION
Capt. C. I. Mansur, of Chicago, Ill., In charge
Sgt. C. H. Wirt, Assistant

SUPPLY DIVISION
Maj. T. J. Dee, of Chicago, In charge
Mr. E. V. Burke and Captain A. F. Best, Assistants

CHECK INSPECTION AND SALVAGE DIVISION
Mr. C. Crossman, of Wolcott, N. Y., In charge
2nd Lt. L. W. Moses, Assistant

CONTROL INSPECTION DIVISION
Maj. S. D. Warner, of Douglaston, L. I., In charge
2nd Lt. H. E. Fisher, Assistant

This organization was unique in that it included both civilians and soldiers under the same authority.

Because of the desire of so many workers to participate in an active way in the winning of the war, the labor problem at the Gas Defense Plant was comparatively simple. Gradually, the general personnel of the plant assumed proportions in which approximately 60 per cent of the employees were female and 40 per cent male. Many female employees were experienced sewing machine operators. Inspection work was carried on by women of high grade, and preference was given to those having husbands or sons at the front.

As the demands for gas masks increased, it became necessary for the Gas Defense Plant to expand. About January 31 an adjoining building, with a total floor area of 78,000 sq. ft., occupied by the Goodyear Tire & Rubber Company, was taken over. On June 20 a warehouse was completed between the two buildings, affording an additional floor space of 30,500 sq. ft. On June 24, the Gas Defense Plant took over the National Casket Company building, located due south of the Stewart Building. This had a floor area of approximately 140,000 sq. ft. Finally on August 15 occupation of the Ford Motor Company's building, adjoining the Goodyear Building, was begun. This added a floor space of approximately 500,000 sq. ft.



FIG. 6—SHOWING FIRST FLOOR OF STEWART BUILDING, JANUARY 15, 1918



FIG. 7—SHOWING FIRST FLOOR OF STEWART BUILDING, FEBRUARY 15, 1918

Thus it can be seen that starting with a floor space of 157,000 sq. ft. the Gas Defense Plant expanded in 7 months to occupy a floor space of 1,000,000 sq. ft., or 23 acres.

Simultaneous growth was taking place in the personnel of the plant. On January 1, ten sewing machine operators were hired. On June 1 the employees numbered 4,686. On November 6 the high-water mark was reached with a total personnel of 12,350.

During the conduct of manufacturing operations at the Gas Defense Plant, two distinct types of masks were manufactured, the box respirator type already described, and a mask developed in this country during the last six months of the war known as the "K. T.," which was without mouthpiece or noseclip.

On March 4 the first actual shipment of box respirator masks was made from the Gas Defense Plant. From this date the production increased by leaps and bounds. Some idea of the production figures attained can be obtained from the fact that between March 4, when the first shipment of masks was made, and November 26, when the last mask was manufactured, a total of 3,146,413 masks of the box respirator type passed through the final inspection of this plant. The greatest daily production of 43,926 completed masks was reached on October 26.

In August 1918, manufacture of the K. T. mask was started. This mask had been developed during the preceding months

by the Technical Section of the Gas Defense Division. This mask, described later, differed radically in design from the box respirator and though considerable difficulty was encountered in its manufacture, on September 14 the first satisfactory K. T. masks were completed, and up to November 11, when the armistice was signed, a total production of 189,603 had been accomplished.

The final manufacturing records of the Gas Defense Plant showed that the total production of finished gas masks was 3,614,925.

DESCRIPTION OF MASK MANUFACTURE

A visitor making a tour of the Gas Defense Plant would have been impressed particularly with the extreme care exercised in each operation and the strict attention paid to the minutest detail of inspection and assembly. In passing through the plant one of the striking features was the extensive use of conveying equipment to move masks and assembled parts from one point to another with a minimum cost. Notwithstanding the fact that the layout of the plant was changed three times with a large increment of floor space, yet throughout it all one could see carefully planned flow of material with a minimum amount of congestion of traffic or of retracing.

Another impressive feature was the arrangement of benches and work tables in such a way that the operators were as close to each other as existing factory codes and individual efficiency



FIG. 8—PORTION OF ONE INCOMING INSPECTION ROOM



FIG. 9—PORTION OF FINAL INSPECTION ROOM



FIG. 10—PORTION OF ASSEMBLY DEPARTMENT

would permit. This in itself was a big point in cutting down the unnecessary moving of material.

A brief description of the manufacture of the mask will be given.

INCOMING INSPECTION—All facepiece materials and parts were received in the National Building. The cases were opened and all the parts, with the exception of fabrics and tapes, were distributed into fiber unit boxes of convenient size for use on the belt conveyors installed throughout the plant. These unit boxes solved the difficulty of keeping together the required number of all parts needed in the assembly operations.

The unit boxes were sent by elevator to the top floor of the building and distributed for incoming inspection. A thorough 100 per cent inspection was made of each part before sending it to the Assembly Department. The inspectors were carefully chosen and were sent to a school for training before they were assigned to this important work. Every feature found to be essential to the manufacture of a perfect gas mask was carefully checked.

The incoming inspection of the flexible rubber hose leading from the canister to the facepiece can be taken as an illustration. Each piece of hose was given a visual inspection for buckles or blisters in the ends or in the corrugations; for cuts, air pockets, or other defects on the interior; for loose seams where fabric covering was cemented to the rubber tube; for weaving defects in the fabric itself; and for careless application of the cement. Special tests were conducted for flexibility, as a stiff hose would produce a strain on the soldier's mouth; for permanent set to insure that the hose was properly cured; for the adhesion of the fabric covering to the hose; and for kinking when the hose was doubled on the fingers. Finally each piece was subjected to a test for leaks under water with a pressure of 5 lbs. per sq. in.

Each eyepiece and the three-way metal connection to the facepiece were subjected to a vacuum test for leakage. The delicate exhalation valve was carefully examined for defects which would be liable to cause leakage. Fabric for the facepiece was given a high-tension electrical test on a special machine developed at the plant to overcome the difficulty met in the inspection of this most important material. It was of course necessary that the facepiece fabric be free from defects but just what constituted a defect was the source of much discussion. The electrical test eliminated all personal views and gave an impartial test of the fabric. The machine consisted of two steel rolls between which a potential difference of 4,000 volts was maintained; the fabric was led through the rolls and

wherever there was a pinhole or flaw the current arced through and burned a clearly visible hole.

PRELIMINARY FACEPIECE OPERATIONS—All preliminary facepiece operations were performed in the National Building. Blanks were died out from the facepiece fabric in hydraulic presses. Each face blank was swabbed to remove bloom and the eye washers were cemented about the eyeholes. The pockets for holding the noseclips were also cemented to the blanks. The bands which formed a gas-tight seal of the mask about the face were died out from rubberized fabric to which a felt backing was attached. The harness consisting of elastic and cotton tapes was also sewed together at this point.

DESCRIPTION OF CONVEYORS—The preliminary operations having been completed, forty sets of each of the parts needed to make a complete facepiece were placed in the unit boxes and sent on trucks to the top floor of the Stewart Building. The third, fourth, and fifth floors of this building, devoted to the making of facepieces, had a double line of roller conveyors running the entire length of each floor. These conveyors started at the rear end of the fifth floor, running the entire length of the building, turning at the front end and running back the entire length. They then passed through the floor on a spiral and continued the entire length of the fourth and third floors in a similar manner.

This conveyor system was laid out to facilitate the flow of materials through operations and also to prevent the material going from one operation to another without being inspected.

After each process the material was inspected before it proceeded to the next operation. The operators and inspectors worked on opposite sides of the conveyor, with the two rows of inspectors between the two rows of conveyors. The unit boxes were fed to the operators on the upper conveyor, the parts being removed as the operator needed work and the finished work placed on the table between the upper and lower conveyors. The inspectors would then inspect the material, replace the accepted parts in the unit boxes, and send them to the next operation on the lower conveyor. On succeeding operations the upper and lower roller conveyors were alternated so that the material was kept separate and the flow of material between the operations was smooth and even.

FACEPIECE OPERATIONS—The sewing machine operations were next performed. First the died out blanks were pleated to form the facepiece. The operator had to register the various notches

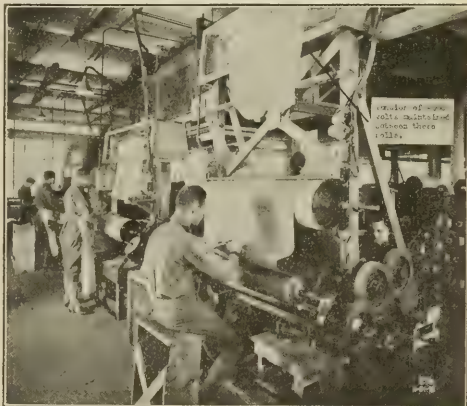


FIG. 11—HIGH TENSION ELECTRICAL TESTING MACHINES FOR FACE FABRICS TO DETERMINE PINHOLES OR FLAWS

in the blank to an accuracy of $\frac{1}{32}$ in. and to locate the stitches in some cases as closely as $\frac{1}{64}$ in. The band was next sewed to the periphery of the facepiece after which the harness was attached. The stitches on the outside of the facepiece were covered with liquid dope, which filled the needle holes and made the seams gas-tight.

In addition to the inspection of each operation, the completed facepiece was submitted to a control inspection to discover any defects that might escape the attention of the inspectors on the various operations.

ASSEMBLY OPERATIONS—The facepieces were now ready for assembly and were sent down the conveyor to the third floor for insertion of the eyepieces, which was done in specially designed automatic presses. The eyepieces had to be carefully inserted so that the facepiece fabric extended evenly around the entire circumference.

After inspection, the facepiece with the eyepieces inserted were sent in the unit boxes from the third to the second floor where the assembly was completed.

Before manufacture began on a large scale, the most satisfactory method of conducting each assembly operation was worked out and the details standardized, so that operators could be quickly and efficiently trained. No detail was considered too small if it improved the quality of the mask. The assembly operations proceeded as follows:

The exhalation valve was first joined to the three-way metal tube which formed the connection between the facepiece, flexible hose, and mouthpiece. Each valve was then tested for leakage under a pressure difference of a one-inch head of water. No valve was accepted which showed leakage in excess of 10 cc. per min. under these conditions.

The metal guard to protect the exhalation valve was next assembled, followed by the flexible hose. The three-way tube was then assembled to the facepiece by means of a threaded connection and the rubber mouthpiece attached. To illustrate the attention to details the following operation may be cited:

The contact surfaces between each rubber and metal part were coated with rubber cement before the parts were assembled. The connection was then tightly wired, care being taken that

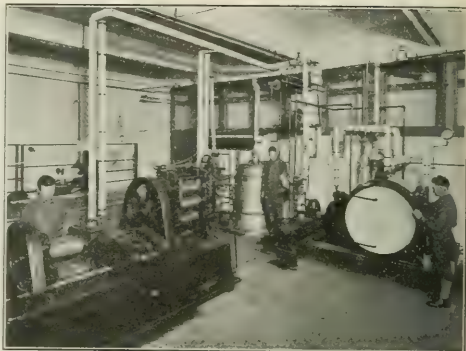


FIG. 13—LONG ISLAND LABORATORY. EXPERIMENTAL RUBBER LABORATORY FOR MANUFACTURE OF RUBBER PARTS ON SMALL SCALE

none of the turns of wire should cross and finally the wire was covered with adhesive tape so that no sharp edges would be exposed.

The masks, completely assembled except for the canisters, were inspected and hung on racks on specially designed trucks which prevented injury in transit, and were delivered to the Finishing Department.

CANISTER FILLING—Meanwhile the canisters were being filled in the Ford Building.

The canisters, canister parts, and chemicals were received on the first floor. All chemicals were tested before they left the manufacturing plant at Astoria and each drum was checked to see that it had been approved.

Canisters and all other parts were sent to the receiving stores department on the sixth floor where they were inspected and the accepted material placed in storage.

The chemicals were first screened in such a way that the fine and coarse materials were separated from the correctly sized materials. They were then carried on a belt conveyor to the storage bins on the seventh floor, whence they were fed by gravity through pipes to various mixing machines on the fourth and fifth floors. A special mixing machine was developed to mix the carbon and granules in the proper proportions for use in the canister. The mixed chemicals were then led to the canister-filling machines. There was a separate mixing machine for each filling machine, of which there were eighteen in all.

The can-filling department was laid out in six units, three located on the fifth floor and three on the fourth. Each unit had a capacity of 20,000 cans per day. A system of double belt conveyors was also installed here to conduct empty canisters to the machines and carry away the filled ones.

Each filling operation was carefully inspected and special stops were placed on the belt conveyors so that a canister could not go to the next operation without having been inspected. Operators and inspectors were stationed on opposite sides of the belt. The chemicals were placed in the canister in three equal layers which were separated by pads of cotton wadding. The first layer was introduced from the filling machine (which delivered automatically the proper volume of chemicals), the canister was shaken to pack the chemicals tightly, the cotton baffle inserted, the second layer of chemicals introduced and so forth. On top of the top layer of chemicals were placed a wire screen and a specially designed spring which held the contents of the canister securely in place. The metal top was then fitted and securely soldered.

Each canister was tested under water for possible leaks in joints or soldering, with an air pressure of 5 lbs. per sq. in. A

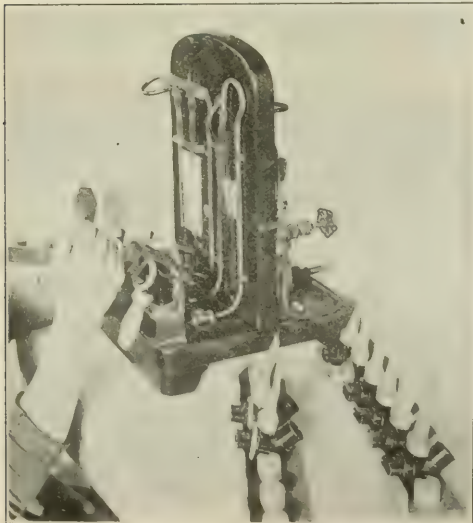


FIG. 12 TESTING EXHALE VALVES FOR LEAKAGE

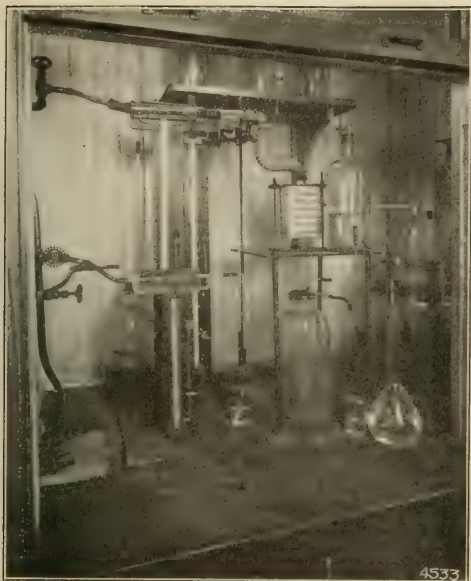


FIG. 14—LONG ISLAND LABORATORY CHEMICAL DEPARTMENT. APPARATUS FOR TESTING LIFE OF CANISTER AGAINST MUSTARD GAS

test was also made for the resistance which it offered to breathing, a rate of flow of air through the canister of 85 liters per min. being maintained and the resistance being measured in inches of water.

The filled canisters were then painted a distinctive color to indicate the type of filling and conducted by conveyor to the second floor of the Stewart Building for assembly to masks.

FINISHING DEPARTMENT—In the finishing department, the filled canisters, as received by conveyor from the Ford Building, were conducted down the middle of the finishing tables and assembled to masks.

The finished masks were then inspected, placed in unit boxes, ten to a box, and returned by belt conveyor to the second floor of the Goodyear Building for the final inspection.

FINAL INSPECTION—Final inspection of the completely assembled masks was as rigid as could be devised, and was closely supervised by army representatives. Only the most painstaking and careful women were selected for this work and the masks were examined in every detail to discover any defect that might have escaped previous inspection. Finally, each mask was inspected over a bright light in a dark booth for small pinholes which the ordinary visual inspection might not have detected.

As a check on the quality on the final inspectors' work a reinspection of 5 per cent of the passed masks was conducted. Where it was found that a particular inspector was making numerous mistakes, her eyes were examined to see whether it was due to faulty eyesight or careless work. Masks containing known defects were purposely sent to these inspectors to determine whether they were capable of continuing the inspection work. In this way the desired standard was maintained.

A daily report of the final inspection was sent back to each of the assembly departments involved so that defects might be eliminated immediately and the percentage of rejects kept as low as possible.

After the final inspection the masks were numbered, packed in knapsacks, and the filled knapsacks placed in packing cases, twenty-four to a case. The cases were conveyed to the Packing Department in the Ford Building, where the covers were nailed on, the cases stenciled and immediately shipped or sent to storage.

EMPLOYEES

No account, no matter how brief, would be complete without some statement describing the spirit of enthusiasm and loyalty shown by the employees of the Gas Defense Plant. Without the organizing talent of Mr. Ralph R. Richardson and the zeal and enthusiasm manifested by the workers, the tremendous production of gas masks in such a short space of time could not have been accomplished.

Furthermore, though the plant was started with quality as its only watchword, and employed in many places one inspector for every three operators, nevertheless the total mask cost, after charging in all equipment expenses, was 50 cents lower than that for masks produced on contracts.

CHEMICAL MANUFACTURE

Extensive facilities were established for the manufacture of the carbon and granules used as gas-absorbing materials in the canister of the gas mask. A full description of the manufacture of these materials will be given in a later issue of *THIS JOURNAL*.

HORSE MASKS

It was also necessary to provide protection for horses against poisonous gases. Fortunately a horse is so constituted that he can stand much greater concentration of tear-producing gases than a man and does not require protection of the eyes. Furthermore, a horse breathes only through his nostrils and it is not necessary to cover his mouth with the gas mask.



FIG. 15—LONG ISLAND LABORATORY CHEMICAL DEPARTMENT. INTERMITTENT FLOW CANISTER TESTING APPARATUS TO TEST AGAINST PHOSGENE AND CHLORPICRIN

The American mask for horses, which was modeled after the English, but much improved, consisted of a cloth nose bag of special material saturated with chemicals to absorb and destroy the various gases employed.

The mask was provided with a harness for attachment to the horse's harness and, when not in use, was enclosed in a small canvas knapsack.

The chemicals employed consisted of a mixture of hexamethylenetetramine, nickel sulfate, sodium carbonate, and glycerin. The hexamethylenetetramine gave protection against phosgene. The nickel hydroxide formed in the reaction was to give protection against the possible use by the Germans of prussic acid.

The process of impregnation was as follows:

A solution of hexamethylenetetramine, glycerin, and nickel sulfate was mixed with a solution of sodium carbonate

This plant produced 378,000 horse masks at the rate of 5,000 per day.

MISCELLANEOUS GAS DEFENSE EQUIPMENT

In addition to man and horse masks, there were many other types of gas defense equipment supplied in large quantities by the Gas Defense Division. These include:

1—Dugout blankets which were used at the entrance of dugouts to make them gas-proof. These were specially woven all-cotton blankets which were treated in the field with a mixture of 85 per cent heavy steam cylinder oil of paraffin base and 15 per cent boiled linseed oil.

2—Protective suits and gloves used for the protection of the body against mustard gas burns. The suits were made of a special oiled fabric and the gloves of cloth impregnated with a pyroxylin compound.

3—Protective ointments applied to the skin for protection against mustard burns. A mixture of zinc oxide, lard, lanolin, and linseed oil was found most satisfactory. The ointment was put up for shipment in small metal containers.

4—Gas warning signals, for gas attack alarms, of which a modified klaxon horn is the best example.

5—Trench fans, which consisted of a canvas flapper on a wooden handle, used for removing gas from trenches and dugouts after gas attacks.

6—Oxygen inhalators, a mechanical apparatus for administering oxygen to gassed persons.

For the development of these devices and for the solution of many other gas defense problems, great credit is due to Dr. W. K. Lewis and an able corps of assistants of the Gas Defense Section of the Research Division, Chemical Warfare Service, which was located at the American University, Washington, D. C.

TECHNICAL LABORATORIES

Laboratories were a necessity as a part of the gas defense production organization. They were located at various points throughout the country to carry on control work, to perform tests required from time to time, and to carry many development problems from the research stage into production.

PHILADELPHIA CONTROL LABORATORY—In October 1917 a chemical laboratory was established at Philadelphia, Pa., to exercise chemical control over the product of the Hero Manufacturing Company, then getting under way as the first plant to produce gas masks under government supervision. This laboratory was constructed in record time, being started on October 10 and finished to the point where operations could begin on November 11. It occupied at first a floor space of 7500 sq. ft.; in January 1918 the size was doubled. Maj. R. P. Rose (then Captain) was assigned as officer in charge, with Capt. E. J. Hull (then 1st Lieutenant) as his assistant. The total personnel numbered 85.

A laboratory for the testing of gas masks and other gas defense apparatus naturally differed radically from an ordinary chemical laboratory. Besides the usual chemical equipment, it was provided with apparatus for testing both finished masks and gas-absorbing materials, such as carbon and granules, for life against the various warfare gases. These tests were of two kinds, machine tests and actual man breathing tests in a gas chamber.

The first gas chamber was completed in this laboratory on November 11, 1917. The chamber measured 24 ft. long, 7 ft. wide, and 9 ft. high, and was divided into three compartments, the gas chamber proper and a small ante-chamber at each end for making it possible to enter without the escape of gas. The sides of the chamber were made of wood with glass windows

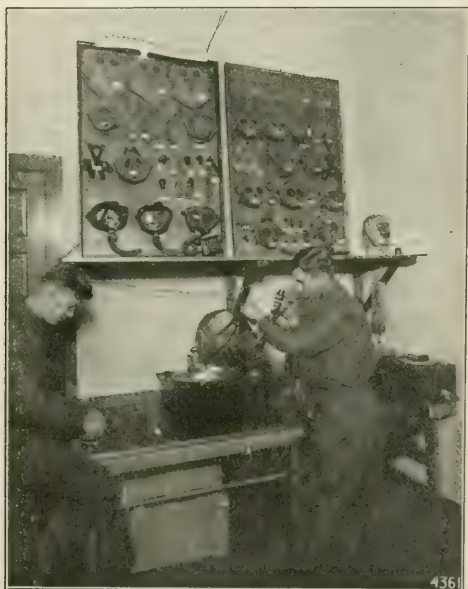


FIG. 16—LONG ISLAND LABORATORY. MACHINE DESIGN UNIT SHOWING DEVICE FOR TESTING COMPLETED MASKS FOR LEAKAGE

and water in a heavy steam-jacketed mixing kettle with heavy geared stirrers. The mixture was conducted by pipes to the impregnating apparatus which consisted of a rotary laundry washing machine. The masks were treated in this machine for a period of 15 min. and then placed in a power-operated wringer and the solution driven off to a definite weight. Following this operation they were suspended on wire supports and conducted through a hot-air drying machine and dried to a definite weight.

For chemical control of the factory production, one-quarter of 1 per cent of all masks produced were tested in a phosgene gas apparatus and had to stand a 15 min. test against a mixture of 2000 parts of phosgene to one million parts of air at a rate of flow of 30 liters per min.

In February 1918 a plant for the manufacture of horse masks was established at the Fifth Avenue Uniform Company, New York City, under the direction of the Gas Defense Division.



FIG. 17—PHILADELPHIA CONTROL LABORATORY. SIDE VIEW OF GAS CHAMBER SHOWING SUBJECTS MAKING OUTSIDE BREATHING TESTS OF CANISTER

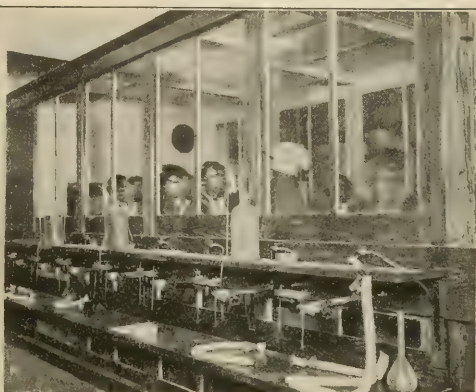


FIG. 18—PHILADELPHIA CONTROL LABORATORY. VIEW OF GAS CHAMBER SHOWING SUBJECTS TESTING MASKS INSIDE

although later the use of double walls with a ventilated air space of 18 in. between was found more satisfactory. The walls and flooring were carefully sealed so as to be gas-tight. A powerful ventilating system was provided whereby the chamber could be emptied in a quarter of a minute and the entire room in which the chamber was situated in one minute. This gas chamber was in continuous operation in the center of the city for a year, using concentrations of phosgene as high as 1 per cent, without any complaints ever being received.

To obtain absolute results as to the protection afforded by a gas mask, actual man breathing tests in a gas chamber had to be employed. This testing throughout the war was done by enlisted men of the Gas Defense Division. Many hours were spent each day by men testing masks and canisters in gas. Too much credit cannot be given to these men for the splendid spirit with which they performed this arduous and dangerous task.

Besides the gas chamber, there were laboratories for making machine gas tests on absorbents, for research and general routine, one for rubber and fabric testing, and a well-equipped machine shop.

This laboratory performed daily routine tests as a control on gas mask production as well as special investigations of chemical problems bearing on gas defense. Routine tests were made for (1) activity of carbon and granules when tested against phosgene, chlorpicrin, hydrocyanic acid, and arsine, (2) permeability of face fabrics by chlorpicrin and mustard gas, (3) man tests and machine tests of completed canisters against various gases, (4) complete dissection with necessary chemical and physical tests of samples of completed masks representing the daily product of the assembly plant.

LONG ISLAND CONTROL LABORATORY—A control laboratory was organized in March 1918 which was to perform the same functions for the Gas Defense Plant that the Philadelphia Laboratory did for the Hero Manufacturing Company. It occupied one floor of the Goodyear Building, comprising 15,000 sq. ft., with Capt. S. H. Lawton in charge and later Capt. J. S. Little. It contained two gas chambers, a rubber laboratory with facilities for permeability tests on gas mask fabric, a canister testing laboratory, and several others devoted to special chemical investigation.

MECHANICAL DEVELOPMENT LABORATORY—This laboratory was organized in March 1918 at Long Island City for the purpose

of developing mechanical features of gas defense apparatus and for testing devices and ideas from all sources.

Maj. L. E. Cover (then Captain) was in charge. This laboratory, occupying approximately one floor of the Goodyear Building, included a complete machine and metal working shop, a complete rubber experimental shop with facilities for mixing, calendering, vulcanizing, and a drafting and blue-print equipment. It carried on progressive development of canisters to meet changing requirements, development of various rubber parts, especially the important exhalation valve, and of new types of mask carriers to permit greater freedom of movement of the soldier.

LONG ISLAND LABORATORY—In July 1918 a consolidation and reorganization of various laboratories took place, with a view to getting better coordination of effort. The Control and Mechanical Development Laboratories, together with a Mask Development Department which had been organized in the Gas Defense Plant, were combined into one laboratory to be known as the Long Island Laboratory. This laboratory occupied three floors of the Goodyear Building and was organized with Maj. C. R. Johnson in charge, and Maj. Waldemar Kops, assistant. It included 43 officers, 265 enlisted men, and 103 civilians, divided into the following departments:

Mask Development Department, responsible for development of the assembled mask with all parts, including the knapsack but excluding the canister; Maj. Waldemar Kops in charge, and Mr. G. S. Meikle, assistant.

Canister Development Department, responsible for development and design of the canister; Mr. B. C. Batcheller in charge, and Capt. R. M. Holmes, assistant.

Miscellaneous Apparatus Department, responsible for all other gas defense apparatus; Mr. W. H. Hampton in charge.

Chemical Department, which carried on the original functions of a control laboratory, with additional development investigations and special chemical service to the other departments of the laboratory, such as testing in the gas chamber of mask designs and canister designs. One-half to 1 per cent of masks and canisters from the Defense Plant were given man-house and machine tests each day. Maj. R. P. Rose was in charge, with Captains R. D. Evans, R. T. Will, and J. J. R. Bristow, assistants.

Mechanical Service Department, combined with the machine shop, drafting room, and outside facilities, provided complete mechanical service for the various departments; Capt. L. E. Fulford in charge, and 1st Lt. D. R. Long, assistant.

Specification Branch, associated with the laboratory and responsible to the Technical Director, wrote all specifications



FIG. 19—TESTING SECTION. STAGING OF MINIATURE SMOKE ATTACK

for the Gas Defense Division and was in close contact with all development work and manufacturing; Maj. O. E. Stevens in charge, and Capt. W. M. Rile, assistant.

Under this new organization much better coördination was secured, and the development work was carried on with more efficiency.

Its function was to take ideas from all sources, including the Research Division of the Chemical Warfare Service, and carry these ideas from the form in which they existed at early inception to the manufacturing stage. It was provided with workshops completely equipped to carry on various mask-making and assembly operations on a small scale.

This organization carried to conclusion the development of the A. T. and K. T. type masks, two new types, of which nearly 350,000 had been completed for expeditionary shipment at the signing of the armistice. Had the war continued, these masks would have put the American Expeditionary Forces in a premier position with respect to gas defense. They eliminated poor vision, uncomfortable noseclip pressure, uncomfortable mouth-piece, and general discomfort in long wear. The old mask gave very unsatisfactory vision, due to the fact that the eyepieces dimmed because of moisture from the face, and had to be wiped frequently, at considerable disadvantage to the soldier, in order to secure proper vision. These new masks made use of the principle originally used by the French, carrying incoming air from the canister over the eyepieces before it was inhaled by the soldier.

The use of mustard gas by the Germans required long wearing of gas masks as the substance itself stayed in the ground very persistently after shell bombardment. It was therefore quite necessary that the soldiers be provided with a mask representing the maximum possible comfort combined with safety. This was embodied in these new types. They made it possible for soldiers to carry on offensive operations in gas masks.

The A. T. type mask was made of stockinette and rubber and was suitable for production in the various rubber plants throughout the country. The K. T. type was made of rubberized fabric and was suitable for sewing operations in the Gas Defense Plant. The two types were identical from the standpoint of the user and both were manufactured in order to secure the maximum possible production.

The final development of the Long Island Laboratory led to a combination of the best features of each mask in a model which could be died out of a sheet of stockinette and rubber, and with the sewing of one seam six inches long made a complete

facepiece. This mask had tremendous manufacturing possibilities and preparations were actually under way to put it in large-scale production at the signing of the armistice.

During this same time, the Canister Development Department was keeping pace with the requirements of the Gas Defense Division, and at the signing of the armistice, complete specifications were available and a small production started for a canister which gave added assurance of protection against smokes together with lower resistance to breathing, which was extremely desirable for fighting efficiency.

As evidence of the variety of work carried on and the multitude of ideas coming from this laboratory, a museum was organized for the careful filing and labeling of all samples and devices produced. When hostilities ceased, the number of specimens in the museum numbered 1300.

AKRON RUBBER TESTING LABORATORY—Many of the component parts of the gas mask were made of rubber and in order to exercise proper control over all such articles a thoroughly equipped testing laboratory was established at Akron in the midst of the rubber companies, under Lt. R. M. Gage. Daily tests for physical and chemical properties were made on samples of the output of each manufacturer. By this means the quality of all rubber stocks and materials used was kept under control.

FIELD TESTING SECTION

Along with development activities of the Gas Defense Division, there grew up an interesting division known as the Field Testing Section. It was organized to provide field testing conditions for the regular product and for the development organization. It was originally composed of 1 officer and 18 enlisted men and its activities expanded until it had a force of 11 officers and 185 men. Capt. K. Atterbury was officer in charge, with Capt. P. B. Moulton, assistant.

The later additional duties of this section included a preliminary course of training for officers for overseas duty in chemical



FIG. 20—AMERICAN HORSE MASK

warfare service, military training of Gas Defense Division officers located in New York City and vicinity, and training of boat crews carrying offensive gas supplies. This organization spent a great amount of time doing all kinds of vigorous physical work and exercise under simulated field conditions while wearing gas masks. They rendered most valuable service in pointing out weaknesses of design as developments took place, and especially those uncomfortable features of the masks which were only apparent through long wear. During the course of its activities it built a complete trench system in the Pennsylvania Railroad yards, with an elaborate dugout which matched any of the famous German quarters on the western front. It carried on a large-scale field test at the Lakehurst Proving Grounds on the A. T. and K. T. masks in which a gas attack under large scale and high concentration conditions was realized.

CONCLUSION

As to the production record of the Gas Defense Division, it is interesting to note without further comment the following extract from the War Department:

A mistaken impression that delayed production compelled American soldiers to depend on British and French masks has been current in this country. This theory is entirely unfounded.

* It may be stated authoritatively that prior to the July counteroffensive against Germany, an American gas mask had been shipped across the Atlantic for every American soldier in France. There is in addition an ample military reserve.

* The American attacking forces are protected against gas by masks which actual field tests prove give twenty times the protection afforded by German gas masks.

The work of this division may be summed up in the statement that the American soldiers were provided with equipment which neutralized the best efforts of German chemical knowledge as evidenced by the offensive methods and materials employed. This was accomplished by an organization located three thousand miles from the point of use and source of practical field information. This organization grew from the acorn stage to the great oak in mushroom time. Its growth was due to the patriotic enthusiasm of its personnel: officers, enlisted men, civilian workers, and clerical force.

GAS DEFENSE DIVISION
CHEMICAL WARFARE SERVICE, U. S. A.
19 WEST 44TH ST., NEW YORK CITY

TESTING NATURAL GAS FOR GASOLINE CONTENT¹

By G. C. OBERFELL, S. D. SHINKLE and S. B. MESERVE

Received January 4, 1919

In a previous article² one of the writers had occasion to describe a method for testing natural gas for gasoline content. The method described in that article was intended especially for testing casing-head gas which is generally rich in gasoline content. That method consisted in extracting the gasoline vapors from the gas with oil as the absorbing medium and recovering the gasoline by distillation. The method described in this article employs the use of a solid absorbing medium such as charcoal and is applicable to both lean and rich natural gas.

DESCRIPTION OF ABSORBER

The series tube absorber shown in Fig. 1 is preferably made of aluminum and consists of 4 tubes, B B, fastened rigidly to the supporting plates, C C. The tubes are each 22 cm. long and have an internal diameter of 2 cm. Each tube has a removable per-

forated disc, D D, 3 cm. from the bottom, which is held in place by a hollow cylinder fastened to the disc and resting against a plate, E, at the bottom of the tubes.

The absorption tubes are connected in series by means of tubes attached to the bottom plate E, and top plate, F. The plates are held in place by means of thumbscrews, G G. The absorber is made airtight by means of rubber gaskets, H H, fitting closely on the plates at each end.

METHOD OF OPERATION

(1) FILLING THE TUBES—Charcoal or other material of high absorption value should be used. The plate F is removed and each tube is filled with the absorbent to within about 3 cm. from the top. The height of the absorbent in each tube is then about 15 cm.

After the tubes are filled the plate F is replaced in such a manner as to connect all 4 tubes in series, providing this arrangement is desired. By proper arrangement of the plate, 2 of the tubes will be in series ready for test while the other 2 will be by-passed. By the latter arrangement duplicate tests may be made with one filling.

(2) ARRANGEMENT OF APPARATUS—The following arrangement of the apparatus has been used in tests conducted in the laboratory: Gas \rightarrow flow meter \rightarrow calcium chloride \rightarrow dry meter \rightarrow manometer \rightarrow absorption tubes \rightarrow manometer \rightarrow suction (when needed).

The flow meter was used to control the rate of gas flow. An orifice flow meter has been used and found satisfactory for rough determination of gravity of the metered gas, the determination being made as follows: The flow meter is checked against the dry meter, the time being recorded for delivery of a certain volume of air, V, with a constant differential height, H, on the manometer of the flow meter. To determine the specific gravity of the gas the flow meter differential is maintained at the height H and volume V of gas passed through it. The time for the gas flow is recorded. The specific gravity of the gas is calculated as follows:

$$\text{Specific gravity of gas} = \frac{(\text{Time for gas flow})^2}{(\text{Time for air flow})^2}$$

The calcium chloride was used to prevent possible deterioration of the absorbent due to moisture. Also, during distillation moisture is liable to condense in the receiving vessel with the other vapors absorbed by the charcoal and thereby cause difficulty in gravity determinations. The open manometers were placed before and after the absorption tubes in order to get the pressure drop through the absorber. The dry meter was arranged with a manometer so that the pressure of the metered gas could be obtained. The temperature of the gas was taken by means of a thermometer placed at the inlet to the dry meter. Suction was used in cases where the gas pressure was insufficient to give the required volume of gas.

(3) METHOD OF DISTILLATION AND GRAVITY DETERMINATIONS—The distillation apparatus and the method

¹ Published by permission of the Director of the Chemical Warfare Service.

² THIS JOURNAL, 10 (1918), 211.

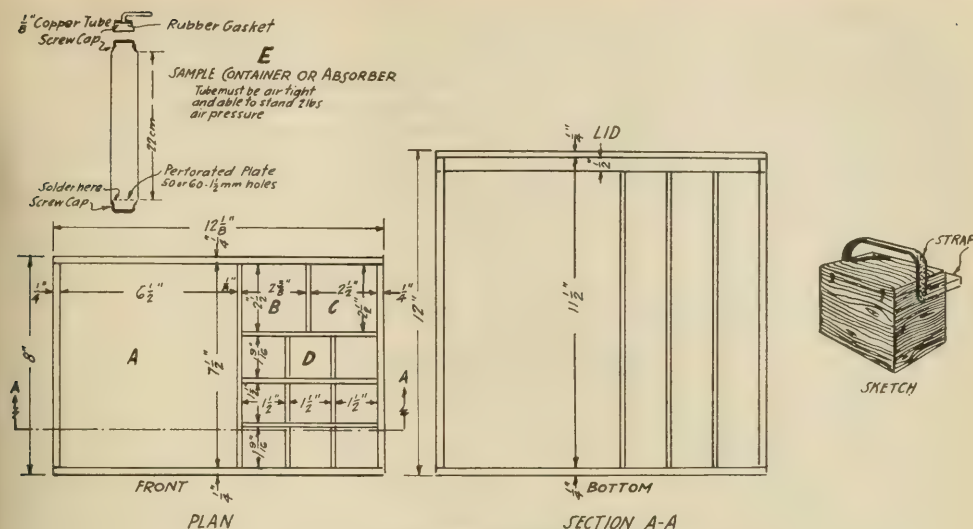


FIG. 2—EQUIPMENT CASE FOR FIELD TESTS

Compartment A holds dry test meter
 Compartment B holds tube water absorber
 Compartment C holds dry orifice meter
 Compartments D (9) hold receptacles for samples

Shellac all parts
 Equip lid with hinges and hooks
 See sketch for arrangement of strap handle

volume of gasoline as would be obtained in a test.

Extensive tests have not been carried out to determine how many times a charcoal can be regenerated and thereby continue to be of value for absorption

RECORD CARD OF TESTS

Yield pts./1000 cu. ft. (60° F. and 30 in. Hg.) = $\frac{\text{Distillate cc.} \times 1000}{\text{Cu. ft. gas used} \times \text{factor} \times 473}$

- 1 Locality: Homer, Ohio
- 2 Date of test: November 15, 1918
- 3 Source of gas: inlet to gasoline plant
- 4 Test began: 10.07 A.M.
- 5 Test finished: 10.52 A.M.
- 6 Test duration, min.: 45
- 7 Barometer, in. of Hg.: 29.13
- 8 Pressure of meter, in. of Hg.: 1.13
- 9 Total gas pressure, in. of Hg.: 30.26
- 10 Temperature of gas, deg. F.: 64
- 11 Conversion factor, 60° F. and 30 in. Hg.: 1.000
- 12 Meter reading, finish, cu. ft.: 925.70
- 13 Meter reading, start, cu. ft.: 925.70
- 14 Meter reading difference, cu. ft.: 10
- 15 Gas rate, cu. ft. per hr.: 13
- 16 Gas used, cu. ft., 60° F. and 30 in. Hg.: 10.00
- 17 Absorbent, kind: charcoal
- 18 Absorbent, preliminary treatment: none
- 19 Absorbent, laboratory number: A-658
- 20 Absorbent, accelerated CCl₄ time, min.: 20.8
- 21 Absorbent, weight before test, grams: 19.0, 19.0, 19.0, 19.0
- 22 Absorbent, weight after test, grams: 24.5, 23.7, 21.6, 21.72
- 23 Distillation method: 600 cc. of oil added
- 24 Distillate, cc., 60° F.: 9.76
- 25 Distillate, sp. gr., 60° F./60° F.: 0.6292 equals 92.5° Bé.
- 26 Distillate, color: water white
- 27 Distillate, odor: ethereal
- 28 Distillate, per cent H₂SO₄ absorption: less than 1 per cent
- 29 Distillate, yields pts./1000 cu. ft. gas (uncorrected): 2.06
- 30 Distillate, yields pts./1000 cu. ft. gas (60° F. and 30 in. Hg.): 206
- 31 Distillate, yields gals./million cu. ft. gas (uncorrected): 258
- 32 Distillate, yields gals./million cu. ft. (60° F. and 30 in. Hg.): 258

REMARKS:

TEST BY.....
 CHECK BY.....

tests of this nature. This would of course depend upon several factors, chief of which is the quality of the charcoal. However, charcoal which had been regenerated three times gave satisfactory results. The method of regeneration used is as follows:

The glycerin is decanted off the charcoal. The

charcoal is then placed on a Buchner funnel and washed with about 500 cc. of water. The water is added to the decanted glycerin and filtered. The filtrate is evaporated until all the water has been removed. The glycerin so recovered is ready to be used over again.

The charcoal is left on the Buchner funnel and a stream of tap water is run through it for 2 hrs. At the end of this period the charcoal is placed in an oven and dried for several hours at 140° C. (usually over night).

(4) DATA RECORDED—The preceding form has been used for recording data of tests.

RESULTS

Tests were made of natural gas for gasoline content. In Table I are presented the results of tests with the series tube absorber using charcoal as the absorbing medium and results of comparative tests with the portable oil absorber.¹ These results show that the two methods compare favorably, the yield by the portable oil absorber being about 6 per cent low. Comparison is also made with plant production for the days during which the tests were made.

TABLE I—COMPARISON OF OIL ABSORPTION METHOD AND CHARCOAL ABSORPTION METHOD IN TESTS OF NATURAL GAS FOR GASOLINE CONTENT

	OIL ABSORPTION METHOD		
	CHARCOAL ABSORPTION METHOD	Portable Absorber	Plant Yield
Number of tests averaged.....	4	2	2 days' product
Source of gas.....	Inlet to gasoline plant		
Gasoline recovered, Bé. 60° F./60° F.....	90.2	90.4	88.6
Gasoline yield, Pts./M. cu. ft. gas.....	1.76	1.65	1.55
Gasoline yield, per cent.....	100.0	93.8	88.1

¹ "Extraction of Gasoline from Natural Gas by Absorption Methods," by G. A. Burrell, F. M. Biddison and G. G. Oberfell, Bureau of Mines Bulletin, 180 (1917).

² Calculated from charcoal absorption method as giving 100 per cent yield.

EQUIPMENT CASE FOR FIELD TESTS

The equipment as shown in Fig. 2 is intended for testing gas wells for flow of gas and for making the absorption tests of the gas for gasoline. The receptacle E may serve either as a sample container or as an absorber. After absorption of gasoline vapors from a measured volume of natural gas in the field the charcoal containing the absorbed vapors is sent to the laboratory for distillation to determine the gasoline content of the gas as described above.

SUMMARY

The principle of this method for testing natural gas for gasoline content consists in absorbing the vapors in a solid absorbing medium such as charcoal, and

subsequently recovering the gasoline by distillation. The method possesses several distinct advantages:

1—The apparatus is simple to construct, easy to operate, and is readily portable.

2—The method gives information both as to yield and gravity of gasoline and offers possibility of construction of an apparatus for determination of the vapor tension of the gasoline.

This work was started under the direction of the Bureau of Mines and was continued under the Research Division of the Chemical Warfare Service.

GAS MASK RESEARCH SECTION
RESEARCH DIVISION
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ORIGINAL PAPERS

METHODS OF VARNISH ANALYSIS

By W. T. PHARCE

Received June 15, 1918

INTRODUCTION

At the present time the status of varnish analysis is not good. It is generally agreed that the following of any of the published methods will give results that vary in the hands of different analysts and that do not represent either the quantities or qualities of the materials used. The consensus of opinion among varnish chemists is that a complete chemical analysis would reveal little as to the relative merits of competitive grades of varnishes. This opinion needs to be fully investigated. The literature on varnish materials clearly indicates the need of more work on the physical and chemical properties of resins and the need of research on the analysis of oil mixtures.

Varnish analysis to date seems to consist chiefly of the following determinations: thinners (turpentine, benzene, etc.), resins, rosin, oil, and drier. Tests for factory control include specific gravity, viscosity, hardness of film, drying test, and panel test.

In outlining the work to be carried out in this laboratory, we thought it wise to make up a few varnishes, differing widely in composition in order to investigate the accuracy of existing methods. Along with this we have studied the problem of identifying and estimating the different oils used.

PREPARATION OF THE VARNISHES

About 20 per cent more of the resin was taken than we wished to use. When it seemed to have cooked enough we weighed the kettle and contents to get the weight of the resin left. This loss in weight was between 20 and 30 per cent, except in the cases where only rosin was used, and then it was nearly 7 per cent. The hot boiled oil (or oils) was then added and the kettle and contents weighed to get the weight of oil added. This mixture was cooked in the usual way. A kettle of the same dimensions containing a volume of oil equal to that in the varnish was heated the same length of time at the same temperature to give the loss in weight of the oil in the varnish. In this way we were able to calculate to within one per cent of the oil and resin in the material. The loss in weight of the oils was between 1 and 2 per cent.

MATERIALS USED

The linseed oil was kept at 200° C. for 2 hrs. with oxide of lead added. The constituents of the varnishes used for the analyses reported in this paper are: No. 2—Sierra Leone copal, rosin (colophony), linseed oil, turpentine, and drier; No. 3—rosin, Chinawood oil, drier, and turpentine; No. 5—East India copal (white), rosin, menhaden, Chinawood and linseed oils, drier, benzene, and turpentine; No. 6—East India copal (white), soy bean, Chinawood and linseed oils, drier, turpentine, and benzene; K—Sierra Leone copal and

No.	RESINS		ROSIN		OIL		THINNERS		BENZINE	
	Estimated	Found	Estimated	Found	Estimated	Found	Estimated	Found	Estimated	Found
2	15.8	13.82 (D) 20.04 (T) 15.65 (B)	4.54	4.12 4.59	36.9	40.98 (D) 34.81 (S) 33.56 (B)	40	39.01		
3			8.01	8.19 7.97	34.3	32.10 36.04 (D)	57.7	56.93		
5	17.1	17.47 17.23 (B) 17.69 25.18 (D)	1.23	1.44 1.30	48.3	39.45 (D) 47.64 (B) 47.97	34.5	33.0	13.8	13.93
6	13.0	13.22 13.43			46.4	46.68 (B) 46.13 31.3 (D)				
Q			15	14.03 14.08	85	84.12 (B) 84.46				
R			20	20.15 21.04	80	77.66 (B)				
M	20	20.60 20.53 (B)			80	79.40 (B) 79.47				
K	40.35	38.67 (B)			59.7	61.33 (B)				
L	19	21.52 (B)			81	78.48 (B)				

linseed oil; L—kauri and linseed oil; M—rosin and Chinawood oil.

METHODS OF ANALYSIS

For the thinner and ash we used the usual methods. For rosin we used McIlhiney's method substituting Wolff's esterification method in the place of Twitchell's and making a few other minor changes. For the separation and estimation of resins and oils we used Boughton's,¹ Darner's,² and Twitchell's, and Scott's methods.

RESULTS

In the table below we have used the following abbreviations: B = Boughton's method; D = Darner's method; T = Twitchell's method; S = Scott's method.

CONCLUSIONS

The results of the analyses show that Boughton's method, although it is long and tedious, is satisfactory for resins and oils. We believe it gives the actual values to within one per cent. The estimation of rosin is accurate to probably three-tenths of one per cent.

We have spent a good deal of time endeavoring to find a shorter method. As the extracting in Boughton's method is made with ether from an aqueous solution containing alcohol, we tried to find a solvent that would not require alcohol to break the emulsion. A large number of solvents were tried but none gave good results. This problem will be included in our next year's work.

ACKNOWLEDGMENT

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THE REDUCTION OF TUNGSTIC OXIDE³

By C. W. DAVIS

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Powdered metallic tungsten is being produced at the present time by several industrial concerns for use in the manufacture of alloys. The available literature on the reduction of tungstic oxide to the metal, although extensive, fails to give definite information concerning the conditions involved. The following work was undertaken to supplement existing data.

GENERAL

Mennicke⁴ shows that tungstic acid, as it comes from the filter press after its precipitation with acid, contains considerable water. When air dried, there is still over 7 per cent total water in the material. This must be removed before reduction, for the steam that would be liberated during the heating would cause the material to fly in all directions, thus tending to separate the tungstic oxide from the reducing material (when carbon in some form is used) due to the great difference in their specific gravities. Even when dried in a

current of air at 100° C., 3.7 per cent total water remains. To get a sufficiently dry product, the material must be dried in a current of air at about 500° C. This may be done in either reverberatory or revolving furnaces. For all reduction experiments, the tungstic oxide was thoroughly dried at 500° C., the color changing from a pure yellow to a greenish yellow.

For a satisfactory reduction, the dried tungstic oxide must be in a state of fine division, and if reduced with some form of carbon, should be completely mixed with it. The most satisfactory treatment consists of grinding together the tungstic oxide and the carbon in a tube mill. Steel or wooden balls should be used, as Mennicke¹ states, for porcelain or flint introduces more impurities. The purpose to which the finished product is to be put, however, determines the permissible impurities. When the tungsten powder is to be added to molten steel for the manufacture of tungsten steel, traces of iron or manganese are not injurious, and silica goes into the slag.

It is well, as Mennicke and others¹ suggest, to use some form of binding material when preparing this mix for reduction. Since the specific gravities of tungstic oxide and carbon are so different, their segregation during the processes of reduction is quite apt to occur. Colophonium, being itself a good reducing agent, easily obtained in a pure condition, and easily pulverized, is to be recommended. The quantity of this material used by different operators varies from 10 to 30 per cent of the carbon requirement of the reduction.

PRELIMINARY EXPERIMENTS

The material used in the experiments described in this article was an impalpable, canary-yellow powder. As received, the tungstic acid gave off 8.3 per cent of water at a temperature of 500° C. Analysis of the tungstic oxide, dried at 500° C., showed a tungstic oxide content of 99.4 per cent; insoluble in potassium hydroxide, 0.55 per cent (largely silica).

The reduction processes used are conveniently treated in two sections, that of using some form of solid carbon being the more common, while the reduction performed by some reducing gas gives a purer product. In both cases, the reduced material must be cooled in a reducing atmosphere as the powdered tungsten readily oxidizes when heated. The oxidation, once started, is pyrophoric in action, and is incandescent after the removal of the source of heat.

The temperature necessary for the reduction of tungstic oxide to the metal, using some form of carbon, is given variously, ranging all the way from red heat up to the temperature obtained with the electric furnace. The following preliminary tests on small samples show what takes place:

Tungstic oxide was mixed with carbon (sugar charcoal). The samples were placed in porcelain crucibles, the covers being luted on with fire clay.

The results in Table I indicate that at a temperature of 650° to 850° C. the reduction produces a blue or purple oxide; at a temperature of 900° to 1050° C. the reduction produces a chocolate-brown material, a

Loc. cit.

¹ Bureau of Standards, *Technologic Paper* 65.

² N. D. Agr. Expt. Sta., *Plant Bulletin*, 1, No. 6.

³ Published by permission of the Director of the U. S. Bureau of Mines.

⁴ "Die Metallurgie des Wolframs," 1911, p. 183.

mixture of oxides; at a temperature above 1050° C. a gray product is obtained which, as will be shown later, is undoubtedly metallic tungsten. Mennicke¹ says that the reduction of tungstic oxide to the blue and brown oxides takes place at 1000° to 1100° C., while the metal is produced at 1100° to 1200° C. Continued heating causes reoxidation with the formation of a green substance. Since this action occurs on the surface and is complete only after the carbon is all gone, its formation was doubtless due to air leaking into the crucibles.

TABLE I

SAM- PLE No.	Weight Sample Grams	Weight Carbon Grams	Temp. De- grees C.	Time Min.	Residue after Heating	Carbon Left
1	1	0.1	700	180	Bulk purple, top green	None
2	1	0.1	1000	10	Top blue, rest chocolate-brown	Some
3	1	0.1	1000	20	Same as No. 2, but more blue	None
4	1	0.1	1000	40	Same as No. 2, but top green	None
5	1	0.1	1000	90	Same as No. 2, but more green	None
6	1	0.2	1100	15	Gray powder, top green	Some
7	1	0.2	1100	45	Gray powder, more green	Some
8	1	0.2	1100	120	All green	None
9	5	1.0	650	30	Bulk blue, top green	Some
10	5	1.0	650	60	Bulk purple, top green	Some
11	5	1.0	800	15	Bulk blue, top green	Some
12	5	1.0	850	30	Bulk blue, top green	Some
13	5	1.0	900	20	Bulk brown, top blue	Some
14	5	1.0	900	40	Bulk brown, top green	Some
15	5	1.0	1000	60	Bulk brown, top green	Some
16	5	0.75	1100	120	Bulk gray, top brown	Some
17	5	0.75	1100	180	Bulk gray, top green	Trace
18	10	1.5	1100	120	Bulk gray, top green	Trace
19	10	1.0	1100	60	Bulk brown, top blue, bottom gray	Trace

TESTS ON THE TEMPERATURE AND THE QUANTITY OF CARBON REQUIRED

To get a more accurate measure of the temperature with its resulting changes in reduction, another set of experiments was carried out. These tests were run in a quartz tube closed with a fire-clay plug at one end; the other end was fitted with a pyrometer tube luted to the main tube so that, in each case, the hot junction was near the center of the charge.

TABLE II

SAMPLE No.	Weight Sample Grams	Weight Carbon Grams	Temp. De- grees C.	Time Min.	Residue after Heating	Carbon Left
1...	25	3.75	1100	90	All gray, green at end	Some
2...	25	3.75	1100	60	Tube broken, all green	Some
3...	25	3.75	900	103	Bulk brown, trace gray	Some
4...	25	3.75	900	300	Bulk brown, some gray	Some
5...	25	3.75	1000	420	Olive-green	None
6...	25	3.75	1000	240	Bulk brown, some gray	Some
7...	25	3.75	1050	180	Bulk gray, ends green	Some
8...	25	2.5	1050	180	Bulk brown, some gray	None
9...	25	3.3	1100	180	Bulk gray, some brown	None
10...	25	3.5	1100	180	Bulk gray, trace brown	None

The results in Table II indicate that the temperature must be at least 1050° C. for the reduction to metallic tungsten. Under the conditions of the test, the carbon content necessary for adequate reduction depended both on the temperature of reduction and the resulting time required, the ratio being about 10 parts tungstic oxide to 1.4 parts carbon. Moissan² used 10 parts tungstic oxide to 1 part of carbon. This was, however, at the temperature of the electric furnace and for a short period of heating. Mennicke³ used 10 parts tungstic oxide, 1.4 parts charcoal, and 0.2 part colophonium, the temperature reaching 1400° C. in about 7 hrs. The carbon requirement, if figured on the basis that the resulting gas is all carbon dioxide, is 10 parts tungstic oxide to 0.77 part carbon. If it is considered that the reaction goes to carbon

monoxide, the carbon requirement is 10 parts tungstic oxide to 1.55 parts carbon.

Analysis of the gray material resulting from reduction at 1100° C. showed:

	Per cent
Carbon.....	2.25
Tungsten.....	97.07
Not determined.....	0.68

This indicates that the material is metallic tungsten.

The brown material resulting from reduction at 1000° C. gave on analysis:

	Per cent
Carbon.....	13.5
Tungstic oxide.....	30.0
Tungsten.....	55.0

The reduction in this case was incomplete.

REDUCTION WITH CHARCOAL IN IRON TUBE

A reduction was conducted with 500 g. of tungstic oxide dried at 500° C. This was mixed and ground with 75 g. of wood charcoal. The apparatus consisted of a 2 in. pipe, 2 ft. 6 in. long, capped at each end; a 1/2 in. pipe was attached to one cap so that a pyrometer could be introduced at the center of the charge. The other cap was fitted with a 1/4 in. pipe so that gas could be introduced if desired. The charge was placed at the center of the large pipe and held in place by fire-clay plugs, one having a hole for the pyrometer. This apparatus, which contained the charge, was placed in a fire-brick furnace so that the portion containing the charge was in the heat zone, while the ends of the tube protruded on each side. The heat was furnished by a gasoline pressure burner. During reduction, the 1/4 in. pipe was closed and the pyrometer tube inserted. The maximum temperature during the 3 hrs. of heating was 1120° C. While cooling, producer gas was admitted at one end of the tube (the other being closed), so that the reducing atmosphere was maintained.

The product resulting from reduction was gray, lumpy, and friable. This seemed to be metallic tungsten, and the following analysis shows its condition of purity:

	Per cent
Tungsten.....	98.2
Carbon.....	0.3
Silicon dioxide.....	0.8
Not determined.....	0.7

A small quantity of partially reduced material was left at the end where the pyrometer was introduced. Some of the silica is due to the poor quality of charcoal used. The ash content of the charcoal was 4.4 per cent. The charcoal used, therefore, should be as pure and free from ash as possible. Since the iron pipe after heating at 1100° C. and cooling again is quite badly oxidized, it would seem advisable to use an alundum or fire-clay tube in the process.

REDUCTION WITH LAMPBLACK IN FIRE-CLAY CRUCIBLE

An experiment was tried showing the reduction of tungstic oxide with lampblack in a fire-clay crucible. 250 g. of tungstic oxide were mixed with 37.5 g. of lampblack and placed in a fire-clay crucible. A fire-clay disk on which was placed a small quantity of

¹ Loc. cit.

² Compt. rend., 116 (1893), 1225.

³ Loc. cit.

lampblack was inserted in the crucible above the charge, leaving sufficient space to cover the crucible. The covered crucible was heated at 1100°C ., the complete time of heating being $1\frac{1}{2}$ hrs. As this includes the time required to heat the furnace, the time of heating at 1100°C . was less than one hour. The crucible was completely cooled before removing the charge. The resulting material, as a whole, was well reduced. There was some oxidized material at the top of the charge, due to air leaking into the crucible around the cover. Analysis of the material from the crucible reduction is as follows:

	Per cent
Tungsten.....	98.6
Carbon.....	0.4
Silica dioxide.....	0.4
Not determined.....	0.6

The lampblack gave an ash content of 0.6 per cent. Although the silica in the product was reasonably low and the reduction excellent, the carbon content was a trifle high. The carbon content can be reduced by regulating the ratio of carbon to tungstic oxide in the charge, or by washing out the carbon. This product was washed to remove the carbon, and dried at 150°C . It then gave an analysis of:

	Per cent
Tungsten.....	99.1
Carbon.....	0.1

The fire-clay crucible was not attacked in the reduction, and the material was easily removed in the form of friable lumps.

CONTINUOUS PROCESS FOR REDUCTION WITH CHARCOAL

In the foregoing reductions there was always some material which was not completely reduced. Although this material could be used again in the next charge, it was thought advisable to try out a continuous process where there would be no material left in an oxidized condition, and where the reduced material would be cooled without cooling the container, which would remain at the temperature required for reduction. The apparatus consisted of a 1 in. pipe, 3 ft. long, set at a slant in a furnace so that a portion 9 in. long was kept at a temperature of about 1080°C . The mixture of tungstic oxide and carbon was of the ratio 10 to 1.5. This mixture was fed in at the top end of the tube, and from time to time was poked through, so that the material was in the hot portion about 30 min. The reduced material would then be forced into the cooled part of the tube (cooled by water). From time to time the reduced material was removed from the cold end of the tube. The product was quite dark or black. The first portion, however, was gray and lumpy. This dark portion analyzed:

	Per cent
Tungsten.....	95.2
Carbon.....	4.4

The dark color is thus seen to be due to excess carbon. The reducing action of the gases which come from the heated mass and pass through the tungstic oxide mixture plays an important part, as evidenced by the first reduction product being gray. That is, the first part of the charge, having no reducing gases passing

through it, was properly regulated with respect to the tungstic oxide and carbon ratio. On the other hand, the later charges, being partially reduced with gas, had an excess of carbon. Although the carbon in this run was excessive, it could be easily regulated by reducing the carbon in the mix. The material was washed with water and showed 98.5 per cent tungsten. The washing as performed consisted of a crude panning, so that better results could be expected by a jig or table treatment. Mennicke¹ states that both carbon and partially oxidized tungsten can be removed by crushing and washing. The tendency to cake in the hot part of the tube could be decreased by using a larger tube. If necessary, the tube could be rotated to insure a proper feed, or a worm feed could be installed at the top, at the bottom, or both, as occasion demanded.

The possible advantages of using a continuous process such as the one suggested would be: Less heat loss, due to keeping the apparatus at a constant temperature; no unreduced oxides of tungsten; small chance of air coming in contact with the hot charge; and less wear and tear on the apparatus, since the greatest deterioration occurs on heating and cooling.

REDUCTION WITH GAS

Hartman² states that tungstic oxide is reduced to the metal with pure dry hydrogen at 1000°C .; Bosch³ states that the reduction takes place with hydrogen at 600°C . under high pressures; Thomson⁴ says that tungstic oxide heated at 600° to 800°C . in a stream of hydrogen for a long time is reduced to the metal. From these statements we were led to believe that the reduction temperature with gas at ordinary pressures might be lower than that required when carbon was used. This would cause less difficulty in maintaining the temperature and would save considerably on the wear and tear of the apparatus.

The following experiments were conducted to determine the temperature required for reduction with hydrogen:

Tungstic oxide was placed in a quartz tube, which in turn was placed inside an iron pipe fitted with a pyrometer, and closed in such a way that hydrogen could be passed through.

TABLE III

Time Heated Hrs.	Temperature Degrees C.	RESULTS
$1\frac{1}{2}$	800	Brown oxides resulted
$1\frac{1}{2}$	900	Brown oxides resulted, with some black, shiny crystals
$1\frac{1}{2}$	1000	Resulting material was practically all brown with just a little gray at the end where the hydrogen was introduced. This gray might be due to the fact that the temperature might have been greater at that portion of the tube, the pyrometer being introduced at the other end

Reduction with hydrogen at 1080°C . for $1\frac{1}{2}$ hrs. gave a steel-gray product. This analyzed 99.4 per cent tungsten.

Reduction with gasoline gas at 1080°C . for 2 hrs. gave a dark gray (blackish) powder. This proved to be 98 per cent tungsten. It contained considerable carbon, due to hydrocarbons in the gas used.

It follows from Table III that reduction with hydrogen at ordinary pressures is not noticeably different from that with carbon. It may be that long heating with

¹ Loc. cit.

² *Pahasapa Quarterly*, 5 (1916), 25.

³ *Chem. Abs.*, 10 (1916), 1411.

⁴ U. S. Patent 960,441.

large excess of hydrogen would reduce the oxide at lower temperatures. This treatment, however, is hardly applicable if the reduction process is to be used commercially. However, at temperatures over 1050°C . the reduction proceeds quickly and the product is a very pure tungsten powder. Producer gas might well be used in place of hydrogen for the reduction, as suggested by Thorpe.¹

SUMMARY

1—The tungstic oxide used for reduction must be pure, dry, and in a state of fine division.

2—When reduced with carbon, the tungstic oxide should be thoroughly mixed with it.

3—At 650° to 850°C . tungstic oxide goes to a blue or purple oxide when heated with carbon; at 900° to 1050°C . a chocolate material is the result; and at temperatures above 1050°C . the gray powdered metallic tungsten results.

4—As the tungsten is easily oxidized, the reduced material must be cooled in a reducing atmosphere.

5—The ratio of tungstic oxide to carbon varies from 10 : 1 to 10 : 1.6, depending on the process used, the temperature of reduction, and the time involved.

6—Excess carbon can be partially removed by washing.

7—Fire-clay crucibles or iron tubes give satisfactory reduction with a product of over 98 per cent tungsten. Under the conditions of the test some oxides resulted at portions nearest the crucible cover and tube ends.

8—Fire-clay is not attacked by the charge at the temperature used. The iron tubes suffer considerable oxidation on the outside.

9—A continuous process could be arranged to get a tungsten powder free from oxides.

10—The time of reduction of small samples at 1100°C . is less than one hour.

11—The temperature of reduction with hydrogen at ordinary pressures is much the same as with carbon. The product is over 98 per cent tungsten.

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BUREAU OF MINES
GOLDEN, COLORADO

SOLUBILITIES, SEPARATION, AND PURIFICATION OF ANTHRACENE, CARBAZOL AND PHENANTHRENE

By JOHN MARSHALL CLARK
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GENERAL

Anthracene, carbazol, and phenanthrene are present in the oils derived from gas-house and coke-oven tars in the oil fraction known to the tar distiller under various names, such as "anthracene oil," "heavy oil," "dead oil," and "green oil." This oil is the fraction obtained in the distillation of tar between 290° and

380°C . When first distilled it is a reddish liquid with a green fluorescence. It soon becomes semisolid on cooling. Besides containing anthracene, carbazol, and phenanthrene, all of which are solid at ordinary temperatures, this fraction also contains varying percentages of about fifteen other hydrocarbons. Chrysogen, one of these substances, imparts the green color to this oil, and acridine, another, causes sneezing if inhaled in sufficient quantity. The amounts of these latter impurities are, however, small in comparison with the amounts of anthracene, carbazol, and phenanthrene present. No definite statements can be made as to the exact percentages of these substances in the tar as these figures vary with the kind of tar, its source, its method of distillation, etc. The following, however, are the analyses of the anthracene oil from representative American gas-house and coke-oven tars and are inserted here solely to give the reader a general idea of what to expect in the way of these oils. A few tests on the tars from which the oils are derived are also included.

The tests on the tars and oils in this paper were conducted after the methods of Church.¹ The percentage of pure anthracene was determined by the method of Luck, Meister, and Lucius,² which was later modified by Brüning³ at Höchst-am-Main and became known as the Höchst test. The carbazol content was determined by a slight modification of the Kjeldahl method for the determination of nitrogen worked out by the writer and given below.

No very accurate method for the determination of phenanthrene could be found. The method of Kraemer and Spilker⁴ was tried, but it was thought that the results were not dependable especially when the material examined contained less than 20 per cent of phenanthrene. The percentages of phenanthrene then as recorded in the following pages represent the difference between one hundred and the sum of the percentages of anthracene and carbazol. It will readily be seen that this will include in many cases a number of other hydrocarbons, and consequently the percentages of phenanthrene in many cases are probably high.

	TABLE I	
	TAR TESTS	GAS-HOUSE TARS AND COKE-OVEN TARS
Sp. Gr. at 15.5°C	1.224	1.168
Free Carbon.....	22.3	6.91
Viscosity (Ender) 100 cc. at 100°C ., seconds.....	64	70
Heavy Oil 290° to 380°C ., per cent.....	16.2	23.0
HEAVY OIL TESTS		
Sp. Gr. at 15.5°C	1.152	1.143
Phenols, per cent.....	3.1	1.7
Anthracene, per cent.....	1.8	1.5
Carbazol, per cent.....	0.7	0.6
Phenanthrene and other solid hydrocarbons, per cent.....	2.6	2.8

From this table one can readily see that even though the percentages of anthracene and carbazol are greater in the oil derived from gas-house tar than that derived from coke-oven tar, yet the actual amount, calculated back to the unit of tar, is less in the former than the latter. This, of course, is due to the difference in the percentage of oil obtained.

It is entirely possible that tars from other sources will show percentages varying from the above. The

¹ *This Journal*, 3 (1911), 229.

² *Iber.*, 6, 1347.

³ *Z. anal. Chem.*, 16, 181.

⁴ Lunge, "Coal Tar and Ammonia," 1916 Edition.

¹ "Dictionary of Applied Chemistry," Vol. 5, 564.

kind of coal used, the type of retort, and the method of firing are all factors that influence the quality of the tar. Even after the tar distiller receives it, it is subjected to more or less cracking depending on the conditions stated above; for instance, tars distilled by the continuous still process give oils lower in solid hydrocarbons than those distilled from the horizontal or vertical type of still.

In the recovery of anthracene, carbazol, and phenanthrene from the heavy oil, it is first necessary to allow the solids to separate out. This will take place to a large extent at ordinary temperatures but the operation can be made more complete and hastened by artificial cooling. The limpid creosote oil is then drained off from the anthracene "salts" thus obtained and the crystals centrifuged or pressed to free them from as much of the creosote oil as possible.

The percentages of hydrocarbons in the solid cake thus obtained will vary, but the sample used in the separation explained later is representative. It analyzed as follows:

	Per cent
Anthracene.....	30.1
Carbazol.....	22.0
Phenanthrene.....	47.9

A number of methods are now suggested to the research chemist for the purification of anthracene. His selection of a method is finally based on the product he has to purify and the means he has at his disposal to accomplish this purification, provided, of course, that all methods give equal results.

The following methods found in the literature seem the most likely ones:

Remy and Erhart¹ effect a purification of anthracene by crystallizing it from oleic acid.

The Farbenfabriken, formerly Frederick Baeyer & Co.,² use liquid sulfur dioxide to dissolve the impurities out from anthracene.

Welton³ uses liquid anhydrous ammonia to dissolve out the impurities.

The Farbenfabriken⁴ in another patent recommend the use of acetone as a solvent for the impurities of anthracene.

The Aktien Gesellschaft für Anilinfabrik⁵ add potassium hydroxide to the melted crude anthracene and distill *in vacuo*. The purified anthracene containing phenanthrene passes over and the carbazol remains behind.

Wirth⁶ separates anthracene by means of its easily soluble nitroso compound.

Catchpole⁷ heats the impure anthracene cake to a temperature of not over 200° C. and thus "sweats" out the impurities from the anthracene.

Vesely and Votocek⁸ find that concentrated sulfuric acid extracts all of the basic impurities of anthracene from a solution of crude anthracene in a solvent immiscible with the acid.

From the preceding one can readily see that the methods used were largely solvent methods. A search of the literature, however, revealed the fact that the solubilities of anthracene, carbazol, and phenanthrene had been determined in only a few solvents and at only a few temperatures.

Versmann,¹ Becchi,² and Findley³ seem to have been about the only ones who recorded their researches in this field and a glance at the references will show how scant is the information they have left.

The writer's method of separation was based on a solvent method in so far as it was practical. Crude coal-tar solvent naphtha was used to remove the phenanthrene, and coal-tar bases (commonly called pyridine) were used to remove the carbazol from anthracene. It was found, however, that after a certain degree of purity had been obtained solvents could no longer be employed in the purification of anthracene and carbazol and then special chemical methods were introduced. Before using the solvent methods to advantage, however, it was necessary to determine the relative solubilities of pure anthracene, carbazol, and phenanthrene in several solvents and at different temperatures.

EXPERIMENTAL

Small quantities of anthracene, carbazol, and phenanthrene were prepared and used for the solubility tests. The methods used in the preparation of these small samples were to a large extent like the methods described later, except that very little attention was paid to yields in the preparation of these pure materials, as the amount of solvent used was more or less guesswork.

The anthracene prepared and used in the following solubility tests had a melting point of 212.7° C. and tested 99.8 per cent pure anthracene; the carbazol had a melting point of 236° C. and tested 99.94 per cent pure; and the phenanthrene had a melting point of 99.8° C.

The following tables show the tests of the solvents used and the solubilities of pure anthracene, carbazol, and phenanthrene in 100 parts of solvent. The specific gravities were determined by means of a pycnometer, and the distillation tests made in a standard Engler 250 cc. distillation flask.

Quite a number of the above solubilities are of interest only from an academic or scientific viewpoint. In the preparation of anthracene, carbazol, or phenanthrene on a commercial scale the manufacturer must select a solvent that is readily obtainable, that is cheap, and that will produce the best results. Toluol and benzol, for instance, would work admirably for separating phenanthrene from anthracene and carbazol, but no manufacturer would now think seriously of using them, especially when coal-tar naphtha will accomplish the same results. Similarly it is seen that acetone and pyridine could be used to separate anthracene from carbazol and phenanthrene, and for apparent reasons pyridine is given the preference.

¹ German Patent 38,417.

² German Patent 68,474.

³ English Patent 27,559.

⁴ German Patent 78,861.

⁵ German Patent 178,764.

⁶ English Patent 14,462.

⁷ English Patent 16,641.

⁸ English Patent 27,596.

¹ Jahresber., 1874, 423.

² Ber., 12, 1978.

³ J. Chem. Soc., 1902, 221.

TABLE II—TESTS ON SOLVENTS USED FOR SOLUBILITY TESTS

NAME	Sp. Gr. at 15.5° C.	1st Drop C.	10 Per cent C.	30 Per cent C.	40 Per cent C.	50 Per cent C.	60 Per cent C.	70 Per cent C.	80 Per cent C.	90 Per cent C.	Dry C.
Benzol, C. P.	0.880	79.8	80.0	80.1	80.1	80.2	80.2	80.3	80.4	80.4	80.6
Toluol, C. P.	0.870	110.0	110.0	110.0	110.0	110.1	110.2	110.2	110.3	110.3	110.4
Coal-Tar Solvent Naphtha											
Refined	0.865	142.0	145.0	146.0	147.0	149.0	150.0	153.0	155.0	160.0	175.0
Crude Coal-Tar Solvent											
Naphtha	0.893	140.0	152.0	153.0	155.0	157.0	160.0	162.0	169.0	174.0	179.0
Heavy Coal-Tar Naphtha	0.909	162.0	165.0	168.0	171.0	174.0	176.2	176.3	176.4	185.0	200.0
Chloroform, C. P.	1.495	59.5	60.4	60.5	60.6	60.7	60.9	61.0	61.4	61.8	63.5
Carbon Bisulfide, C. P.	1.270	45.2	45.7	46.2	46.2	46.3	46.4	46.4	46.5	46.6	49.0
Acetone	0.800	56.0	56.0	56.1	56.1	56.2	56.3	56.3	56.4	56.5	58.0
Light Pyridine	0.952	115.0	125.0	131.0	133.0	137.0	138.0	143.0	145.0	150.0	171.0
Heavy Pyridine	1.057	112.0	202.0	214.0	225.0	229.0	233.0	237.0	240.0	244.0	274.0
Hydrated Pyridine, C ₅ H ₅ N											
3H ₂ O Carbon	1.050	93.5	94.0	94.2	94.6	94.8	95.0	95.2	95.4	95.6	98.0
Carbon Tetrachloride	1.600	74.0	75.5	75.8	76.0	76.1	76.2	76.2	76.3	76.4	76.7
Gasoline	0.742	61.0	90.0	100.0	111.0	118.0	128.0	135.0	140.0	150.0	180.0
Ether	0.720	34.8	35.0	35.1	35.2	35.3	35.3	35.4	36.0	37.1	40.2

¹ These are the bases derived from coal-tar oils by abstraction with sulfuric acid and liberation of the base with caustic soda. They probably contain but very little pyridine, C₅H₅N.

TABLE III—PARTS OF ANTHRACENE, CARBAZOL AND PHENANTHRENE SOLUBLE IN 100 PARTS OF SOLVENTS

SOLVENT	At 15.5° C.			At 30° C.			At 50° C.			At 80° C.			At 100° C.			Above the melting point of phenanthrene
	Anth.	Carb.	Phen.	Anth.	Carb.	Phen.	Anth.	Carb.	Phen.	Anth.	Carb.	Phen.	Anth.	Carb.	Phen.	
Benzol	1.04	0.72	16.72	2.10	1.01	40.10	5.05	7.88	2.90	..	12.20	4.78	..	Above the melting point of phenanthrene
Toluol	0.53	0.42	13.80	1.90	0.78	29.10	3.10	1.60	..	..	..	..	..	..	..
C. P. Solvent Naphtha Refined	0.46	0.48	12.52	1.42	0.70	22.42	2.90	1.37	30.8	6.58	3.00	84.4	10.10	3.72	..	
Crude Coal-Tar Solvent Naphtha	0.50	0.54	15.30	1.71	0.94	31.80	3.25	1.70	74.2	7.20	3.84	240.0	8.82	7.00	..	
Heavy Coal-Tar Naphtha	0.32	0.48	11.94	1.35	0.75	21.30	3.10	1.52	60.3	7.65	3.63	193.0	10.53	4.70	..	
Chloroform	0.83	..	18.70	1.64	0.60	29.20	7.10	1.08	..	..	..	..	..	..	..
Carbon Bisulfide	0.52	..	26.42	1.62	0.44	..	..	..	..	..	..	..	..	..	..
Acetone	0.55	6.12	15.08	1.42	9.74	22.40	2.48	62.30	..	..	..	..	..	..	..
Light Pyridine	0.85	12.45	25.54	2.15	16.90	38.00	4.10	26.74	78.9	11.22	66.80	241.0	16.72	..	..
Heavy Pyridine	0.38	2.72	20.0	1.40	4.10	24.50	2.98	10.57	64.7	7.87	16.54	182.0	8.82	22.87	..	
Hydrated Pyridine	NH	0.42	0.43	NH	0.81	1.32	0.001	1.90	7.4	1.53	4.70	11.1	..	..	..
Carbon Tetrachloride	0.67	0.09	7.40	1.15	0.11	11.24	1.30	0.30	..	..	..	..	..	..	..
Gasoline	0.12	0.11	4.53	0.37	0.12	6.30	0.76	0.16	..	..	..	..	..	..	..
Ether	0.70	2.54	8.93	1.03	2.90	15.24	..	..	..	..	..	..	..	..	..

Briefly then, the method finally adopted as giving the best results was to use crude coal-tar solvent naphtha and pyridine as the solvents, to heat the crude anthracene cake in the selected solvent until practically everything passed into solution, and to filter at a lower temperature at which it was found convenient to work and the best results were obtained. It may seem unnecessary perhaps to some to heat beyond the point of filtration. However, this was found necessary in actual practice both for obtaining a whiter product and better results from the use of the solvent.

After filtering, the solvent was distilled off, recovered, and the crystallized material, as well as the residue from the distillation, subjected to the action of solvents again. By altering the solvents and repeating the process, the hydrocarbons were obtained in a degree of purity that will permit of their use in dye manufacture.

The following diagram illustrates the process used on one of the final runs. It shows the amount and purity of the product at the start and shows how much and what kind of solvents were used in the purification and separation.

This diagram illustrates all the steps that are necessary for the preparation of anthracene and carbazol of a purity sufficient for use in dye manufacture, as well as the steps necessary in the preparation of the pure materials. Anthracene and carbazol of from 85 to 90 per cent purity seem to work very well for use in the preparation of most dye intermediates. Phenanthrene does not play a very important part in the arts, but as it forms the main impurity in anthracene and carbazol it is given prominence in this paper.

A temperature of 30° C. seems to be a very good temperature at which to carry out the crystallization. It is generally just a little above room temperature and is easily maintained by using steam-jacketed kettles.

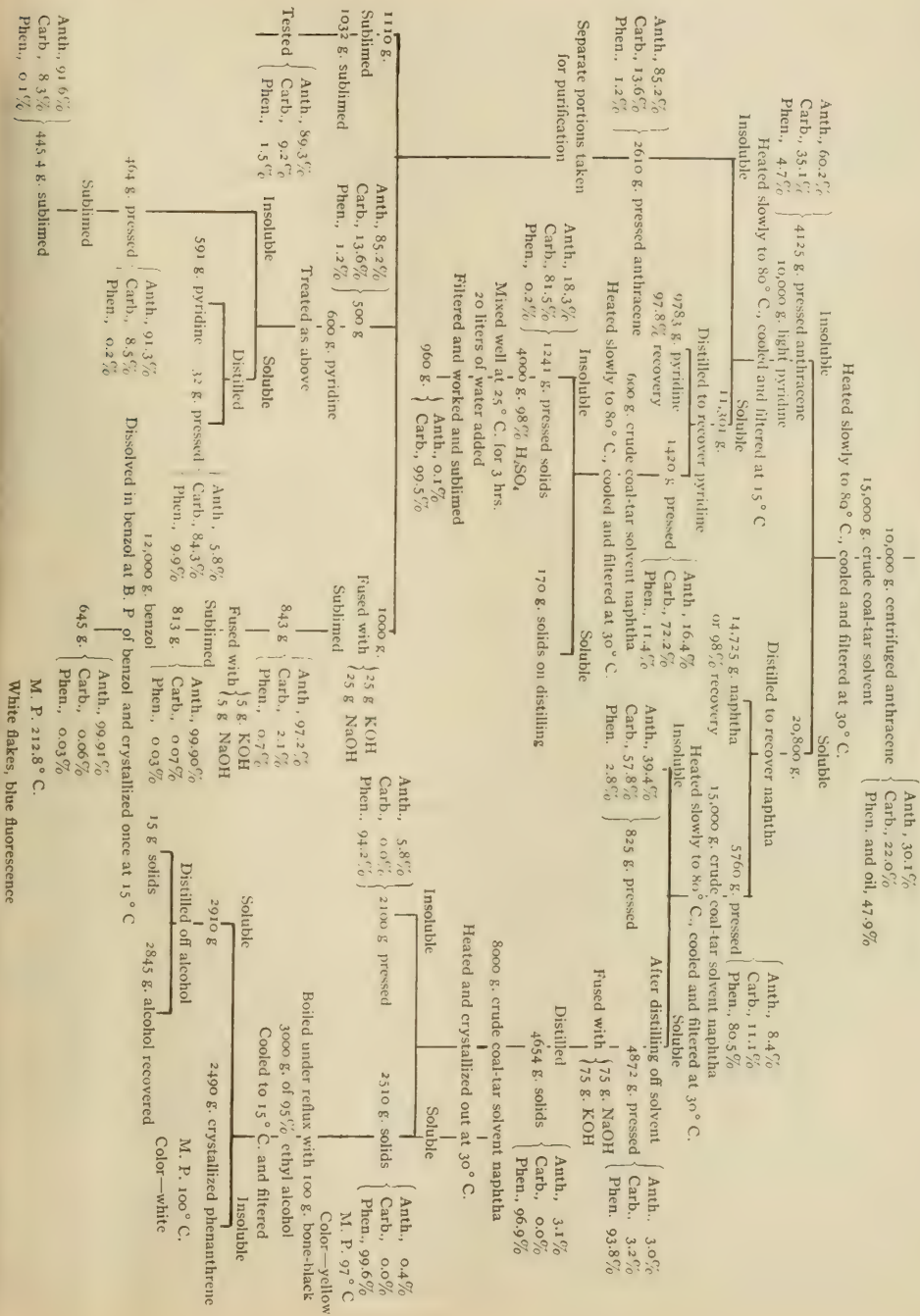
In one or more places in the scheme depicted there may seem to be a discrepancy in the phenanthrene figures. As the phenanthrene is calculated by difference it is probable that some unexpressed solvent remained behind, thus introducing an error in the phenanthrene content.

The reader will readily see from the experimental data that it is impossible to purify anthracene and carbazol by strictly solvent methods. Once a mixture of 90 per cent anthracene and 10 per cent carbazol is obtained, or *vice versa*, purification by solvent methods is of no avail. Mixed crystals of these substances in this proportion are found in the filtrate on evaporation as well as in the crystallized material. Phenanthrene, owing to its far greater solubility in coal-tar solvent naphtha, can be separated, or nearly so, from anthracene and carbazol in the purification of the latter substances. In the purification of phenanthrene, however, it is easier to take out the carbazol with alkali and then the anthracene by the use of solvents.

The complete purification of anthracene and carbazol is only accomplished by special chemical methods. The anthracene is separated from carbazol by subliming or distilling after fusion with alkali. The carbazol forms the alkali compound, remains behind, and the anthracene distills over. The carbazol can then be set free from its alkali derivative by the use of mineral acid, but the material thus liberated usually contains anthracene in such large percentages that this is not considered good material for use in making pure carbazol. It is, however, returned to the process and worked along with other inferior residues.

Carbazol, on the other hand, is purified from anthracene by means of sulfuric acid of 98 per cent purity or by any other convenient strength that will sulfonate anthracene in the cold. At ordinary temperatures

SEPARATION AND PURIFICATION OF ANTHRACENE, CARBAZOL, AND PHENANTHRENE



anthracene forms with the acid a sulfonic derivative which is soluble in large quantities of water, whereas the carbazol is scarcely affected. The anthracene, however, is not recovered when this method is used and consequently the solvent methods are used unless a carbazol of high degree purity is desired and at the expense of loss of anthracene.

The following table is designed to show the relative value of different alkalies in the purification of anthracene from carbazol. The material used tested 90.6 per cent anthracene and 9.3 per cent carbazol. It was finely ground, mixed well with the alkali, and then sublimed. The charge in each case consisted of 200 g. of the mixed hydrocarbons and the quantity of alkali indicated. Some writers referring to this method of purification state that caustic soda cannot be used to advantage. The following table would seem to disprove this as it was found that a mixture of caustic soda and caustic potash gave better results than either alkali alone, while caustic soda gave nearly as pure anthracene as caustic potash.

TABLE IV—EFFECT OF DIFFERENT ALKALIES AS AGENTS FOR REMOVAL OF CARBAZOL

	15 g. KOH	20 g. NaOH	10 g. KOH 10 g. NaOH	30 g. K ₂ CO ₃	35 g. CaO	8 g. KOH 20 g. CaO
Anthracene, per cent.....	98.6	98.2	98.9	96.4	93.1	97.3
Carbazol, per cent.....	1.3	1.7	1.1	3.5	6.75	2.6
Yield in Anthracene, per cent.....	98.4	99.0	98.2	97.8	96.2	98.0
Alkali Recovered, per cent.....	88.0	85.0	83.7	82.0	...	...

In the purification of carbazol free from anthracene the following table gives the results of some of the experiments conducted. Once the anthracene in the carbazol had been sulfonated by means of the sulfuric acid, dissolved in water, and the carbazol thrown down in a very finely divided colloidal state, the question of filtration arose and gave the most trouble. Several methods of filtration were tried out but the best results were probably accomplished by diluting the sulfonated mixture with a large quantity of water and then centrifuging with a high velocity centrifuge. 100 g. of carbazol testing 89.3 per cent carbazol and 10.1 per cent anthracene were used for each of the following runs. The acid used was 98 per cent sulfuric acid. In all cases the acid was added slowly while stirring and the temperature never exceeded 35° C. The mass was allowed to stand for 4 hrs. after the addition of water before filtering.

TABLE V—EFFECT OF DIFFERENT QUANTITIES OF SULFURIC ACID AS AGENTS FOR REMOVAL OF ANTHRACENE

RUN No.	Sulfuric Acid 98 Per cent Used Grams	Water Used Grams	Dried Sample Grams	Carbazol Per cent	Anthracene Per cent
1.....	100	8000	86	95.7	4.2
2.....	200	10000	84	98.4	0.9
3.....	300	12000	83	98.8	0.0
4.....	400	15000	83	98.9	0.0

From the table it will be seen that an excess of sulfuric acid is necessary for obtaining good results. Thus 100 g. of material containing 10 g. of anthracene had but slightly more than half of its anthracene content sulfonated by 100 g. of acid, whereas 90 per cent of the anthracene were sulfonated by the use of sulfuric acid when 20 times as much acid as anthracene was used, and all was sulfonated when 30 times as much acid was used. This excess of acid seemed to have

had but little effect on the carbazol as in all cases about 8 per cent of the carbazol present seems to have been sulfonated.

The foregoing methods of separation and purification have been successfully applied to mixtures of anthracene, carbazol, and phenanthrene from widely different sources and varying greatly in purity. It does not pay, however, to work up the "green salts" for anthracene if they contain less than 15 per cent of this hydrocarbon.

The carbazol contents in this paper were determined by the modified Kjeldahl method described below. This method was found to be both accurate and quick, and gave check results when compared with the Du Pont nitrometer.

To a 0.5 g. sample of the material to be tested are added 30 cc. of concentrated C. P. sulfuric acid and 0.7 g. of mercuric oxide in a 500 cc. Kjeldahl digestion flask. This is digested for one hour over a low gas flame, allowed to cool, 10 g. of potassium acid sulfate added, and the whole boiled until the solution is clear. This usually takes from one to two hours after the addition of the acid sulfate. The flask and contents are then cooled to about 35° C., and then 200 cc. of distilled water and 10 g. of sodium thiosulfate are added. The solution is made strongly alkaline with 25 per cent caustic soda solution, a few beads are added to prevent bumping, and the free ammonia is distilled through block tin condensers into an excess of standard acid.

The following are the results obtained on a sample of nearly pure carbazol:

Modified Kjeldahl Method	Du Pont Nitrometer Method
8.03	8.07
7.97	7.89
7.89	7.84
7.93	7.97
Av. 7.955	7.943

Theoretical quantity for pure carbazol = 8.383.

SUMMARY

I—A review of the obtaining of the "green salts" from crude coal tar is given along with representative analyses of tars and oils and the effect of different tars and methods of distillation on the oils.

II—The relative solubility of anthracene, carbazol, and phenanthrene in fourteen different solvents and at five different temperatures is shown.

III—Procedures are described whereby anthracene and carbazol are obtained from 80 to 90 per cent in purity by means of selected solvents and the proper control of temperatures. The solvents used are crude coal-tar naphtha and light coal-tar bases.

IV—A method for the preparation of pure anthracene is shown whereby the phenanthrene is removed by crude coal-tar solvent naphtha and the carbazol by fusion with a mixture of sodium and potassium hydroxides. The sublimed anthracene is then crystallized out from pure benzol.

V—A method for the preparation of pure carbazol is shown whereby the phenanthrene is removed by crude coal-tar solvent naphtha and the anthracene by the formation of a sulfonic derivative which is formed by the action of 98 per cent sulfuric acid in the cold and which derivative is soluble in water. The unsulfonated carbazol is filtered and made pure by subliming.

VI—A method for the preparation of pure phenanthrene is shown whereby the phenanthrene is separated from the anthracene and carbazol by dissolving in crude coal-tar solvent naphtha, and further purified by boiling with boneblack and crystallizing from 95 per cent ethyl alcohol.

VII—The effect of different alkalies as agents for the removal of carbazol is tabulated.

VIII—A table is given showing the effect of different quantities of 98 per cent sulfuric acid and water as agents for the removal of anthracene from carbazol.

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CHLORINE ABSORPTION AND THE CHLORINATION OF WATER¹

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INTRODUCTORY

The disinfection of waters by means of various forms of chlorine has been practiced in this country and abroad for many years. During this period a general theory of chlorination has grown up, particularly on this side of the water, which has had little or no scientific basis. The general hypothesis concerning the effects of chlorination, the proper dosage, and the nature of the chemical and biological reactions have been deduced from a few well-controlled experiments on waters of certain characteristics. The results of these experiments, however, have led to the universal adoption of chlorination for waters differing materially from those upon which earlier experimental data were made available. When, therefore, a number of water supplies were treated with standardized doses of chlorine, or its compounds, failures in performance were soon recorded.

In the supervision and control of a single water supply, the problem of chlorination offers far less difficulty than in the case of a group of water supplies, all of which have distinctive and disconcertingly variable qualities. The control of disinfection of a city water supply, supported by daily chemical and bacteriological examinations, may at least approach a scientific procedure, although surprisingly few cities even at this late date actually do more than a superficial dosing at a more or less constant rate. The supervision of chlorination becomes, however, a problem of major importance where a large series of supplies are to be treated under the direction of some central authority, like a State Department of Health. With 10 or 15

¹ The data submitted are the results of a study of the question of chlorination control in Maryland, upon which the writers have been detailed under the general direction of Mr. R. B. Morse, Chief Engineer, Maryland State Department of Health.

water supplies—inadequately sampled, some in the raw state, some just after coagulation, some filtered, ranging through every degree of color and turbidity, now free from organic material and an hour later loaded with surface wash—what form of control should be adopted? Here a speedy, safe, easy method of antecedent control, rather than of subsequent failure, is essential. On this phase of chlorination, the preliminary routine control of widely different types of waters, scientific literature, with some few exceptions, is silent.

In the state of Maryland, as in other states, experience indicates that, in general, chlorination control has been inadequately studied. When we bear in mind that a number of supplies are under the supervision of laymen, it becomes clear that consistently good results in disinfection are hardly attainable without the use of some presumptive indicator of an efficient chlorine dose. Presumptive tests of chlorine efficiency have been discussed by various students of the problem; but their contributions, although suggestive, have been based upon such meager experimental evidence that they cannot yet be considered definitive.

The present brief discussion is the result of a study, carried on during the past 18 months, of the application of chlorinators under variable conditions. The data here set forth are fragmentary. They are reported in order to invite attention to the extreme intricacy of the whole problem rather than as the basis of a formula designed to furnish the proper doses of chlorine and its allied compounds. It may be stated, however, that observation of the conditions in this state has served to point out a wide field for further intensive experimentation and, in this respect, the material here presented may be of some little value.

ABSORPTION OF AVAILABLE CHLORINE

The importance of the absorption of so-called "active chlorine" by different waters is somewhat ill-defined in its relation to disinfection or the elimination of objectional bacterial life. Some experimenters assert that the amount of absorption discloses little concerning the destruction of bacteria, while others assume that the chlorine consumed in "oxidizing organic matter and sometimes ferrous salts or sulfides will not effect sterilization."¹ Since the latter assumption necessarily permits an increased factor of safety in the control of the chlorination, it is probably advantageous to use the hypothesis as a base until the collection of adequate data indicates what quantitative variations therefrom may be necessary.

In order to study the significance of the absorption of chlorine by waters, it is of interest for scientific and practical purposes to obtain some idea of the factors which influence or predetermine the losses of chlorine in different waters. Owing to the complexity of conditions under which the action of chlorination proceeds, such data as the above and any conclusions pertaining thereto may be ascertained in only an empirical manner. A few apparently elementary features of chlorine absorption, therefore, are described briefly in

¹ Dakin and Dunham, "Handbook of Antiseptics," 1918, p. 106.

order to establish at least some salient characteristics of the phenomenon of the disappearance of the active agency in chlorination.

THE RATE OF CHLORINE ABSORPTION—A few experiments were tried to determine the velocity of absorption of available chlorine by the same water during varying time intervals. The data were collected in order to compare with similar work reported by Race.¹ The results are set forth in Table I. A comparison of

TABLE I—ABSORPTION OF CHLORINE BY WATERS AT 20° C. VARIATIONS IN K WITH TIME

SAMPLE	Values of $K = \frac{1}{t - t_0} \log \frac{N_1}{N_2}$		
	5 min.	30 min.	60 min.
1 Surface.....	0.052	0.009	0.005
2 Surface.....	0.069	0.012	0.006
3 Surface.....	0.032	0.013	0.007
4 Surface.....	0.041	0.013	...
5 Surface.....	0.082	0.018	...
6 Surface.....	0.066	0.017	0.009
7 Surface.....	0.071	0.013	0.013
8 Surface.....	0.082	0.023	0.015
9 Surface.....	0.032	0.011	0.007
10 Surface.....	0.099	0.026	...
11 Surface.....	0.036	0.015	...
12 Surface.....	0.017	0.007	...
13 Filtered.....	0.007	0.004	...
14 Well.....	0.014	0.005	0.003
15 Well.....	0.007	0.008	0.006
16 Well.....	0.013	0.003	0.002
17 Well.....	0.009	0.009	...
18 Surface.....	0.104	0.018	0.010
19 Surface.....	0.036	0.007	...
20 Surface.....	0.044	0.004	...
21 Surface.....	0.026	0.014	0.010
22 Surface.....	0.120	0.023	0.014

TABLE II—SUMMARY OF DATA IN TABLE I

Initial Chlorine Absorbed in 5 min.	Ratio K_5/K_{15}	Ratio K_5/K_{50}
0.08	1.8	1.1
0.08	1.1	...
0.10	1.0	...
0.14	4.3	6.5
0.15	2.8	3.3
0.18	2.4	...
0.26	1.8	1.3
0.31	2.5	4.6
0.31	2.9	4.6
0.34	2.8	...
0.34	5.1	...
0.38	3.2	...
0.40	11.0	...
0.45	5.9	10.4
0.53	3.9	7.3
0.53	5.6	11.5
0.56	5.5	5.5
0.61	4.6	...
0.61	3.5	5.5
0.68	3.8	...
0.70	5.8	10.4
0.75	5.2	8.6

these findings with the values reported by Race indicates that K, the velocity constant, in general, decreases with the time of contact. These values are in agreement with the conclusions noted by Race. It should be pointed out, however, that the value of K approaches a constant for different time intervals in those waters whose organic content is low. It appears, therefore, that the rate of chlorine absorption deviates from the ideal monomolecular law of chemical reaction in an increasing degree with waters of increased organic content. In other words, the monomolecular law with K constant is fairly well typified in those few waters which have only slight organic content, such as well and filtered waters, Nos. 13, 15 and 17. This is to be expected, since it is only in these latter waters that the compounds acted upon are probably of such simple chemical structure as to result in a constant reaction velocity.

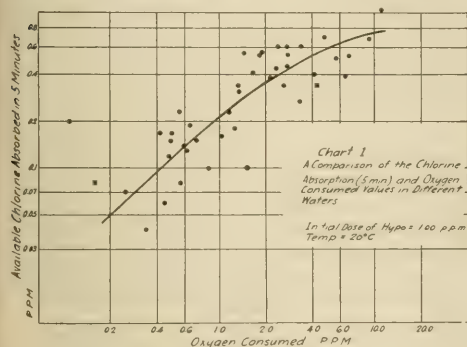
COLOR AND THE RATE OF CHLORINE ABSORPTION—The use of color readings as a presumptive indicator of the

amount of chlorine which would be absorbed by a water in a given period has been suggested as a convenient procedure for routine operation of disinfectant plants. To be of any value, such readings should be the result of a long series of correlated experimental observations. Such continuous series have not been developed, it is believed, for many individual water supplies, while still less has been done in the way of comparative readings on different water supplies. Data upon this question are now being collected in this department. They are not reported in this paper on account of their insufficient number, but the evidence from the observations now available would seem to indicate that for the same water supply, changes in color are not necessarily concomitant with variations in chlorine absorption during a constant time interval, while for different water supplies the same conclusion is indicated as far as interdependent chlorine absorptions are concerned. It would appear, from the evidence now at hand, that color readings in different water supplies cannot be adapted to the prediction of chlorine absorption readings, because of the absence of any adequate conversion factor.

TURBIDITY AND THE RATE OF CHLORINE ABSORPTION—In order to study the variation of chlorine absorption in a surface water within different ranges of turbidity, a series of 350 samples of the Potomac River water at Luke, Md., were examined during June and July 1918. A study of the turbidity readings and the chlorine absorption tests indicates practically no correlation whatever between these two phenomena, although the turbidities ranged from 0 to 90 parts per million. The Potomac River water at the above station offers an interesting illustration of the necessity for guarding against unwarranted correlations between the physical property of a water and its biochemical conduct. In the case of the above water, the chlorine absorption values (during five minutes) showed no increase whatever with increases of turbidity, but rather a slight decrease. That the absorption remained almost constant and even decreased, in a degree, with an apparent physical degradation of the water is probably explained by the fact that the Potomac River at the point under discussion contains considerable oxidizable mine wastes. Sudden rainfalls create dilutions of these wastes, but at the same time raise the turbidity readings on the river. It comes about, therefore, that the increased muddiness in the water is in reality accompanied by a reduction in oxidizable material, without a consequent increase in chlorine absorption values. The situation is somewhat analogous to the reductions in alkalinity frequently observed with rises in turbidity. It is clear from the above situation that the direct variation of dosage with increase of turbidity would have been fallacious and contrary to the demand of the water. When the attempt is made to correlate turbidities of different waters with their corresponding chlorine absorptions, even less success is experienced. This situation is to be expected in different supplies, because of the variance in character and degree of watershed pollution. It may be postulated as a preliminary conclusion, that turbidity readings are not a

safe index of chlorine absorption for different water supplies, but may be adapted, with sufficient precautionary measures, to use for an individual supply. Even in the latter case, the conversion of turbidity to chlorine absorption is accomplished only after long studies of widely varying phases of the same supply.

OXYGEN CONSUMED AND THE RATE OF CHLORINE ABSORPTION—Inasmuch as the oxygen-consumed values of waters represent approximately the oxidizable compounds present in such supplies, it would seem that this chemical index should bear some relation to the complex action of chlorine absorption, of which some portion at least partakes of the nature of an oxidation. In order to study this phase of absorption, a series of widely varying waters, of surface and underground types and of different ranges of pollution, were examined during portions of 1917 and 1918. In all of these waters the oxygen consumed and the chlorine absorbed (5 min.) values were obtained. These readings are graphically shown on Chart 1, where the individual



and average values have been plotted, in order to permit of the construction of an empirical curve. The data there shown apparently disclose a fairly close variation of chlorine absorption with the oxygen-consumed values of different supplies. This correlation, it should be emphasized, is independent of the source or nature of the water, since the 45 waters tabulated include those from raw surface streams, deep wells, and filtered supplies.

TABLE II—A COMPARISON BETWEEN CHLORINE ABSORPTION INTERVALS AND EQUAL OXYGEN-CONSUMED INTERVALS

Oxygen Consumed Reading	Interval	Chlorine Absorbed Reading	Interval
0.5	0.5	0.117	0.117
1.0	0.5	0.211	0.094
1.5	0.5	0.290	0.079
2.0	0.5	0.350	0.060
2.5	0.5	0.402	0.052
3.0	0.5	0.449	0.047
3.5	0.5	0.488	0.039
4.0	0.5	0.520	0.032
4.5	0.5	0.550	0.030
5.0	0.5	0.577	0.027
5.5	0.5	0.600	0.023
6.0	0.5	0.620	0.020
6.5	0.5	0.635	0.015
7.0	0.5	0.652	0.017

The empirical curve indicates at once that the amount of chlorine absorbed in a definite time interval does not increase in direct proportion with the increase in pollution of the water (as measured by the oxygen-consumed test), but that the 5 minute rate of

chlorine absorption shows a decreasing acceleration with increases in pollution. In other words, increases in oxygen-consumed values appear to result in *relative* decreases in the intervals between successive chlorine absorption values. This phenomenon is made clearer by reference to Table II, wherein are compared certain values obtained from the empirical curve shown in Chart 1.

The apparent correlation discussed above has considerable practical importance aside from its use in the chlorination of water supplies. Its probable existence may result in the development of an extremely rapid presumptive indicator of the quality of a water, namely, its chlorine absorption in a definite time interval. It has been found comparatively simple, in this laboratory, for instance, to differentiate between an underground supply of good quality and a comparatively poor surface supply, simply by means of a chlorine absorption test made in 5 minutes. The information gained would seem to be capable of wider application to the entire field of water treatment. As a rapid diagnostic index of changes in quality of water supplies, the chlorine absorption test appears to offer a fruitful field for investigative effort.

CHLORINE ABSORPTION AND EFFECTIVE DISINFECTION DOSAGE

The practical effectiveness of any chlorine treatment is necessarily measured and conditioned by its ability to eliminate the significant bacterial life in the water. The preliminary determination of a dose which may be subsequently found to be effective has been the primary objective of past investigations in this field. In practically all of these methods of presumptive testing for effective dosage, chlorine absorption tests have played an important rôle. It is of interest, therefore, at this point to review briefly several of the methods of chlorine control now in use and to discuss the principles underlying their application.

American practice in the chlorination of water supplies has always been sharply differentiated from the foreign. In general, the foreign sanitarians have employed chlorine doses appreciably higher than those in use on this continent. This policy has been the resultant of a conservative conception of the whole question of chlorination and has therefore left its impress upon the modern systems of chlorination control. A study of the various methods of presumptive tests for the effective doses discloses the common assumption, independently promulgated, that the chlorine absorption in definite intervals bears some definite but apparently unknown relation to disinfection accomplishment. This definite relationship is, however, the subject of a wide difference of opinion among individual sanitarians, with always the sharp demarcation between the foreign and domestic viewpoints.

The principle underlying practically all of the chlorination control procedures is that of measuring the amount of available chlorine absorbed by the water to be disinfected in a given period of time. To this amount a factor of safety is usually added, giving a resultant so-called effective chlorine index. It is clear

that the important element in the above procedure is the time element. The time interval taken for the measurement of the chlorine absorption is dependent upon the consideration of the death rate of the bacteria under the particular conditions. A dose measured in the light of the above principle is a safe dose only if the time interval used in its evaluation is amply sufficient to provide for adequate bacterial destruction. The problem of measurement of chlorine dosage resolves itself, therefore, into the question, "What is the safe time interval for the chlorine absorption test?"

The literature of chlorination suggests various answers to this question. Adams,¹ in his discussion of the chlorination of the water for Toronto, Canada, seems to assume that 3 minutes (plus a factor of safety) is a sufficient time interval for such a test. The basis for his criterion is not apparent. He states, however, that "by conducting a series of tests it was determined that Color No. 2 represented a surplus of chlorine in the finished water that would guarantee efficiency in bacterial destruction at all times, and in the great majority of cases would not give taste or odor, and under no circumstances a bad taste or odor." Color No. 2 was equivalent to the intensity of color existing with a definite excess of available chlorine.

That such a short time interval as the above is not universally applicable is evidenced by a survey of the data reported by Race.² It would appear from a number of the experiments there cited that effective sterilization or even approximately fair destruction is frequently not obtained even after a 60 minute interval. The application of a 3 minute absorption test to such a condition would demand, of course, an auxiliary factor of safety of high proportions in order to eliminate the danger of ineffective dosage.

Dienert,³ of the city of Paris, France, approaches this problem in the conservative manner suggested in the preceding statement. He not only stipulates factors of safety abnormally high in comparison with American practice, but uses in addition a chlorine absorption time interval of 15 minutes. His procedure of presumptive testing is of sufficient interest to quote at length in this discussion. His statements follow:

For the treatment of water we use always a quantity of available chlorine equal to that absorbed in a quarter of an hour increased by 0.5 p. p. m. We estimate that to sterilize a clear water with a quantity of chlorine determined as we have just said, 3 hours contact are necessary. If, for certain reasons, we are obliged to distribute water before this delay, we must increase the quantity of chlorine and bring it up to 1.00 instead of 0.5 p. p. m.

Thus, let us take a water whose absorption of available chlorine in a quarter of an hour is equal to 0.2 p. p. m. If the water must be distributed in a very short time we would add 1.2 p. p. m. in order to sterilize it. If we should store the water longer than 3 hours, we would use only $0.2 + 0.5 = 0.7$ p. p. m. of available chlorine.

We have established, in following the bacterial content of river or turbid waters treated with doses of free chlorine of from

1.00 to 1.5 p. p. m., that at certain moments *B. coli* was not destroyed. Safety in treatment demands the use of a dose of free chlorine a little higher than the doses given above.

Professor Santoliquido,¹ of Italy, adds to the general theory by stating that "the bactericidal action of chlorine is not instantaneous for any particular bacterium; in order that the action should result, there is always necessary a contact period, which, at a minimum, must be from 10 to 20 minutes."

Costa and Pecker² modify somewhat the system of presumptive test for chlorine dosage by eliminating the factor of safety and using their so-called "chlorine index." The index appears to differ but slightly, in its evaluation, from the usual chlorine absorption tests reported by other authors and in our own discussion. They establish as a principle or hypothesis that the useful dose for the purification of water is determined by the total quantity of chlorine fixed by the water in a given time and under definite conditions. They have determined, as a result of experience, that the initial dose of chlorine to be used in evaluating their index should be 5 p. p. m. As to the period of contact for the test, the authors have taken the figure of 30 minutes, which they state "is generally adopted for the purification of water by chemical substances."

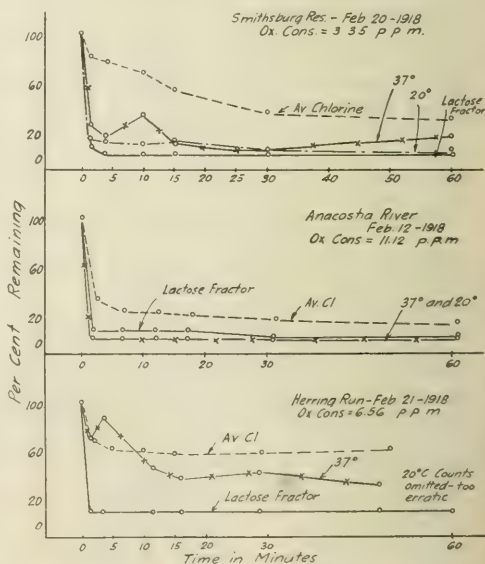


FIGURE 2. A COMPARISON OF THE RATES OF CHLORINE ABSORPTION AND BACTERIAL DESTRUCTION

These authors declare further, that they have been able to decide after more than 2 years' experimental work that the sterilization of water is not very often obtained if the quantity of chlorine used does not reach the figure fixed by the index, and that these latter figures give quantities sufficient for purification.

¹ "Note on the Purification of Potable Water by Calcium Hypochlorite," Office International D'Hygiene Publique, May 1918.

² "The Determination of the Useful Dose of Chlorine for the Purification of Water: The Chlorine Index," *Compt. rend.*, February 1918.

¹ "Water Chlorination Experiences at Toronto, Canada," *Am. J. Pub. Health*, August 1916.

² "Some Aspects of Chlorination," *J. Am. Water Works Assoc.*, June 1916; "Chlorination and Chloramine," *Ibid.*, March 1918.

³ "New Perfections in the Chlorination of Waters," *La Technique Sanitaire et Municipale*, February 1917.

The foregoing discussion seems to indicate the absence of any general agreement either as to the necessary time interval for the chlorine absorption test or the relative scale of factor of safety. The evidence as to the velocity of bacterial destruction under widely varying conditions is far from complete. If the rates of disinfection on Chart 2 (experimental data) are approximately as shown, it would seem that a 30 minute absorption plus a high factor of safety is hardly necessary. It is doubtful, too, whether such factors of safety as 0.5 to 1.00 can be universally employed under such conditions as exist in Maryland, where frequently the period of contact before consumption is so brief as to preclude a dose which would result in such excessive amounts of free chlorine at the tap.

A general survey of this phase of chlorination discloses a need for additional data regarding the velocities of disinfection under actual operating conditions. That the conceptions of this phase are inadequately developed is evidenced by the wide discrepancy in the phenol coefficients of chlorine, for example, quoted in current literature.¹

FIVE OR THIRTY MINUTE ABSORPTION TEST?

For practical purposes, any rapid method of presumptive indication of efficient dosage is particularly valuable. It remains to be determined, however, whether the substitution of a rapid 5 for a safer 30 minute test will result in any practical diminution of a necessary safety factor. The demonstration of such an effect either in the positive or negative direction would demand manifestly far more experimental proof than the present writers are in a position to adduce.

TABLE III—SHOWING THE ADDITIONAL PERCENTAGES OF AVAILABLE CHLORINE ABSORBED BY DIFFERENT WATERS IN INCREASED TIME INTERVALS

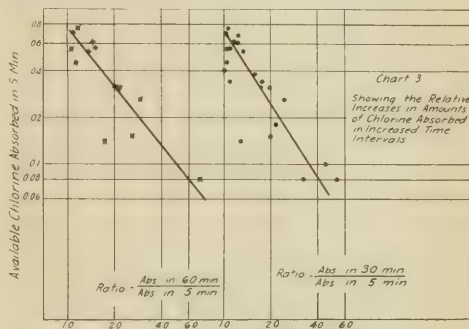
SAMPLE	Initial Dose of Chlorine = 1.00 p. p. m.			Temperature 20° C		
	Per cent of Initial Chlorine Absorbed in—			Ratio of Per cent Chlorine Absorbed—		
	5 min.	30 min.	60 min.	5 min.	30 min.	60 min.
1 Surface.....	45	47	50	1.04	1.12	1.12
2 Surface.....	53	57	58	1.04	1.06	1.06
3 Surface.....	31	60	62	1.95	2.00	2.00
4 Surface.....	38	60	..	1.59	..	..
5 Surface.....	61	71	..	1.17	..	..
6 Surface.....	53	70	72	1.32	1.36	1.36
7 Surface.....	56	61	84	1.09	1.50	1.50
8 Surface.....	61	79	88	1.21	1.44	1.44
9 Surface.....	31	53	63	1.71	2.02	2.02
10 Surface.....	68	84	..	1.24	..	..
11 Surface.....	34	59	..	1.74	..	..
12 Surface.....	18	39	..	2.15	..	..
13 Filtered.....	08	25	..	3.22	..	..
14 Well.....	15	30	38	2.00	2.53	2.53
15 Well.....	08	42	56	5.25	7.00	7.00
16 Well.....	14	18	24	1.29	1.71	1.71
17 Well.....	10	45	49	4.50	..	..
18 Surface.....	70	72	75	1.03	1.08	1.08
19 Surface.....	34	37	..	1.09	..	..
20 Surface.....	40	40	..	1.00	..	..
21 Surface.....	26	64	75	2.48	2.90	2.90
22 Surface.....	75	80	85	1.07	1.14	1.14

It is of interest, however, in connection with this problem, to refer to the experimental data shown in Table III and Chart 3. These experiments² were de-

¹ Rideal, *J. Roy. San. Inst.*, 31 (1910), 33-45, gives 2.2, while Schneider, "Bacteriological Methods—Food and Drugs," p. 260, gives 12.5.

² The determinations were all made according to the 1917 A. P. H. A. Standard Method of Water Analysis. The oxygen-consumed readings were obtained in acid digestion, with a period of digestion of 30 minutes at a boiling temperature. No corrections for oxidizable mineral substances were applied to the oxygen-consumed values, since these latter were to be used to represent the total oxygen demand of the water supply. In the measurement of available chlorine in the different experiments the temperature used was 20° C.

signed to answer in a preliminary manner the question as to the effect of increased time intervals upon the total amounts of available chlorine absorbed by different waters. In other words, what additional information is gained by extending absorption tests from 5 to 30 or 60 minutes? Chart 3, with its few empirical values, seems to suggest that the importance of increasing the period of test decreases materially with the increased values of the initial 5 minute absorptions. The evidence in Table III would appear to point to the conclusions that increased safety in dosage is occasioned by the 30 minute test in those waters where the factor of safety is least essential, whereas little additional safety is gained in waters of higher initial absorption or in those where it is most necessary.



If the 5 minute chlorine absorption test is at all indicative of the pollute content of a water, then the evaluation of a 30 minute test seems to add but little necessary information as to effective dosage. It would hardly be advantageous to use a 30 minute test, in preference to a 5, when the former increases greatly the dosages for good waters and affects but little those of poorer waters. The addition of a constant factor of safety as, for instance, 0.2 to the 5 minute absorption value would apparently accomplish the same result in the routine control of chlorination as the use of a longer absorption time interval.

STATE OF MARYLAND
DEPARTMENT OF HEALTH
BALTIMORE

ACCURATE DETERMINATION OF SOIL NITRATES BY PHENOL DISULFONIC ACID METHOD

By H. A. NOYES

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Nitrates play such an important rôle in plant nutrition and the amounts present in the soil are so dependent on bacterial activities that frequent determinations of soil nitrates are important in soil fertility investigations. The two general methods used for the determination of nitrates are the reduction and the colorimetric methods. Both methods have been criticized by various investigators. The present paper is a report of work to determine how and to what extent the different errors in the colorimetric (phenol disulfonic acid) method can be overcome in soil work.

The more important points studied in connection with the method were: first, the nature of the soil and the amount of nitrates contained; second, the method of extracting nitrates; third, the effect of chlorides on the nitrate determination; fourth, the method of obtaining clear, colorless soil extracts; fifth, the removal of interfering substances; sixth, the size of the aliquot; seventh, the evaporation of the aliquot and the adding of reagents; eighth, the colorimeter and how to use it; and ninth, the method of expressing results.

MODIFIED METHOD

Place 50 g. of soil in salt mouth bottles, add 200 cc. of distilled water to each bottle, stopper each bottle and shake it vigorously in turn with the other bottles, for one minute. Repeat the shakings of all bottles twice, allowing about one-half hour to elapse between shakings. Prepare 4-in. funnels, place good grade, 24-cm. folded filter papers in them. Filter off the soil extract from each bottle into a 200 to 300 cc. beaker as follows: Each bottle, in turn, is picked up and shaken vigorously. Then such a portion of the soil and water mixture as will about two-thirds fill the filter is poured, including as much as possible of the soil, onto the filter. When a number of such filtrations have been started pick up the beaker under the first filtration, shake it, and pour its contents back into the filter paper. Do the same with the other beakers and repeat in order until all the filtrates are clear. When upwards of 50 cc. of clear filtrate have been obtained, pipette off 5 cc. of each filtrate into 2 1/2-in. porcelain evaporating dishes. Evaporate the solutions to dryness on a steam bath. Remove the dishes from the steam bath as soon as dry and place them in order on the laboratory table. In order to have a standard for comparison, 5 cc. of a potassium nitrate solution containing 0.0001 g. of nitrate per cc. are placed in an evaporating dish and treated as one of the soils undergoing the test. When the dishes are cool 1 cc. of the phenol disulfonic acid solution prepared according to Chamot, Pratt and Redfield* is added to each dish. Add the phenol disulfonic acid drop by drop in a ring about the dish and let these drops spread down over the dry residue. Rotate each dish so as to make sure that the acid will come in contact with all the residue and react with all the nitrates present. Allow the dishes to stand about 15 min. and then add down the side of each dish, so as not to have the water and acid mix too rapidly, approximately 15 cc. of cold distilled water. Now, by means of a wash bottle having a fine jet, add dilute (4 to 8 per cent) ammonium hydroxide solution until the yellow color is permanent. The fine jet of ammonium hydroxide solution is played over and through the solution in such a way as to prevent violent local heat reactions between the acid and the salts present. The standard is washed out into one of the cylinders for a Schreiner¹⁰ colorimeter and made up to the 100 mm. mark. Each division of this standard gives an easily discernible change in the nitrate color. The standard, after shaking, is placed in the right-hand side of the colorimeter. The solutions to be tested are then made up directly in the other colorimeter tube to the 100 mm. mark providing they are not over two-thirds as strong as the standard. The unknown is set at the 100 mm. mark in the left-hand side of the colorimeter and the standard is pushed up until the colors are the same. Five readings are made and the average of these is recorded.

There are occasions when some variations are advisable in the method given above.

QUANTITY OF SOIL—It is customary to use 100 g. of field soil for nitrification tests and when this is done the 100 g. of soil are put with 400 cc. of distilled water.

COLOR SOIL EXTRACTS—If the soil gives a colored water extract, or contains soluble iron, 5 g. of calcium hydroxide are added to the soil just previous to the addition of the 200 cc. of distilled water. Some mucks and manures require the addition of more than 5 g. of calcium hydroxide.

LOW NITRATE CONTENTS—If the soils contain less than 100 lbs. of nitrate per million pounds of soil, 20 cc. aliquots of the water extract are taken for the determination. This makes one division on the colorimeter with the standard equal 1.0 part nitrate per million parts of soil.

DILUTION OF STANDARD—If the soils contain but little nitrate (less than 5 parts per million) the standard is diluted one-half to increase the accuracy of the determinations.

HIGH NITRATE CONTENTS—If the solution being tested is much over one-half as strong as the standard it is diluted as follows: A tall, slender cylinder is graduated in multiples of the volume of solution necessary to fill a colorimeter tube to the 100 mm. mark. The unknown is washed directly into this cylinder and diluted with weak (0.25 to 0.5 per cent) ammonium hydroxide until the yellow color is approximately as weak as desired. The volume is then brought to the next multiple of that used in the colorimeter, the whole mixed, and the colorimeter tube filled to the 100 mm. mark and read in terms of the standard. If it is necessary to dilute the unknown more than eight times a smaller aliquot of the soil extract is worked.

THE NATURE OF SOILS AND SOIL NITRATES CONTAINED

Soils may be classified with respect to the difficulties encountered in the determination of nitrates, as follows: (1) light, medium, dark, or black sands, loams, clays, and peats; (2) those containing low, medium, or high concentrations of soluble salts; (3) those acid, neutral, or alkaline in reaction; (4) those aerated and moist, unaerated and water-logged.

The physical nature of the soil, sand, silt, peat, or clay often determines the ease with which a clear water extract can be obtained. A high concentration of soluble salts sometimes means a high concentration of nitrates⁷ and the larger the amount of soluble salts present the greater the care that has to be taken to prevent heat reactions causing losses of nitrates. Many acid soils and some sweet soils contain water-soluble organic matter. The color given by the organic matter interferes with the accuracy of the determinations made. Unaerated and water-logged soils may contain substances which interfere with the determination of nitrates.

EXTRACTION OF NITRATES FROM SOILS

No uniformity exists among different workers as to the amount of water to put with a gram of soil to extract its nitrates. Allen and Bonazzi² give a table in which they calculate that all the nitrates present in the soil are not extracted when 100 g. of soil are put with 500 cc. of water. They express the belief that nitrates are absorbed by soils. Noyes¹³ when working on the absorption of different radicals by

* Numbers refer to corresponding number in References, p. 218.

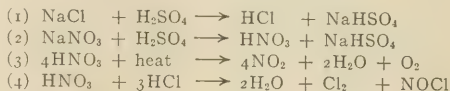
soils and decaying leaves found no absorption of nitrates but obtained nitrates from all the materials worked with. Since the nitrates of all the metals are soluble and soils contain enough soluble metallic elements to go with all the nitrates present, the work reported in Tables I and II was carried out on soils of different organic content.

TABLE I—EXTRACTION OF NITRATES FROM SOILS WITH VARYING AMOUNTS OF WATER

Soil	Nitrate Content per Million	COLORIMETER READINGS IN MILLIMETERS		
		From 50 g. Soil and 100 cc. of Water	From 50 g. Soil and 200 cc. of Water	From 50 g. Soil and 400 cc. of Water
White Sand	64	16.5	8.0	4.0
Greenhouse Loam	208	27.0	13.0	7.0
Black Sand	276	22.0	11.5	5.5
Muck	960	30.0	15.0	7.5
AVERAGE		24.0	12.0	6.0

reduced to a minimum, *i. e.*, the reagent must be added to the dry residue for best results.

The principal reactions taking place when nitrates are lost are undoubtedly the following:



The modified method, given above, is intended to overcome the losses due to chlorides by keeping the temperatures of the systems below that at which the above rapid reactions take place readily.

A small aliquot gives little material to make aqua regia and thus avoids losses from that source.

The phenol disulfonic acid reagent added drop by drop to different parts of the cold dish insures contact with all the residue and prevents high temperatures.

The addition of 15 cc. of cold water keeps down the temperatures which would favor vitiating reactions.

Slow and scattered additions from a wash bottle of the weak ammonium hydroxide solution prevent high local temperatures due to the heat of neutralization of the acid.

To study the effect of chlorides on the determination of nitrates, the results obtained with 2 and 3 times the quantity of sodium chloride, which Hilgard⁹ gives as toxic to the sugar beet, are given in Table III.

TABLE III—EFFECT OF SODIUM CHLORIDE ON NITRATE DETERMINATIONS

Soil	Nitrate Content per Million	COLORIMETER READINGS IN MILLIMETERS		
		From 50 g. Soil and 100 cc. of Water	From 50 g. Soil and 200 cc. of Water	From 50 g. Soil and 400 cc. of Water
White Sand	64	16.5	8.0	4.0
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Muck	960	30.0	15.0	7.5
AVERAGE		24.0	12.0	6.0

¹ Five cc. aliquots evaporated in each case. Roman numerals denote number of times solution was diluted for reading. Changes in reading due to added nitrate depend on number of times solutions were diluted just before reading.

² This is the only case in which the sample was the same as that used in Table I.

The tables show that water in the ratio of 2 parts of water to one part of soil was as efficient in extracting nitrates as 8 parts of water to one part of soil; and that nitrates added to soils are recovered when the nitrates are determined in the water extracts of the soils.

EFFECT OF CHLORIDES ON NITRATE DETERMINATIONS

Most investigators have recognized that chlorides when present cause a loss of nitrates by reacting with the phenol disulfonic acid reagent when it is added to the dry residue. Schreiner and Failyer,¹⁷ Stewart and Greaves,¹⁹ besides others, advocate the removal of chlorides with silver sulfate. Lipman and Sharp¹¹ object to the precipitation of chlorides by silver sulfate for they have found sulfates to cause losses of nitrates. Gericke⁸ has found that the losses of nitrates due to the presence of chlorides are overcome by adding the phenol disulfonic acid reagent directly to the aqueous extract when it is partially evaporated. Phelps and Shoub¹⁴ evaporated nitrate solutions containing 5 parts of nitrate per million to dryness. They then added 0.5, 1.0, and 2.0 cc. of distilled water before adding the phenol disulfonic acid reagent and lost nitrates where the water was added. They conclude from these results that the volume must be

Soil	Nitrate Content per Million	COLORIMETER READINGS IN MILLIMETERS		
		From 50 g. Soil and 100 cc. of Water	From 50 g. Soil and 200 cc. of Water	From 50 g. Soil and 400 cc. of Water
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Black Sand	276	22.0	11.5	5.5
Muck	960	30.0	15.0	7.5
AVERAGE		24.0	12.0	6.0

¹ The sodium chloride was added in all cases to the soil at the same time as the 200 cc. of distilled water.

² Five cc. aliquots evaporated in each case. Roman numerals denote number of times colored solution was diluted for reading.

From the results in Table III it is seen that sodium chloride in amounts as high as 24,900 parts per million may be present when nitrates are determined by this method without influencing the accuracy of the results.

THE OBTAINING OF CLEAR, COLORLESS SOIL EXTRACTS

Stewart and Greaves,¹⁸ Hill,¹⁰ Chamot, Pratt, and Redfield^{6,9} have all used either potassium alum crystals

or aluminum cream to clarify nitrate solutions. Lipman and Sharp¹¹ find potassium alum, aluminum cream, and boneblack to cause changes in the nitrate content of the soil extracts and advocate calcium oxide as the precipitant to use. Potter and Snyder¹⁵ have followed up the work of Lipman and Sharp using both calcium carbonate and calcium oxide as precipitants. They believe that calcium carbonate is the more satisfactory.

In humus work it is always recognized that calcium forms insoluble compounds known as calcium humates. In this laboratory calcium compounds have been used to precipitate water-soluble organic substances which color the solutions. In preliminary tests calcium carbonate was more efficient than calcium oxide. It is known that calcium oxide does not slake well in the presence of large quantities of water and so calcium hydroxide and calcium carbonate were compared as precipitants. The calcium hydroxide was made from calcium oxide by adding distilled water to the lumps of calcium oxide until they yielded a fine white powder.

The method of filtration described in the procedure removes all silt, clay, and suspended matter making the calcium hydroxide unnecessary for the removal of these substances.

Table IV gives the relative efficiency of freshly prepared calcium hydroxide and carbonate for precipitating colored soluble organic matter from water extracts of two soils and manure when added to the material just before the 200 cc. of distilled water were added.

TABLE IV—COMPARISON OF CALCIUM HYDRATE AND CALCIUM CARBONATE FOR REMOVING SOLUBLE ORGANIC COLORS FROM SOIL EXTRACTS

	Comparative Colors of Soluble Organic Material as Measured by Colorimeter Readings
Manure, sweet ¹	
Water extract alone.....	1.00
Water and calcium carbonate ¹ extract.....	0.56 and 1.00 Av. 0.78
Water and calcium hydroxide ¹ extract.....	0.10 and 0.11 Av. 0.11
Hudson Peat, acid	
Water extract alone.....	1.00
Water and calcium carbonate extract.....	1.78
Water and calcium hydroxide extract.....	0.61
Water, calcium carbonate and hydroxide extract.....	0.95
Water and 10 g. calcium hydroxide extract.....	0.25
Water and 15 g. calcium hydroxide extract.....	0.25
Greenhouse Soil, sweet	
Water extract alone.....	1.00
Water and calcium carbonate extract.....	1.19
Water and calcium hydroxide extract.....	0.29
Water, calcium carbonate and hydroxide extract.....	0.29

¹ Five grams used unless otherwise noted.

The results reported in Table IV show 5 g. of calcium hydroxide to be a much more efficient precipitant of the water-soluble organic matter than the calcium carbonate.

It was considered advisable to see what effects calcium carbonate and calcium hydroxide had on the determination of nitrates in a well fertilized silt loam, an acid black sand, a partially decayed sample of horse manure, a sweet muck, a very acid muck, a soil containing soluble iron, and a rich greenhouse soil. It was considered that if it could be shown that the interfering color was removed from these soils by either reagent and that the reagent did not affect the nitrate content of the soil a big difficulty in the determination of soil nitrates on soils that yield colored extracts

would be overcome. To obtain data nitrates were determined on the selected soils both with and without precipitants and with a known amount of added nitrate. The results of these tests and a test on a clay loam, showing that a precipitant is not needed to remove the silt and clay when the modified method is used, are given in Table V.

With the silty clay loam which gives a colorless extract the method of filtering has taken care of the silt and clay and all three determinations give 60 parts of nitrate per million pounds of soil. This is confirmatory of the statement of Gericke⁸ that, "The use of calcium oxide and also calcium carbonate for the clarification of aqueous extracts, especially from soils, is recommended as a precipitant that is both efficient and non-interfering in the nitrate determinations."

The silt loam gave a water extract slightly colored; calcium carbonate caused the solution to be much more colored, while calcium hydroxide removed the color. The hydroxide was superior to the carbonate.

With the acid black sand the hydroxide and the carbonate yielded very similar results to those obtained on the silt loam.

The horse manure gave a highly colored extract. The calcium carbonate while not giving a strong colored water extract still gave an extract which yielded more color after evaporation and treatment with the phenol disulfonic acid reagent than the water extract by itself did. The calcium hydroxide did not entirely remove the color but gave results that were close to correct when we consider that one millimeter difference in the colorimeter reading was equivalent to 32 parts of nitrate.

In the case of sweet muck the calcium carbonate gave very high results for the added nitrate. The lower results with calcium hydroxide showed the removal of water-soluble organic matter and nearly the correct result for the added nitrate.

With the acid muck instead of adding nitrate, one and two additional applications of the calcium hydroxide were used with this soil, since it was found that the colorimeter readings were showing that the calcium carbonate and water extracts were much higher than the water extract and that the amount of calcium hydroxide used had only taken out a part of the color (Table IV). The additional applications of calcium hydroxide reduced the color slightly more but gave the same nitrate results. The water, calcium carbonate, and calcium hydroxide extract lies between the calcium carbonate alone and the water extract.

The greenhouse soil had been heavily manured and fertilized for at least two years. The calcium carbonate extracted more color than the water alone while the calcium hydroxide gave an extract containing much less color than the water extract (Table IV). Diluting the solutions 32 times before reading removed the interference of the colored extracts since the nitrate determinations agreed exactly when read by the precision method to be described later.

The results obtained show that calcium hydroxide should be used to prevent the water-soluble organic

TABLE V—COMPARISON OF CALCIUM HYDRATE AND CALCIUM CARBONATE FOR CLARIFYING WATER EXTRACTS OF SOILS

	Colorimeter Readings Mm.	Difference in Readings Due to Clarifying Agents	Difference in Readings Due to Clarifying Agents and Added Nitrates	Nitrates per Million Parts of Soil	Effects of Clarifying Agents on Parts Nitrate per Million Parts of Soil	Effects of Added Nitrate on Parts Nitrate per Million Parts of Soil
Silty Clay Loam						
Water extract.....	15	..	..	60	..	...
Water ¹ and calcium carbonate ² extract.....	15	0	..	60	0	...
Water and calcium hydroxide ³ extract.....	15+	0+	..	60	0	...
Silt Loam Conn. Valley Onion Soil						
Water extract.....	12	..	..	48	..	...
Water and calcium carbonate extract.....	45	+33	..	180	+132	...
Water and calcium hydroxide extract.....	11	..	..	44	-4	...
Water, added nitrate and calcium carbonate extract.....	65	..	+20	260	+132	+80
Water, added nitrate and calcium hydroxide extract.....	29	..	+18	116	-4	+72
Black Sand, Acid II(a)						
Water extract.....	30	..	..	240	..	...
Water and calcium carbonate extract.....	47	+17	..	376	+136	...
Water and calcium hydroxide extract.....	30	0	..	240	0	...
Water, added nitrate and calcium carbonate extract.....	59	..	+12	472	+136	+96
Water, added nitrate and calcium hydroxide extract.....	38.5	..	+8.5	308	0	+68
Hum. Maure VIII						
Water extract.....	65	..	..	2,082	..	...
Water and calcium carbonate extract.....	75	+10	..	2,400	+320	...
Water and calcium hydroxide extract.....	40	-25	..	1,280	-800	...
Water, added nitrate and calcium carbonate extract.....	70.5	..	-4.5	2,256	+320	-144
Water, added nitrate and calcium hydroxide extract.....	42+	..	+2.0	1,344	-800	+64
Muck, Sweet IV						
Water extract.....	56	..	..	896	..	...
Water and calcium carbonate extract.....	49	-11	..	720	-186	...
Water and calcium hydroxide extract.....	55+	-1	..	880+	-16	...
Water, added nitrate and calcium carbonate extract.....	62	..	+17	992	-186	+272
Water, added nitrate and calcium hydroxide extract.....	59	..	+4	944	-16	+64
Sand Containing Soluble Iron II						
Water extract.....	2	..	..	16	..	...
Water and calcium carbonate extract.....	18	+8	..	80	+64	...
Water and calcium hydroxide extract.....	18	+16	..	144	+128	...
Water, added nitrate and calcium carbonate extract.....	19	..	+9	152	+64	+72
Water, added nitrate and calcium hydroxide extract.....	26	..	+8	208	+128	+64
Muck, Acid II						
Water extract.....	14	..	..	112	..	...
Water and calcium carbonate extract.....	52	+38	..	416	+304	...
Water and calcium hydroxide extract.....	10	-4	..	80	-32	...
Water, calcium carbonate and calcium hydroxide extract.....	41	+27	..	328	216	...
Water and calcium hydroxide (10 g.) extract.....	10	-4	..	80	..	...
Water and calcium hydroxide (15 g.) extract.....	10	-4	..	80	-32	...
Greenhouse Soil XXXII						
Water extract.....	61	..	..	7808	..	...
Water and calcium carbonate extract.....	61	0	..	7808	0	...
Water and calcium hydroxide extract.....	61	0	..	7808	0	...
Water, calcium carbonate and calcium hydroxide extract.....	61	0	..	7808	0	...

(a) Roman numerals state number of times solution made from 5 cc. aliquot was diluted for reading.

¹ Fifty grams air-dry soil and 200 cc. of water in each case.² Six grams precipitated calcium carbonate added to each 50 g. soil before the 200 cc. of distilled water.³ Six grams precipitated calcium hydroxide added to each 50 g. soil before the 200 cc. of distilled water.⁴ Nitrate added to increase the nitrate content 68 parts per million parts of soil.⁵ Solutions filtered before reading to get rid of precipitated iron compounds.

matter appearing in the water extract of soils from affecting the nitrate determination. The method of filtering gives clear extracts free from clay.

REMOVAL OF INTERFERING SUBSTANCES

In Table V we have the results obtained by comparing, on one soil, calcium carbonate and calcium hydroxide as precipitants of water-soluble iron. The hydroxide was found by chemical tests to have removed all the water-soluble iron while the carbonate only removed a portion of it. It is to be noted that the presence of soluble iron in the solution used for the nitrate determination not only interfered with the reading due to presence of precipitated iron oxide and hydroxides but caused a loss of nitrates as well. Phelps and Shoub¹⁴ remove iron and manganese from water by boiling with sodium hydroxide, while our results lead us to believe that if calcium hydroxide is added to the soil at the same time the water used for extraction is added, extracts are obtained which are free from soluble substances that may be precipitated on the subsequent neutralization of the solution with ammonium hydroxide.

SIZE OF ALIQUOT

Stewart and Greaves¹⁸ advocate a 50 cc. aliquot or other convenient quantity, while Allen¹ uses 250 cc. of the soil extract which represents 50 g. of soil. The standard decided on in this laboratory contains only 0.5 mg. of nitrate. We use the small aliquot of extract for two reasons:

1—To keep down the quantity of soluble salts in the residue which come in contact with the sulfuric acid reagent.

2—To avoid the necessity of diluting solution just before reading.

As mentioned previously, a 20 cc. aliquot of the water extract is desirable where the nitrogen content is under 100 parts per million. In cases of very high concentrations of nitrates less than 5 cc. aliquots have been successfully used provided they were procured with accurately calibrated pipettes.

EVAPORATION OF ALIQUOT AND ADDING OF REAGENTS

The aliquot is evaporated to dryness on the steam bath, removed, cooled, and when cold the residue is treated with 1 cc. of phenol disulfonic acid made according to the directions of Chamot, Pratt, and Redfield.⁶ The time for and the method of adding reagents are given in detail under the directions for carrying out the modified method.

THE COLORIMETER AND HOW TO USE IT

No uniformity exists in the colorimeters used in different laboratories. In ten of the articles listed in the bibliography attached no mention is made of the make of colorimeter used. The colorimeters mentioned were Schreiner's, Sargent-Kennicott, Lovibond's, and Duboscq's.

The monocular telescope, the verniers, and the prism glass tubes of the Duboscq colorimeter are features desired. The small length of the columns of

liquid used make this colorimeter undesirable for use in reading soil nitrates for any small volume error is too large a per cent of the total aliquot read.

Lovibond's tintometer is accurate but expensive. To use this tintometer advantageously with soils it would be necessary to use one or perhaps two colors standardized to specific nitrate contents and make dilutions to correspond to these colors. Tubes for such dilutions and the making of dilutions to exactly check specific standards would not be applicable to the conditions under which the major portion of the soil nitrate work is done.

The Campbell-Hurley⁴ colorimeter has the monocular telescope, compares long columns of liquid, and gets results in terms of cubic centimeters of standard equivalent to a larger number of cubic centimeters of the unknown. It was not the one chosen for it is too easily broken in the routine laboratory.

Schreiner^{16,17} has improved on the Whitson²⁰ colorimeter which works on the same principle as the Campbell-Hurley apparatus. The Schreiner, commonly known as the Bureau of Soils colorimeter, when properly made, seems adapted to soil nitrate determinations in both agronomical and chemical laboratories. The advantages of this apparatus are that it is a simple camera of wood, all working parts can be handled individually, and the solutions come in contact with glass only. Tubes meeting the following requirements have been found satisfactory and can be obtained under the following specifications. Tubes are to be of clear glass having flat bottoms, inside and out, of same thickness. Graduations are to be in millimeters, zero being the level of the top of the glass bottom. Bore of all tubes should be exactly the same. Tubes meeting these specifications will each hold the same amount when filled to equal heights.

READING OF COLORIMETER

In the procedure given it was advocated that the unknown be diluted until it is less than two-thirds as strong as the standard. This is based on experience in reading nitrates where it was found that when the unknown and standard are almost the same strength we are not sure of the reading to within 3 or 4 mm., while if the standard is, for example, 4 times as strong as the unknown, the slightest movement of the standard up or down makes a sharp change in the color comparison. The following figures show how closely five readings on the same solutions agree.

TABLE VI—REPRESENTATIVE COLORIMETER READINGS
INDIVIDUAL READINGS

INDIVIDUAL READINGS					AVERAGE
16.0	16.0	16.0	16.5	16.5	16.2
19.0	20.0	19.0	20.0	19.0	19.4
23.0	22.5	22.5	22.5	22.0	22.4
10.5	9.5	10.0	10.0	10.0	10.0
13.5	13.5	13.0	13.0	13.5	13.3
30.0	30.0	29.0	29.5	30.5	29.8
36.0	37.0	35.0	37.0	36.5	36.3
37.5	35.5	36.0	36.5	36.0	36.3
60.0	62.0	61.0	60.5	62.5	61.2

SUMMARY

1—The phenol disulfonic acid method for nitrates is adapted to the accurate determination of soil nitrates in large as well as in small amounts.

2—Nitrates are completely extracted from soil by water, and nitrates added to soils were completely recovered in addition to those present in the soil.

3—Chlorides have no effect on nitrate determinations made by the phenol disulfonic acid method when the precautions outlined are taken.

4—Clear soil extracts always result when solutions are properly filtered through paper filters.

5—Calcium hydroxide has been found to be the best precipitant of colored water-soluble organic matter.

6—Calcium hydroxide removes interfering inorganic substances such as water-soluble iron.

7—The use of small aliquots of the water extract reduces the amounts of interfering salts, prevents heat reactions with the sulfuric acid, and thereby increases the accuracy of the determination.

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THE EFFECT OF FERTILIZERS ON THE COMPOSITION OF HOPS

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INTRODUCTION

It is well recognized that the effect of fertilizers on the total yield of crop per unit of land can be readily interpreted, usually in favor of the fertilizers employed. It is equally well recognized that a study of some one of the principal constituents of the crop, as influenced by the fertilizers, does not reveal such easily interpreted results. In fact, the results obtained from such a study are usually of such a heterogeneous character as to preclude any positive conclusions. The major portion of the vast amount of work done on the effect of fertilizers deals with results of yield per

unit of land, a small portion deals with effects on the quality of the crop, and a very small remainder deals with the effect on some one or more constituents of the crop.

The material presented here has to do largely with the effect of systematic fertilization over a period of years on some of the principal constituents of hops grown on experimental plots in the Sacramento Valley, California. The numerous other factors that influence yield and quality have of necessity been more or less ignored, mainly because at present there are no known methods of measuring the effect of these factors. Furthermore, these factors become more or less conflicting especially when the investigation covers a long-time experiment.

A search of the literature shows that no work on fertilizer experiments on hops has been directed toward the increase or improvement of the principal economic constituents.

DESCRIPTION OF THE FERTILIZER PLOTS

The plots to be fertilized were laid out in the spring of 1913 at Wheatland, California. Two one-acre plots were selected and labeled J. R. field and No. 1 field, respectively. The former is located on upland, or, as it is known locally, "red land;" the latter on a sandy loam, formerly the bed of Bear River, and is sedimentary in character.

The J. R. field was laid out as follows: One acre of red land was selected which lies close to a slough and laid out into plots such that each plot contained four rows of hops of one hundred hills each. The rows run from east to west and the numbered plots from south to north. The general slope of the field is from south to north and Plot 1 is at the best end of the field, while Plot 15 is very near the slough. The field was not irrigated.

TABLE I—PLOT NUMBERS AND PLAN OF FERTILIZATION

PLOT NO.	FERTILIZER	Rate per Acre Lbs.	Dealer's Analysis Per cent
1.....	Sulfate of Potash	270	K ₂ O, 50
2.....	Acid Phosphate	500	P ₂ O ₅ , 17 to 18
3.....	Nitrate of Soda	240	N, about 16
4.....	Check		
5.....	Acid Phosphate	500	P ₂ O ₅ , 17 to 18
6.....	Sulfate of Potash	270	K ₂ O, 50
7.....	Check		
8.....	Acid Phosphate	500	P ₂ O ₅ , 17 to 18
9.....	Nitrate of Soda	240	N, about 16
10.....	Sulfate of Potash	270	K ₂ O, 50
11.....	Acid Phosphate	500	P ₂ O ₅ , 17 to 18
12.....	Nitrate of Soda	240	N, about 16
13.....	Check		
14.....	Lime	750	Hydrated pure lime, about 74
15.....	Check		
16.....	Sulfate of Potash	270	K ₂ O, 50
17.....	Acid Phosphate	500	P ₂ O ₅ , 17 to 18
18.....	Lime	750	Hydrated pure lime, about 74
19.....	Check		
20.....	Rotted Barnyard Manure	2000	Hydrated pure lime, about 74
21.....	Check		
22.....	Complete Hop Fertilizer	500	Phosphoric acid (basic bone superphosphate), 10 Available phosphoric acid soluble and available, 7.5 Equal to bone phosphate of lime, 21.80 Sulfate of potash, 9.25 Nitrogen from bone and blood, 2 to 4 Nitrogen from nitrate, 2 Nitrogen estimated as ammonia, 3.64

The No. 1 field was selected and laid out in the old bed of Bear River and arrangements made for irrigation. This field is about one mile distant from the J. R. field. Each plot contains three rows of hops of

one hundred hills each, the rows running from south to north and the numbered plots from east to west. The soil varies somewhat, being poorest at the east end of the field. In both fields the rows are 7 ft. apart and the hops 6½ ft. apart in the row.

The numbered plots and the amount of fertilizer applied per acre are given in Table I. The analyses on the dealer's tags are included in this table.

EXPERIMENTAL WORK

The hops for experimental purposes were picked each year from Row 2 in each plot of each field. By picking the inner row of each plot a representative sample was obtained, and all danger of influence of the fertilizer of the neighboring plots eliminated. The crops of 1914, 1915, and 1916 were dried, sulfured in the usual manner, and then sent to Washington, D. C., for analysis. The analyses were made approximately one hundred days after the hops were picked. The picking was done each year on the same date, the last week in August.

On receipt in Washington, D. C., the hops were stored in a dry laboratory until analyzed. The following determinations were made on each sample: moisture, determined only in order to have a comparable working basis; soft resins, hard resins, total resins, soluble ash, insoluble ash, and total ash. The moisture was determined by drying over sulfuric acid; the soft and hard resins by a method formerly found satisfactory;¹ the soluble and insoluble ash by the Optional Official Method in *Bulletin 107* of the Bureau of Chemistry.²

RESINS IN HOPS FROM THE FERTILIZED PLOTS

The experiment brings out clearly the difficulties encountered when a correlation is sought between fertilizer applied and percentage of yield of hop constituents. The results of the resin determinations from the J. R. field are presented in Table II.

The percentage of soft resins in the hops from year to year shows no cumulative effect of the fertilizers, neither do the results indicate any special benefit from the fertilizers applied. The percentage of yield of hard resins varies in like manner as do also the total resins.

Taking each plot as an individual, with one exception that of Plot 2, no continuity is noted in the results year by year. The yield of resins is found to vary from year to year with as much irregularity in the fertilized plots as it does in the check plots. Such a seasonal variation has been found to be true in the case of hops from other sections. The check plots yield the same varying results. Taken generally, the check plots yield as high or higher a percentage of resins than do the fertilized plots. This result is no doubt due to the fact that the fertilizer tends to produce a high vegetative yield with a corresponding diminution in the percentage of the resins present.

¹ C. A. Russell, "The Resins in Hops from Various Geographic Localities," *TMS JOURNAL*, 7 (1915), 1033.

² "Official and Provisional Methods of Analysis," U. S. Department of Agriculture, Bureau of Chemistry, *Bulletin 107* (revised), 238.

TABLE II—YIELD OF RESINS IN THE HOPS FROM THE J. R. FIELD, FROM 1914 TO 1916, INCLUSIVE

PLOT No.	SOFT RESINS				HARD RESINS				TOTAL RESINS			
	1914 Per cent	1915 Per cent	1916 Per cent	Three- Year Average Per cent	1914 Per cent	1915 Per cent	1916 Per cent	Three- Year Average Per cent	1914 Per cent	1915 Per cent	1916 Per cent	Three- Year Average Per cent
1.....	9.02	6.09	14.78	9.96	4.70	5.38	4.35	4.81	13.72	11.47	19.13	14.77
2.....	12.23	14.23	12.79	13.09	4.06	2.17	3.34	3.26	16.29	16.42	16.33	16.34
3.....	10.00	11.33	16.85	12.73	4.79	4.03	2.48	3.77	14.79	15.36	19.33	16.49
4.....	13.30	6.56	16.88	13.25	5.97	5.66	2.11	4.58	19.27	12.22	18.99	16.82
5.....	14.40	12.16	13.94	13.50	4.03	5.44	2.58	3.35	18.43	15.60	16.52	16.85
6.....	12.91	9.89	9.37	10.62	3.81	3.70	3.47	3.68	16.72	13.55	12.84	14.30
7.....	11.41	7.00	16.45	11.62	3.88	6.33	2.00	4.07	15.29	13.33	18.45	15.69
8.....	10.00	4.00	10.20	8.07	3.95	3.38	2.82	3.38	13.95	7.38	13.02	11.45
9.....	13.66	14.32	12.21	13.40	4.06	2.98	3.08	3.38	17.72	17.30	15.29	16.77
10.....	12.90		11.89	12.39	2.49		2.30	2.54	15.69		14.29	14.99
11.....	12.70	12.58	16.80	14.03	4.08	4.00	2.25	3.44	16.78	16.58	19.05	17.47
12.....	12.22	15.50	12.79	13.50	3.79	4.52	3.16	3.82	16.01	20.02	15.95	17.32
13.....	11.65	10.38	9.00	10.34	3.39	3.61	3.33	3.44	15.04	13.99	12.33	13.78
14.....	11.97	15.04	10.31	12.44	3.27	5.87	3.12	4.09	15.24	20.91	13.43	16.52
15.....	10.62	16.82	11.47	12.97	3.53	2.18	2.79	2.83	14.15	19.00	14.26	15.80
YEARLY AVERAGE.....	11.93	11.11	13.05	...	4.01	4.09	2.89	...	15.93	15.21	15.94	...

AVERAGE PERCENTAGE OF YIELD IN CHECK PLOTS

Year	Soft Resins	Hard Resins	Total Resins
1914.....	12.172	3.914	16.092
1915.....	13.156	4.232	17.388
1916.....	12.306	3.062	15.368

TABLE III—YIELD OF RESINS IN THE HOPS FROM THE NO. 1 FIELD, FROM 1914 TO 1916, INCLUSIVE

PLOT No.	SOFT RESINS				HARD RESINS				TOTAL RESINS			
	1914 Per cent	1915 Per cent	1916 Per cent	Three- Year Average Per cent	1914 Per cent	1915 Per cent	1916 Per cent	Three- Year Average Per cent	1914 Per cent	1915 Per cent	1916 Per cent	Three- Year Average Per cent
1.....	15.70	8.91	11.05	11.88	3.88	1.77	2.24	2.63	19.58	10.68	13.29	14.51
2.....	16.12	8.52	10.10	11.58	3.21	2.23	2.81	2.75	19.33	10.75	12.91	14.33
3.....	14.58	10.61	12.05	12.41	3.31	4.68	2.91	3.63	17.89	15.29	14.97	16.04
4.....	15.62	14.78	10.90	13.76	4.62	3.21	3.02	3.61	20.24	17.99	13.92	17.37
5.....	10.58	12.94	12.19	11.90	3.47	2.11	2.14	2.57	14.05	15.05	14.33	14.47
6.....	12.23	9.51	10.87	10.87	3.13	4.43	3.49	3.35	15.36	13.94	14.36	14.22
7.....	16.48	7.48	10.00	11.32	2.65	5.33	3.33	3.77	19.13	12.81	13.33	15.09
8.....	12.89	8.68	10.10	10.35	3.39	6.13	3.33	4.28	16.28	14.81	13.43	14.83
9.....	13.02	13.89	10.87	12.59	5.28	5.10	3.57	4.65	18.30	18.99	14.44	17.24
10.....	12.17	10.09	12.83	11.53	3.99	4.06	3.81	3.95	16.16	14.15	16.14	15.48
11.....	13.51	11.19	14.12	12.94	2.48	3.91	3.11	3.16	15.99	15.10	17.23	16.10
12.....	13.08	12.22	11.63	12.31	3.70	3.60	3.66	3.65	16.78	15.82	15.29	15.96
13.....	14.55	14.65	9.57	12.92	3.72	3.21	5.44	4.12	18.27	17.86	15.01	17.04
14.....	15.05	14.94	11.30	13.76	2.37	2.86	3.68	2.97	17.42	17.80	14.98	16.73
15.....	11.82	11.59	10.65	11.35	3.09	3.16	4.11	3.45	14.91	14.75	14.76	14.80
YEARLY AVERAGE.....	13.80	11.33	11.18	...	3.49	3.71	3.37	...	17.29	15.04	14.55	...

AVERAGE PERCENTAGE OF YIELD IN CHECK PLOTS

Year	Soft Resins	Hard Resins	Total Resins
1914.....	13.59	3.56	17.15
1915.....	12.23	4.13	16.37
1916.....	11.34	3.46	14.81

In other words, the plant working under the stimulus of the fertilizer produces many cones but does not produce a corresponding amount of resins. The ratio of yield of cones to percentage of resins does not remain constant.

The results of the analyses of the hops from the J. R. field show in the aggregate that the application of the various fertilizers did not increase the percentage of soft or hard resins, neither did these applications cause any marked diminution in the percentage of yield of resins.

The percentage of yield of resins in the hops from the No. 1 field is given in Table III.

The yield of resins from this irrigated field shows seasonal variations similar to those of the J. R. field. There is, however, a difference in the yearly averages. A marked diminution is apparent in the yearly average percentage of yield of soft and total resins in all the plots. The percentage of hard resins does not diminish but varies with the year. Here it is clearly demonstrated that the various fertilizers produce vegetative matter but do not produce a corresponding percentage of resins, rather the percentage of yield of resins diminishes year by year even in the check plots. This gradual decrease in resins in the check plots is due, it is believed, to the cumulative effect of the irrigation. A comparison of the 3-year average of the various

plots shows that the percentage of yield of soft resins is generally greater in the check plots than it is in the fertilized plots. This variation is not so marked in the percentage of yield of hard resins, nor in the percentage of yield of total resins. However, the general tendency throughout is for the check plots to yield a greater percentage of resins than do the fertilized plots. As was found true in the J. R. field, no particular fertilizer or combination of fertilizers produced a percentage of yield that stands out distinctly above the general run. Plot 15 is the only one that gives any indication of continuity.

For the purpose of more careful comparison, the percentage of yield of total resins from the J. R. field and the No. 1 field is tabulated in Table IV.

From Table IV the decrease in percentage of total resins in the No. 1 field plots is very apparent, compared as they are with the corresponding plots in the J. R. field. In 1914, 20 per cent of the plots in No. 1 field yielded a smaller percentage of resins than did similar plots in the J. R. field, and in 1915 and 1916 this number had increased to 60 per cent. The 3-year average also shows that the No. 1 field has 60 per cent of the plots with a lower yield of resins than corresponding plots in the J. R. field.

The yearly averages from all the plots in the J. R. field are very uniform; those in the No. 1 field diminish

from 17.29 per cent yield of resins in 1914 to 14.55 per cent in 1916. The check plots of the No. 1 field diminish in like manner, whereas similar plots in the J. R. field show no such uniformity.

TABLE IV—COMPARISON OF THE YIELD OF TOTAL RESINS IN HOPS FROM THE FERTILIZED PLOTS IN THE J. R. AND THE NO. 1 FIELD

PLOT No.	1914		1915		1916		Three-Year Average	
	J. R. Field	No. 1 Field	J. R. Field	No. 1 Field	J. R. Field	No. 1 Field	J. R. Field	No. 1 Field
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1.....	13.72	19.58	11.47	10.68	19.13	13.29	14.77	14.51
2.....	16.29	19.33	16.42	10.75	16.33	12.91	16.34	14.33
3.....	14.79	17.89	15.36	15.29	19.33	14.97	16.49	16.04
4.....	19.27	20.24	12.22	17.99	18.99	13.92	16.82	17.37
5.....	18.43	14.05	15.60	15.05	16.52	14.33	16.85	14.47
6.....	16.72	15.36	13.35	13.94	12.84	14.36	14.30	14.22
7.....	15.29	19.13	13.33	12.81	18.45	13.33	15.69	15.09
8.....	13.95	16.28	7.38	14.81	13.02	13.45	14.45	14.83
9.....	17.72	18.30	17.30	18.99	15.29	14.44	16.77	17.24
10.....	15.69	16.16	...	14.15	14.29	16.14	14.99	15.48
11.....	16.78	15.99	16.58	15.10	15.05	17.23	17.47	16.10
12.....	16.01	16.78	20.02	15.82	15.95	17.32	15.99	15.99
13.....	15.04	18.27	13.99	17.86	12.33	15.01	13.78	17.04
14.....	15.24	17.42	20.91	17.80	13.43	14.98	16.52	16.73
15.....	14.15	14.91	19.00	14.75	14.26	14.76	15.80	14.80
YEARLY AVERAGE	15.93	17.29	15.21	15.04	15.94	14.55	...	...

COMPARISON OF THE YEARLY AVERAGE YIELD OF TOTAL RESINS FROM THE CHECK PLOTS

FIELD	1914	1915	1916
	Per cent	Per cent	Per cent
J. R.	16.09	17.38	15.36
No. 1.....	17.15	16.37	14.81

To complete the data on yield of resins from the fertilized plots, the available soft resins, which are of most economic importance, in pounds per acre have been calculated, from data on yield of hops per acre not incorporated in this paper, and are presented in Table V.

TABLE V—COMPARISON OF THE CALCULATED AVAILABLE SOFT RESINS IN POUNDS PER ACRE FROM THE FERTILIZED PLOTS IN THE TWO EXPERIMENTAL FIELDS

PLOT No.	1914		1915		1916		Three-Year Average	
	J. R. Field	No. 1 Field	J. R. Field	No. 1 Field	J. R. Field	No. 1 Field	J. R. Field	No. 1 Field
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1.....	203	434	178	240	440	425	273	366
2.....	267	418	335	248	448	525	377	377
3.....	250	425	294	217	436	390	326	344
4.....	345	474	211	513	492	523	349	503
5.....	362	246	195	459	419	576	325	460
6.....	273	330	175	533	219	410	223	331
7.....	275	397	326	264	598	452	399	371
8.....	281	359	178	395	466	581	308	445
9.....	324	351	334	528	282	419	313	432
10.....	293	363	...	337	356	602	325	434
11.....	305	415	282	339	404	740	330	498
12.....	240	394	268	342	232	516	246	417
13.....	279	399	221	555	224	473	241	475
14.....	283	476	464	437	187	410	311	480
15.....	208	344	384	296	349	488	313	376
YEARLY AVERAGE	279	385	280	362	370	508	...	...

COMPARISON OF THE YEARLY AVERAGE YIELD OF THE CHECK PLOTS

FIELD	1914	1915	1916
	Per cent	Per cent	Per cent
J. R.	274	307	271
No. 1.....	395	355	448

The effect of fertilizers, in general, on the yield of available soft resins per acre of land is fairly evident. In 1914 the J. R. field had an increase of 70 per cent of the fertilized plots over the yearly average of the check plots; in 1915 this percentage of increase fell to 50 and in 1916 it rose to 80. The increase in resins in the fertilized plots over the average of the 3-year averages of the check plots likewise amounts to 80 per cent of the total number of fertilized plots. In 1914 the No. 1 field had an increase in soft resins in 50 per cent of the fertilized plots over the yearly average of the check plots; in 1915 this percentage of increase fell to 40, and in 1916 it rose to 90. The in-

crease in resins in the fertilized plots, over the average of the 3-year averages of the check plots, fell to 60 per cent of the total number of check plots.

Comparing the yields of soft resins from the two fields, year by year, we find that in 1914, 93 per cent of the plots of the No. 1 field yield more resins than the corresponding plots in the J. R. field; in 1915, 64 per cent; and in 1916, 80 per cent. Taken as a whole, the No. 1 field plots average higher each year than the J. R. field plots. This higher yield can be attributed to irrigation which no doubt makes the plant food in the fertilizers more available.

The tabulated results do not indicate that any particular fertilizer or combination of fertilizers is particularly adapted to increasing the yield of available soft resins in pounds per acre over the other fertilizers or combinations employed. In 1916, Plots 10 and 11 in the No. 1 field, which contain lime, produced a high yield of soft resins. In 1915 and in 1914 no large increase was noted for these plots. Here again the question of outside factors enters the problem and it is difficult to say if the influence of the lime is responsible for the large yield of resins. It appears that the only conclusion that can be drawn with any certainty is that irrigation on any fertilized plot tends to produce more hops and incidentally more available soft resins, even though the percentage of yield is decreased.

ASH IN HOPS FROM THE FERTILIZED PLOTS

It was expected that the ash of hops from the various fertilized and check plots would show considerable variation. A certain gradual increase in the amount of ash present was also expected, since the hop roots are perennial and the plant food was available in good quantity. The results of the analyses indicate that the suppositions were not true. In fact, the same erratic variations are found in the percentage of ash as were found in the percentage of resins, with this difference that there is slightly less range from season to season.

The percentages of ash in the hops from the J. R. field are given in Table VI.

The soluble ash, which contains the chlorides, sulfates, phosphates, and carbonates of potassium and sodium, and slight amounts of the chlorides and sulfates of calcium and magnesium, shows considerable range of variation, not only plot by plot each year, but also year by year. The effect of the fertilizers on the ash in hops from the plots of the J. R. field shows no greatly significant differences. The variation in percentage does not remain constant from season to season. The check plots yield like variable results. Plots 3 and 9, which are checks, yield fairly uniform results throughout the time of the experiment.

Plot 2, fertilized with nitrate of soda, indicates a gradual yearly decrease in percentage of soluble ash, whereas Plot 4, fertilized with acid phosphate only, shows a gradual yearly increase in soluble ash of the hops. Plot 5, fertilized with sulfate of potash only, shows a marked yearly decrease in soluble ash of the hops. When nitrate of soda is added to the formula,

TABLE VI—ASH IN THE HOPS FROM THE J. R. FIELD, FROM 1914 TO 1916, INCLUSIVE

PLOT No.	SOLUBLE ASH				INSOLUBLE ASH				TOTAL ASH			
	1914 Per cent	1915 Per cent	1916 Per cent	Three- Year Average Per cent	1914 Per cent	1915 Per cent	1916 Per cent	Three- Year Average Per cent	1914 Per cent	1915 Per cent	1916 Per cent	Three- Year Average Per cent
1.....	1.20	2.34	1.73	1.756	10.15	7.28	10.05	9.16	11.35	9.62	11.78	10.92
2.....	1.90	1.59	1.28	1.590	9.40	7.98	11.32	9.57	11.30	9.57	12.60	11.16
3.....	1.90	1.68	1.48	1.686	10.65	8.33	10.76	9.91	12.55	10.01	12.24	11.60
4.....	1.65	1.98	2.10	1.910	10.45	10.73	9.20	10.13	12.10	12.71	11.30	12.04
5.....	3.20	2.10	1.69	2.330	9.45	10.58	10.58	10.12	12.65	12.43	12.27	12.45
6.....	1.70	3.50	1.51	2.255	12.70	9.28	11.29	11.09	14.40	12.78	12.80	13.33
7.....	2.65	2.23	2.83	2.570	9.65	9.90	10.24	9.93	12.30	12.13	13.07	12.50
8.....	1.75	2.61	1.87	2.076	9.95	8.93	10.15	9.68	11.70	11.54	12.02	11.75
9.....	1.12	1.38	1.19	1.230	10.93	9.23	10.73	10.30	12.05	10.61	11.92	11.33
10.....	3.00	3.65	2.05	2.900	9.85	9.79	11.67	10.44	12.85	13.44	13.72	13.34
11.....	3.30	2.43	1.06	2.263	12.33	10.03	10.01	10.79	15.63	12.46	11.07	13.05
12.....	1.90	3.26	1.61	2.256	12.05	8.92	9.97	10.31	13.95	12.18	11.58	12.57
13.....	2.00	3.64	2.27	2.636	11.45	8.91	10.70	10.35	13.45	12.55	12.97	12.99
14.....	3.13	1.67	2.15	2.650	9.35	8.98	10.84	9.72	12.48	10.65	12.99	12.04
15.....	2.70	2.83	1.83	2.453	10.05	8.71	11.01	9.92	12.75	11.54	12.84	12.38
YEARLY AVERAGE.....	2.20	2.45	1.77	...	10.56	9.13	10.56	...	12.76	11.58	12.33	...

AVERAGE PERCENTAGE OF ASH IN CHECK PLOTS

Year	Soluble Ash	Insoluble Ash	Total Ash
1914.....	1.950	11.136	13.086
1915.....	2.298	8.948	11.246
1916.....	1.588	10.718	12.306

TABLE VII—ASH IN THE HOPS FROM THE NO. 1 FIELD FROM 1914 TO 1916, INCLUSIVE

PLOT No.	SOLUBLE ASH				INSOLUBLE ASH				TOTAL ASH			
	1914 Per cent	1915 Per cent	1916 Per cent	Three- Year Average Per cent	1914 Per cent	1915 Per cent	1916 Per cent	Three- Year Average Per cent	1914 Per cent	1915 Per cent	1916 Per cent	Three- Year Average Per cent
1.....	3.10	2.77	3.26	3.04	7.53	9.96	8.79	10.65	12.73	12.13	11.83	11.83
2.....	3.90	2.85	2.83	3.19	9.15	8.32	7.68	8.38	13.05	11.17	10.51	11.57
3.....	2.85	1.37	3.31	2.51	8.45	7.07	6.88	7.46	11.30	8.44	10.19	9.97
4.....	3.35	1.79	2.94	2.69	7.55	7.49	7.58	7.54	10.90	9.28	10.52	10.23
5.....	3.30	2.51	2.21	2.67	8.05	5.90	7.81	7.25	11.35	8.41	10.02	9.92
6.....	3.85	1.71	3.26	2.94	12.25	9.08	11.33	10.88	16.10	10.79	14.59	13.82
7.....	2.75	2.66	2.74	2.71	9.20	7.34	8.88	8.80	11.90	10.00	12.62	11.51
8.....	3.05	3.07	3.42	3.18	9.45	8.52	8.02	8.66	12.50	11.59	11.44	11.84
9.....	2.90	1.36	2.83	2.36	10.00	9.04	7.73	8.92	12.90	10.40	10.56	11.28
10.....	1.20	3.25	3.84	2.66	8.20	9.33	9.23	8.92	9.40	12.58	12.77	11.58
11.....	2.30	4.27	3.21	3.26	9.75	6.14	9.15	8.34	12.05	10.41	12.36	11.60
12.....	2.25	2.12	3.71	2.69	10.00	9.58	8.30	9.29	12.25	11.70	12.01	11.98
13.....	2.42	2.01	2.22	2.21	7.75	9.35	8.63	9.23	11.77	10.85	11.44	11.44
14.....	1.50	1.25	2.76	2.38	8.75	9.48	8.22	8.81	12.50	10.73	10.98	11.39
15.....	2.52	2.31	2.23	2.01	9.82	8.21	8.28	8.77	11.32	10.52	10.51	10.78
YEARLY AVERAGE.....	2.69	2.35	2.96	...	9.16	8.34	7.84	...	11.85	10.69	10.80	...

AVERAGE PERCENTAGE OF ASH IN CHECK PLOTS

Year	Soluble Ash	Insoluble Ash	Total Ash
1914.....	3.12	7.89	13.01
1915.....	1.56	8.85	10.41
1916.....	3.17	8.49	11.66

making the combination acid phosphate, nitrate of soda, and sulfate of potash, as in Plot 7, the soluble ash increases and remains fairly constant throughout the time of the experiment. Lime in combination with sulfate of potash and acid phosphate, Plot 10, yields a hop with a high percentage of soluble ash, which varies from year to year. Lime applied alone, as in Plot 11, apparently causes the soluble ash content of the hop markedly to diminish throughout the experimental season. Rotted barnyard manure, as applied on Plot 13, causes no significant differences in the soluble ash, other than those which can be laid to seasonal variation. The percentage of insoluble ash was found to vary from season to season without apparent regularity due to any influence of the fertilizer. The amount of total ash present also varies from year to year throughout the time of the experiment. The yearly averages indicate that approximately the same results are obtained in the aggregate throughout the time of the experiment, that is, no definite increase or decrease in the percentage of soluble, insoluble, or total ash. The ash of the hops grown on the check plots apparently follows the general run and no doubt is influenced to a considerable degree by seasonal variations.

In the No. 1 field, the results of the ash determinations indicate that variations occur which apparently

follow no definite lines and that irrigation does not influence these variations into definite order. The results of the ash determinations on hops from the No. 1 field are given in Table VII.

The soluble ash content of hops from the various plots is without doubt increased by the use of irrigation. This increase is not, however, uniform or regular. On comparing this field plot by plot with the J. R. field, quite different effects of the fertilizers are noted. Plot 2, fertilized with nitrate of soda, shows a gradual diminution in the percentage of soluble ash from year to year. This is also true of Plot 2 of the J. R. field. Plot 4, fertilized with acid phosphate, shows a most erratic yield of soluble ash from season to season. Plot 5, fertilized with sulfate of potash, shows a gradual falling off in the percentage of soluble ash each season. Likewise in this irrigated field, when nitrate of soda, acid phosphate, and sulfate of potash are added in combination, as in Plot 7, a constant percentage of soluble ash is obtained throughout the time of the experiment. Lime in combination with sulfate of potash and acid phosphate, Plot 10, yields a hop with marked increase in soluble ash, after the first season of application. Lime applied alone, Plot 11, causes a growth of hops that yields a high percentage of soluble ash but the yearly variation is marked. Rotted barnyard manure plus the irrigation affects the yield

TABLE VIII—COMPARISON OF THE YIELD OF SOLUBLE ASH IN THE HOPS FROM THE TWO EXPERIMENTAL FIELDS

PLOT No.	1914		1915		1916		Three-Year Average	
	J. R. Field	No. 1 Field	J. R. Field	No. 1 Field	J. R. Field	No. 1 Field	J. R. Field	No. 1 Field
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
1.....	1.20	3.10	2.34	2.77	1.73	3.26	1.75	3.04
2.....	1.50	3.90	1.59	2.85	1.28	2.83	1.59	3.19
3.....	1.90	2.85	1.68	1.37	1.48	3.31	1.68	2.51
4.....	1.63	3.35	1.98	1.79	2.10	2.94	1.91	2.69
5.....	3.20	3.30	2.10	2.51	1.69	2.21	2.33	2.67
6.....	1.70	3.85	3.50	1.71	1.51	3.26	2.25	2.94
7.....	2.65	2.75	2.23	2.66	2.83	2.74	2.57	2.71
8.....	1.75	3.05	2.61	3.07	1.87	3.42	2.07	3.18
9.....	1.12	2.90	1.38	1.36	1.19	2.83	1.23	2.36
10.....	3.00	1.20	3.65	3.25	2.05	3.34	2.90	2.66
11.....	3.30	2.30	3.27	4.27	1.06	3.21	2.68	3.26
12.....	1.90	2.25	3.26	2.12	1.61	2.71	2.25	2.69
13.....	2.00	2.42	3.64	2.01	2.27	2.22	2.63	2.21
14.....	3.13	3.75	1.67	1.25	2.15	2.76	2.65	2.58
15.....	2.70	1.50	2.83	2.31	1.83	2.25	2.45	2.01
YEARLY AVERAGE.....	2.20	2.69	2.45	2.35	1.77	2.96	..	..

COMPARISON OF THE YEARLY AVERAGE OF SOLUBLE ASH IN THE HOPS FROM THE CHECK PLOTS

FIELD	1914	1915	1916
	Per cent	Per cent	Per cent
J. R. No. 1.....	1.95	2.29	1.58
No. 1.....	3.12	1.56	3.17

of soluble ash fairly uniformly year by year. The yearly average of all the fertilized plots and check plots indicate that taken generally the percentage of soluble ash is not widely influenced by the use of fertilizers and irrigation. Specific plots do show wide variation due to the effect of the two agents, fertilizer and irrigation. The average percentage of ash in the check plots varies widely.

The percentage of insoluble ash in hops from the No. 1 field is variable from season to season, but at the same time there is a gradual tendency for the amount of insoluble ash to decrease. This decrease is especially noticeable in the yearly average which shows marked diminution each year. There is also a tendency for the total ash content of the hops from the plots of the No. 1 field to grow less each season.

For purposes of comparing the ash content of hops from the two experimental fields, the soluble, insoluble, and total ash percentages have been tabulated in Tables VIII, IX, and X.

In general, the amount of soluble ash in hops is largest in the No. 1 field. This increase over the J. R. field results is due to irrigation, for both fields received a like amount of fertilizer. The yearly average percentage of soluble ash in hops from the check plots of the No. 1 field was approximately twice that of the J. R. field. In 1915 the J. R. field plots show more soluble ash than the No. 1 field.

The yearly average percentage of yield of soluble ash of all the plots is largest in the No. 1 field in both 1914 and 1916, but slightly less in 1915. It is difficult to attribute the results obtained in 1915 to any one cause or combination of causes, but rather it appears that this varying year's returns must be attributed to the uncertainty that applies to all fertilizer long-time experiments.

The amount of insoluble ash present in hops from the various plots of both experimental areas, varies to a considerable degree, not only plot by plot in each year but also year by year. No definite important differences can be traced throughout the experiment for any particular plot. There is, however, a marked falling off in percentage of insoluble ash throughout

TABLE IX—COMPARISON OF THE YIELD OF INSOLUBLE ASH IN THE HOPS FROM THE TWO EXPERIMENTAL FIELDS

PLOT No.	1914		1915		1916		Three-Year Average	
	J. R. Field	No. 1 Field	J. R. Field	No. 1 Field	J. R. Field	No. 1 Field	J. R. Field	No. 1 Field
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
1.....	10.15	7.55	7.28	9.96	10.05	8.87	9.16	8.79
2.....	9.40	9.15	7.98	8.32	11.32	7.68	9.56	8.38
3.....	10.65	8.45	8.33	10.07	10.76	6.88	9.91	7.46
4.....	10.45	7.55	10.73	7.49	9.20	7.38	10.12	7.54
5.....	9.45	8.05	10.33	5.90	10.58	7.81	10.12	7.25
6.....	12.70	12.25	9.28	9.08	11.29	11.33	11.09	10.88
7.....	9.65	9.20	9.90	7.34	10.24	9.88	9.93	8.80
8.....	9.95	9.45	8.82	10.15	10.15	8.02	9.67	8.66
9.....	10.93	10.00	9.23	9.04	10.73	7.73	10.29	8.92
10.....	9.85	8.20	9.79	9.33	11.67	9.23	10.43	8.92
11.....	12.33	9.75	10.03	6.14	10.01	9.15	10.79	8.34
12.....	12.05	10.00	8.92	9.38	9.97	10.40	10.31	9.99
13.....	11.45	9.35	8.91	9.74	10.70	8.63	10.35	9.23
14.....	9.35	8.75	8.98	9.48	10.84	8.22	9.72	8.81
15.....	10.05	9.82	8.71	8.21	11.01	8.28	9.92	8.77
YEARLY AVERAGE.....	10.56	9.16	9.13	8.34	10.56	7.84	..	..

COMPARISON OF THE YEARLY AVERAGE OF INSOLUBLE ASH IN THE HOPS FROM THE CHECK PLOTS

FIELD	1914	1915	1916
	Per cent	Per cent	Per cent
J. R. No. 1.....	11.13	8.94	10.71
No. 1.....	7.89	8.85	8.49

the time of the experiment in the yearly average of the No. 1 field. Also there is a marked difference in the amount of soluble ash present in hops from the irrigated and non-irrigated fields. The decrease in amount of insoluble ash present in the No. 1 field hops from year to year is attributable to the fact that the plant contains more soluble ash constituents due to the effect of irrigation plus plenty of available plant food.

TABLE X—COMPARISON OF THE YIELD OF TOTAL ASH IN HOPS FROM THE TWO EXPERIMENTAL FIELDS

PLOT No.	1914		1915		1916		Three-Year Average	
	J. R. Field	No. 1 Field	J. R. Field	No. 1 Field	J. R. Field	No. 1 Field	J. R. Field	No. 1 Field
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
1.....	11.35	10.65	9.62	12.73	11.78	12.13	10.91	11.83
2.....	11.30	13.05	9.57	11.17	12.60	10.51	11.15	11.57
3.....	12.55	11.30	10.01	8.44	12.24	10.19	11.60	9.97
4.....	12.10	10.90	12.71	9.28	11.30	10.52	12.03	10.23
5.....	12.65	11.35	12.43	8.41	12.27	10.02	12.45	9.92
6.....	14.40	16.10	12.78	10.79	12.80	15.99	13.32	13.82
7.....	12.30	11.90	12.13	10.00	13.07	12.62	12.50	11.51
8.....	11.70	12.50	11.34	11.59	12.02	11.44	11.75	11.84
9.....	12.05	12.90	10.61	10.40	11.92	10.56	11.32	11.28
10.....	12.85	9.40	13.44	12.58	13.72	12.77	13.33	11.58
11.....	15.63	12.05	12.46	10.41	11.07	12.36	13.05	11.60
12.....	13.95	12.25	12.18	11.70	11.58	12.01	12.57	11.98
13.....	13.45	11.77	12.53	11.74	12.97	10.85	12.99	11.44
14.....	12.48	12.50	10.65	10.73	12.99	10.98	12.04	11.39
15.....	12.75	11.32	11.54	10.52	12.84	10.51	12.37	10.78
YEARLY AVERAGE.....	12.76	11.85	11.58	10.69	12.33	10.80	..	..

COMPARISON OF THE YEARLY AVERAGE OF TOTAL ASH IN THE HOPS FROM THE CHECK PLOTS

FIELD	1914	1915	1916
	Per cent	Per cent	Per cent
J. R. No. 1.....	13.08	11.24	12.30
No. 1.....	13.01	10.41	11.66

Comparison of the total percentage of ash in hops from the two experimental fields reveals the fact that no one fertilizer or combination of fertilizers tends to produce more ash than do other fertilizers or combinations, neither does fertilization increase the ash content over that of check plots. The variations that exist plot by plot and year by year are normal and due entirely to factors outside of control. The one prominent difference is that on the irrigated field the total percentage of ash, as revealed by the yearly average of all the plots, is less than on the non-irrigated field. This difference also holds good in the yearly average percentage of total ash in hops from the check plots.

SUMMARY

In 1913, experiments on the effect of fertilizers on the composition of hops were begun at Wheatland, California. Two fields, each one acre in area, were laid out into fifteen plots each. The J. R. field was not irrigated, whereas the No. 1 field was irrigated. Corresponding plots in each field received like amounts of fertilizer each year during 1914, 1915, and 1916.

Each year a sample of hops from each plot was analyzed for soft resins, hard resins, total resins, soluble ash, insoluble ash, and total ash.

The percentage of yield of resins in the J. R. field varied with the various plots but the variations were not constant from year to year, the yearly average of all the plots being approximately the same throughout the experiment.

The percentage of yield of resins in the No. 1 field varied, as in the J. R. field, but the yearly average of all the plots gradually decreased.

The available soft resins in pounds per acre varied in each plot in each field each year. No continuity was noted as the effect of any fertilizer applied. There is, however, an increase in the amount of soft resins available each year. This increase is greatest in the No. 1 field.

The increase in amount of resins available is not due to an increase in the percentage of resins due to fertilizers, but is due to an increased yield of cones which are less rich in resins as the vegetative yield increases. In other words, the fertilizer causes a great increase in vegetative yield which, due to forced succulent growth, causes a smaller percentage of resins to be formed.

The percentage of soluble ash in the hops from the J. R. field varied with the season. Some apparent regularities in certain plots are traceable throughout the time of the experiment. It is doubtful if these regular effects are due wholly to the effect of the fertilizer; and the supposition is advanced that the effect of other factors plays an important rôle in producing the results as found.

The percentage of insoluble ash in the hops from the J. R. field likewise varied with the season. The percentage of total ash was fairly constant in 1914 and in 1916, but decreased somewhat in 1915.

The percentage of soluble ash in the hops from the No. 1 field also varied with the season, but plot for plot it ran higher than in the corresponding plots in the J. R. field, except in the year 1915 when considerable variation occurred.

The percentage of insoluble ash in the hops from the No. 1 field likewise varied with the season, being always lower plot for plot than the corresponding plots in the J. R. field, except in the year 1915 when variation occurred, and with this exception, that the yearly average shows a gradual decrease in the amount of insoluble ash present.

The total ash of the two fields varied with the various plots but shows no apparent significant differences throughout the time of the experiment. The yearly average of the ash from all the plots is less

each year in the No. 1 field than it is in the J. R. field, and this yearly average likewise grows somewhat less from year to year.

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THE SOLVENT ACTION OF DILUTE CITRIC AND NITRIC ACIDS ON ROCK PHOSPHATE

By J. A. STENIUS

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This Station has recently undertaken a series of experiments, one of the objects of which is to ascertain under what conditions the process of sulfur oxidation, termed sulfonation, will bring about an increase in the availability of phosphorus in rock phosphate.

In connection with the experiments in progress, it was of course of prime importance to secure a method by which a reliable index of the changes in availability of the phosphorus compounds in rock phosphate and soil mixtures attributable to sulfonation could be obtained.

Although the monocalcium and dicalcium phosphates are the forms of phosphorus commonly regarded as available, the sulfonation process, being to a great extent the result of biological agencies, will very probably convert some of the phosphorus into organic forms which may be more available than the tricalcium phosphate in the phosphate rock itself.

Neutral ammonium citrate has for a number of years, although without really valid and conclusive reasons, been regarded as the reagent whereby these two groups of phosphorus compounds, the available and non-available, could be distinguished one from the other, because it has been generally considered that neutral ammonium citrate possesses the faculty of dissolving dicalcium as well as monocalcium phosphate, leaving tricalcium phosphate intact. This is not strictly true, however, as neutral ammonium citrate will also dissolve varying amounts of phosphorus from tricalcium phosphate, the amount taken into solution depending upon the conditions under which the extraction is made.

In so far as the adaptability of neutral ammonium citrate is concerned, one cannot refrain from being skeptical as to its value for the determination of the availability of phosphorus, especially when this procedure is applied to composts or mixtures including rock phosphate and soil.

It was found, for instance, in the investigations pertaining to the effect of sulfur oxidation on the availability of phosphorus, that the available phosphorus of the untreated Wooster soil was 30 parts per million of soil; this comparatively high figure is surely contradicted by the fact that this particular soil responds very readily to applications of fertilizers carrying phosphorus. In fact, crop yields in fertility experiments of this soil show that phosphorus is the limiting element.

When neutral ammonium citrate is used to measure changes in mixtures of soil and rock phosphate, the amount of organic matter extracted from the soil,

judged by the color of the solution, approaches that obtained when the soil is extracted with the usual strength of ammonium hydroxide used for humus determinations.

While it must follow from this that neutral ammonium citrate cannot serve as a means for determining the absolute amount of available phosphorus, there still remains the possibility that it may be used to obtain an indication of changes which have occurred as a result of treatment.

Before the precipitation of the phosphorus with ammonium molybdate solution, there must be a complete oxidation of the organic material extracted from the soil, in order to convert any organic phosphorus compounds present into the form of orthophosphate, and at the same time to destroy the citrate itself, the presence of which will prevent the complete precipitation of the phosphorus.

The oxidation of the organic matter with aqua regia or with fuming nitric acid is unsatisfactory on account of the large amount of reagents and time required as well as the close attention necessary.

Destruction of the organic matter by ignition with magnesium nitrate is undoubtedly the most convenient method, the only possible objection being that the high temperature necessary may cause a partial change of the phosphorus compounds into forms which are not soluble in either hydrochloric or nitric acid.

The questionable value of the neutral ammonium citrate procedure for determining the availability of phosphorus produced in various mixtures which include rock phosphate and soil, together with the difficulties involved in destruction of the organic matter extracted from the soil, and that contributed by the neutral ammonium citrate, led to tests being made to determine the possible value of dilute citric and nitric acid solutions as substitutes for neutral ammonium citrate solutions.

SOLUBILITY IN CITRIC ACID

Citric acid of various strengths has been recommended as a suitable solvent for the determination of available phosphorus, and has been used with reported satisfaction in soil investigations.

In experimental work in which a number of acids were employed as solvents for the phosphorus of the soil, Russell and Prescott¹ found that the amount of phosphorus dissolved varies greatly with the nature of the acid employed. They also found that some of the acids were themselves absorbed by the soil. As a rule they found that an acid which is absorbed by the soil to a considerable extent also possesses a high extraction power for phosphorus.

The acids investigated were absorbed in the following order:

Oxalic	} most
Citric	
Phosphoric	
Sulfuric	
Hydrochloric	} least
Nitric	

It should not be inferred from this that citric acid when present will entirely satisfy the soil's absorptive properties; the fact is that when both are present, citric acid takes the place of some of the phosphoric acid in the absorption complex. It must be remembered that the solubility of the phosphorus in the soil as determined by a solvent is the resultant of the difference between the phosphorus dissolved and that absorbed from the solution by the soil. From a soil with a great absorptive power there is always a smaller percentage of the phosphorus capable of being taken into solution by the solvent extracted than from a soil with a small absorption power, although the absolute amounts of such soluble phosphorus compounds may stand in the reverse order.

Citric acid, which shows a high extractive power due to the fact that this acid is itself absorbed when brought into contact with the soil, would therefore seem to be a very desirable acid for extracting the phosphorus of the soil for the purpose of discrimination between the available and the unavailable phosphorus compounds.

To determine the solvent action of dilute solutions of citric acid varying in concentration within comparatively narrow limits, from 0.1 per cent to 0.05 per cent, extractions were made under the following conditions:

3 g. portions of rock phosphate were extracted with 100 cc. of citric acid of the prescribed strength by shaking in shaking machine at ordinary room temperature for 30 min. The solutions were diluted to a volume of 500 cc. After filtering, 200 cc. portions were taken for the phosphorus determinations.

From the amounts of phosphorus extracted, as shown in Table I, it is evident that variations in the strength of citric acid, even when a very weak solution is employed, decidedly influence the solubility of the phosphorus of rock phosphate.

TABLE I—SOLUBILITY OF ROCK PHOSPHATE IN CITRIC ACID SOLUTIONS OF VARIOUS CONCENTRATIONS

Strength of Acid Per cent	Phosphorus Extracted Per cent
0.5	0.4287
0.4	0.3700
0.3	0.2569
0.2	0.1918
0.1	0.1113

The availability of the phosphorus in the particular rock phosphate used in this experimental work was 0.2 per cent when 3 g. of rock phosphate were treated with 100 cc. neutral citrate solution for 30 min. at 65° C.; the citrate solution was then diluted to 500 cc., filtered, and 200 cc. taken for determination of phosphorus.

From the results obtained with the different strengths of citric acid it appears that an extraction with 0.2 per cent citric acid under these conditions has given a value for the availability of phosphorus in rock phosphate which is about equal to that obtained by using neutral ammonium citrate.

The additional data presented in Table II show that varying the amount of rock phosphate treated with a given volume of citric acid has a decided bearing on the solvent power of this acid for the phosphorus in rock phosphate.

¹ "The Reaction between Dilute Acids and the Phosphorus Compounds of the Soil," *J. Agr. Science*, September 1916, pp. 65-110.

TABLE II—INFLUENCE OF QUANTITY OF ROCK PHOSPHATE EXTRACTED

Weight of Rock Phosphate Treated Grams	Total Phosphorus Extracted Per cent
0.1	4.289
0.5	1.334
1.0	0.747
3.0	0.1918

When 0.1 g. of rock phosphate instead of 3 g. was treated with 100 cc. citric acid, it was found that 4.289 per cent of the phosphorus was taken into solution, and a still higher figure would doubtless have been obtained if a smaller amount of rock phosphate had been treated with the same strength of acid, or a larger volume of acid of the same strength had been used.

The weights of rock phosphate indicated were extracted with 100 cc. of 0.2 per cent citric acid in 500 cc. flasks, shaking every 5 min. during a period of 30 min., after which the solutions were diluted to 500 cc. and filtered.

When 0.1 g. of rock phosphate was treated with 100 cc. of 0.2 per cent citric acid, with continuous agitation in a shaking machine for a period of 30 min., it was found that 5.390 per cent of phosphorus was dissolved as compared with 4.289 per cent obtained when the shaking was not continuous during the extraction period.

When the same weight, 0.1 g., of phosphate rock was mechanically shaken for 30 min. with 500 cc. of 0.2 per cent citric acid, it was found that not less than 6.410 per cent phosphorus was extracted.

EFFECT OF BASICITY

As pointed out by Cousins and Hammond¹ citric acid cannot be used as a discriminating agent for available phosphorus if applied to calcareous soils unless the basicity due to carbonates, etc., is compensated for by the use of a corresponding extra amount of citric acid.

For the purpose of determining the amount of phosphorus extracted by citric acid from rock phosphate alone and from a mixture of rock phosphate and soil with and without additions of calcium carbonate, the experimental data in Table III were obtained.

TABLE III—EFFECT OF BASICITY

No.	Material Treated	Phosphorus Extracted Per cent
1	0.1 g. Rock Phosphate.....	6.410
2	0.2 g. Rock Phosphate.....	5.527
3	0.2 g. Rock Phosphate + 0.05 g. Calcium Carbonate.....	5.000
4	0.2 g. Rock Phosphate + 0.1 g. Calcium Carbonate.....	3.300
5	0.2 g. Rock Phosphate + 0.20 g. Soil.....	3.587
6	0.2 g. Rock Phosphate + 0.20 g. Soil + 0.05 g. Calcium Carbonate.....	2.497
7	0.2 g. Rock Phosphate + 0.20 g. Soil + 0.1 g. Calcium Carbonate.....	1.950
8	0.2 g. Rock Phosphate + 0.20 g. Soil + 0.2 g. Calcium Carbonate.....	1.222
9	0.2 g. Rock Phosphate + 0.20 g. Soil + 0.5 g. Calcium Carbonate.....	0.712

The extractions of phosphorus were made in the same way and under uniform conditions, so far as the temperature, the strength of citric acid, time and manner of extraction and filtration were concerned. The strength of the citric acid was adjusted to equal 0.2 per cent at the end of the extraction, care being taken to neutralize the basicity due to the slight basic properties of the rock phosphate, the calcium carbonate added, and the soil itself which was naturally cal-

careous. This was done by addition of the necessary extra amount of citric acid to the 0.2 per cent citric acid employed. That the strength of the solution was as desired was ascertained by titration of the filtered extract with standard alkali and phenolphthalein.

When 0.2 g. rock phosphate was treated with 500 cc. citric acid, 5.527 per cent phosphorus were extracted. The addition of 0.05 g. and 0.1 g. calcium carbonate to the same weight of rock phosphate reduced this figure to 5.000 and 3.300 per cent, respectively. As might be expected, similar results in regard to phosphorus extracted were obtained when soil was mixed with rock phosphate and different amounts of calcium carbonate added.

The results obtained pertaining to the influence of basicity do not lend support to the contention of Cousins and Hammond that citric acid can be employed as discriminating agent for available phosphorus in calcareous soils, even though provision is made to add enough extra citric acid to neutralize the soluble bases present in the soil and have the final acidity of the solution at the required strength.

NITRIC ACID

Another solvent which has been considered to afford useful information with respect to the availability of the supply of phosphorus in the soil is fifth-normal nitric acid. As this strength of nitric acid dissolves practically all the phosphorus in rock phosphate, it was decided to determine whether a weaker strength of nitric acid would be more satisfactory. By shaking for 30 min. 2 g. of rock phosphate with 500 cc. nitric acid of various strengths the percentages of phosphorus shown in Table IV were extracted.

TABLE IV—SOLUBILITY OF PHOSPHORUS IN DIFFERENT STRENGTHS OF NITRIC ACID

Strength of Acid Per cent	Phosphorus Dissolved Per cent of Sample
0.06	11.918
0.045	11.488
0.030	10.811
0.015	8.131

The sample of rock phosphate used in this work contained 12.37 per cent total phosphorus. It is evident, from the amount of phosphorus dissolved by weak nitric acid solutions, that this acid is no more satisfactory than citric acid for differentiating that part of the phosphorus which is more easily dissolved and therefore might be regarded as available, especially when one bears in mind that the figure for the availability of the phosphorus of the same sample of rock phosphate as determined by neutral ammonium citrate under accepted standard conditions is only 0.2 per cent.

Contrary to the results obtained with citric acid, the depressing influence of basicity of the sample on the extraction power of nitric acid for phosphorus can be wholly overcome by adding exactly the amount of nitric acid corresponding to the bases present, in this case calcium carbonate. This is shown by the results in the following table. The extraction was made for 30 min. with 100 cc. nitric acid corresponding to 0.2 per cent citric acid plus sufficient extra nitric acid to neutralize the calcium carbonate.

¹"The Determination of Available Phosphoric Acid and Potash in Calcareous Soils," *The Analyst*, 1908, p. 238.

TABLE V—BASICITY AND EXTRACTION POWER OF WEAK NITRIC ACID

Material Extracted	Phosphorus Extracted Per cent
0.1 g. Rock Phosphate.....	8.555
0.1 g. Rock Phosphate + 0.1 g. Calcium Carbonate.....	8.413
0.1 g. Rock Phosphate + 0.2 g. Calcium Carbonate.....	8.362

The percentages of phosphorus extracted would have been higher had a larger volume of the nitric acid been employed for the extraction. Table VI shows that with various larger volumes of solvent, practically identical percentages of the phosphorus were dissolved, in all cases approaching the total phosphorus content of the rock phosphate, 12.37 per cent. The strength of the acid used was 0.01 per cent. The time for extraction was 30 min. as before and the amount of rock phosphate treated, 0.2 g.

TABLE VI

Volume of Acid Used Cc.	Phosphorus Extracted Per cent
500	11.094
1000	12.150
1500	12.124
2000	12.131

SUMMARY

Summing up our results as to the solubility of the phosphorus of rock phosphate in very dilute citric and nitric acids with a view to obtaining an indication as to the available phosphorus in this particular

material, we find that both possess too high a solvent power.

An additional objection to the use of citric acid is that basicity has a decidedly depressing influence on the solvent power and this cannot be altogether overcome by the addition of an extra amount of citric acid equivalent to the basicity present.

While neutral ammonium citrate cannot serve as a means for measuring the absolute amount of available phosphorus, it probably gives as reliable an indication of the available phosphorus of rock phosphate and eventual changes in availability due to sulfonation and other processes as any solvent can be expected to furnish. It is necessary, however, that two determinations be made, one at the beginning and one at the end of the experiment, and absolutely uniform conditions maintained in both instances.

This latter point must be observed because many factors, including the amounts of the material taken and the volume of solvent, will appreciably affect the availability of phosphorus as measured by neutral ammonium citrate.

DEPARTMENT OF CHEMISTRY

OHIO AGRICULTURAL EXPERIMENT STATION
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LABORATORY AND PLANT

THE RECOVERY OF WASTE PARAFFINED PAPER BY EXTRACTION WITH VOLATILE SOLVENTS

By OTTO KRESS AND L. F. HAWLEY

Received August 19, 1918

Some time ago the Forest Products Laboratory was requested to determine whether there was a suitable method for recovering the paraffin and paper stock from waste paraffined paper. This waste paraffined paper has only a very limited value and in the majority of cases it is burned under the boilers. Other forms of paper waste such as oiled paper, asphalt-impregnated papers used for wrapping and case lining, board made damp-tight by means of asphalt or tar for the manufacture of cartons and containers of washing powder, coffee, etc., have very little application either, and are usually burned. Occasionally a small amount of the waste containing asphalt, not to exceed 2 per cent, is worked up in the beater with fresh paper stock, but the difficulties experienced with the pitch on the wire and presses of the paper machine, and the consequent loss of production due to breaks and the necessity of frequent clean-ups, makes the desirability of the practice very questionable.

No accurate statistics are available on the production of paraffined paper, but from a number of sources it is estimated that the production is close to 2,400,000 lbs. per week. Assuming a 4 per cent waste, there would be available 48 tons per week. In the above estimate no account has been taken of the waste incident to the manufacture of paraffined drinking cups, food containers, wrappers for special foods such as breakfast foods, etc.

From a review of the literature and from the experience of the manufacturer who brought the problem to us, it was believed that an attempt to remove the paraffin by melting it with hot water would not be successful. Several runs were made in which the paraffined paper was shredded and then opened up in a beater, the contents of which could be heated by the direct introduction of live steam. By this treatment it was possible to remove part of the molten wax by skimming and part by means of a washer, but the disintegrated pulp apparently held on tenaciously to a portion of the wax.

The resulting pulp was run off in the form of paper on our experimental paper machine, and an analysis for the percentage of wax in the finished paper is given for Run 7 in Table I. While the pulp prepared by this hot water treatment could be run over our experimental machine into finished paper, we believe, in view of the high wax content of the pulp, that it could not run for any length of time on a commercial machine. It was found from our experiment that the treatment of paraffined stock with hot water, heated by means of live steam, caused a decrease in the paraffin content to 0.90 per cent. In this experiment, however, the steaming operation was continued for 2 days, the condensed water carrying with it the extracted paraffin, overflowing constantly from the tub in which the stock was heated. A treatment of this nature, requiring so much time and steam expenditure, would not be commercially feasible.

Our coöperator supplied us with several hundred pounds of waste paraffin paper, some of which had

been printed previous to paraffining. Seven runs were made in our experimental extraction apparatus, using gasoline as the solvent, with the object of recovering the paraffin and waste paper stock and determining the general conditions of extraction.

The apparatus used for the extraction experiments consisted of a vertical cylindrical extractor 3 ft. high and $1\frac{1}{2}$ ft. in diameter, provided with a closed steam coil and a steam jet. This extractor was connected with a condenser in such a manner that the vapors of solvent, when boiled off, could be led to the condenser, condensed, and returned again to the extractor, all in a closed system. In the experiments a weighed amount of the paraffined paper was placed in the extractor and a measured amount of the solvent (a middle fraction of gasoline, b. p. $90-140^{\circ}$ C.) was added; then the cover was put on and by means of the closed steam coils the solvent was boiled slowly through the condenser, returning continuously to the extractor. The steam was then turned off and the solution drained from the bottom of the extractor. An amount of fresh solvent equal to that drained off was applied and the process repeated. The solvent remaining after the second extraction and draining was recovered by blowing live steam through the extractor to a condenser and collecting the mixed condensate of water and solvent.

Different proportions of solvent and paper and charges of different weights of paper per extractor were used in order to determine the best conditions for extraction. The conditions used and the results obtained are shown in Table I. In Runs 1 to 4 more solvent was used than was found to be necessary, that is, the small amount of paraffin left on the paper was apparently a minimum uninfluenced by the amount of solvent used. Runs 5 and 6 were made to determine how little solvent could be used and satisfactory extractions still be obtained. The maximum amount of paper which could be charged into the tractor was also determined in these runs. In Run 5 the paper scraps, as received in irregular, fairly large sized pieces, were packed directly into the extractor, with occasional tearing of the larger sheets or breaking up of the matted lumps. The material used in Run 6 was run through a Williams shredder; and as may be seen from the table, a larger amount of the shredded paper can be charged in a given space than of the larger sized scrap.

As would be expected, a larger amount of paraffin was left on the paper after extraction in Runs 5 and 6, where much smaller proportions of solvent were used than in the previous runs. It must be remembered that the method used in these experimental extractions would not be used in a commercial process, since in a commercial process where a large number of charges are to be extracted in just the same way, it is preferable to use the countercurrent system of extraction, in which one lot of solvent may be used in regular order on several different charges of paper. By such a method it would be possible to obtain a more complete extraction with the use of even less solvent.¹

Under the conditions used in Run 6, the solvent ratio is $\frac{1}{3}$, since, of the 8 gal. added to the paper, 5 gal. are drained off and 3 gal. are retained after draining. By using solvent at the rate of 8 gal. per 20 lbs. of paper in a series of 4 extractions, according to the countercurrent principle, it should be readily possible to obtain a 97.0 to 97.5 per cent extraction (theoretical, 98.02). If it were found that extraction in this way left too much paraffin in the extracted paper, an increase in the amount of solvent used would give more complete extraction. For instance, 12 gal. of solvent to 20 lbs. of paper would give a solvent ratio of 4 which in 4 treatments in series would give a theoretical extraction of 99.61 per cent.

These experiments have determined the conditions under which various degrees of extraction can be obtained, but which of these conditions would be most desirable in commercial practice can be determined only from a study of the costs of different parts of the process. For instance, let us compare the conditions outlined above, of 20 lbs. of shredded paper per 3 cu. ft. of extractor space and 8 gal. of solvent per 20 lbs. of paper, with another set of conditions such as those of Run 5, *viz.*, 15 lbs. unshredded paper per 3 cu. ft. of space and 10 gal. of solvent per 15 lbs. of paper. In the latter case the unshredded and loosely packed paper retains less solvent; the solvent ratio is therefore greater and the extraction percentage which can be obtained in the same number of treatments is higher. The disadvantages of these conditions are a decreased capacity of apparatus and an increased cost of handling the larger amount of solvent (including probably larger solvent loss). These advantages and disadvantages must be compared in terms of costs before the most desirable conditions can be decided upon.

RUN NO.	Paper Used, Lbs.	SOLVENT			PERCENTAGE PARAFFIN			
		Gal. Used at One Time	Gal. Retained after Draining	Solvent Ratio $a = \frac{\text{Gal. 3}}{\text{Col. 4}}$	On Basis Extracted Paper	On Basis Original Paper	Theoretical	$\frac{1}{(\text{Col. 5} + 1)} \times \text{Col. 6}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1.....	7	20	0.65	30	25.5	0.21	0.15	0.03
2.....	11	16	1.1	15	26.8	0.24	0.16	0.11
3.....	11	16	1.0	15	23.5			0.09
4.....	11	16	1.2	13	19.5	0.46	0.35	0.08
5.....	18	10	2.1	4	19.5	2.03	1.67	0.86
6.....	20	8	3.0	$\frac{1}{3}$	19.1	3.40	2.67	2.67
						2.90		

Our coöperators supplied us with some samples of their mill run of paper before impregnation in order that its strength might be compared with that of the paper made from the extracted pulp. Sample 1 was made at the mill on the following furnish:

50 per cent bleached sulfite pulp
25 per cent bleached soda pulp
25 per cent unbleached sulfite pulp

Sample 2:

20 per cent bleached soda pulp
80 per cent bleached sulfite pulp

All the extracted pulps were made into paper on our experimental paper machine and it may be of interest to compare (Table II) a paper made on Run 7

¹ For complete consideration of this and other points of the extraction process, the reader is referred to the article, "Discontinuous Extraction Processes," by L. F. Hawley, THIS JOURNAL, 9 (1917), 886.

with the original unimpregnated paper. The paper made from the extracted pulp from Run 7 had the poorest pulp in so far as thoroughness of paraffin extraction was concerned. The strength data clearly indicates that the extraction process had no decided influence on the strength of the pulp.

Some experiments were also made at an earlier date at the request of a manufacturer of damp-tight cartons and packages to determine whether the waste paper scraps from his plant might be treated to recover the paper stock. The damp-tight carton stock consisted of two boards cemented together with asphalt or tar to render the board impervious to moisture. The scrap as received contained 6.6 per cent moisture and 8.6 per cent of ether-soluble material. After treatment in the laboratory extractor the paper residue was made into board on our experimental machine and showed no spots of unextracted material. The extracted paper scrap showed an ether-soluble extract of 0.76 per cent.

TABLE II—STRENGTH TESTS ON COMMERCIAL SAMPLES 1 AND 2, AND CALENDERED SHEET FROM RUN 7. TESTS MADE AT 65 PER CENT HUMIDITY AND 76° F.

	Weight per Ream 24 × 36/500 Test Lbs.	Mullen Points	Strength		Factor		Breaking		Folds	
			Ratio per lb. Points	per 0.001 Thickness Points	per lb. Average Points	per 0.001 Thickness Points	Average Meters	Average No.	Stretch Per cent	
Sample 1....	25.5	7.4	0.290	3.7	3010	4	1.27			
Sample 2....	26.5	5.3	0.20	2.62	1910	3	1.27			
Run 7.....	32.0	9.2	0.287	3.03	2330	4	1.43			

Some of the paraffined waste paper had been printed with advertisements in a blue ink previous to impregnation. It was found that the solvent extraction of the wax did not affect the blue ink, nor did bleaching with ordinary bleaching powder after the extraction and pulping of the paper. This ink could be removed by means of an alkaline treatment of hydrosulfite and subsequent washing, but reoxidation to the original blue color occurred in the air unless the reduced and consequently soluble dyestuff was removed by washing. No examination was made to determine the particular pigment employed, but from the general reaction there is no question that it was of the nature of a vat dye similar to the indanthrenes. For the printing of bread wrappers, where no great permanency of the printed matter is required, cheaper printing inks which could be readily bleached with chlorine might be used with a consequent saving in cost and ease of bleaching of the resulting pulp.

From the above, it can readily be seen that the extraction of waste paraffined paper by means of gasoline and the consequent saving of the pulp and wax can be accomplished without undue difficulties. The resulting paper stock carries no more material soluble on extraction with petroleum ether than will be found in the form of pitch and resin in good grades of commercial sulfite pulp. Further, the paper stock is not injured, and, with possibly a slight bleaching treatment, may be used again for the manufacture of waxing paper.

The main difficulty attending such a recovery project lies in the fact that the amount of waste available in the United States is just about sufficient for the operation of a medium-sized extraction plant. With the constant increase, however, in the use of paraffined

paper for the manufacture of bread wrappers, food containers, etc., the extraction of the paper waste and the recovery of the paraffin, if handled at a centralized plant, may well become a profitable conservation.

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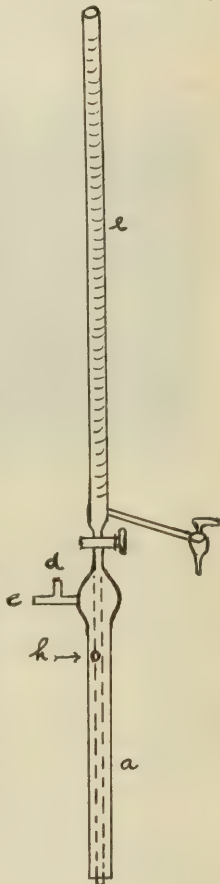
AN IMPROVED AUTOMATIC BURETTE

By GEORGE J. HOUGH

Received December 30, 1918

The burette herewith illustrated was devised by the writer several years ago, and has been found very handy and convenient. Its principal merits are, first, that it requires no bracket or support to hold it on the solution reservoir, and second, that it can be quickly cleaned and used for some other solution; this I have found to be a great advantage as only one burette is required for a large number of standard solutions, especially solutions that are not in constant use, thus obviating a number of permanently attached burettes.

As is seen in the illustration, the base of the burette consists of a glass tube, *a*, for elevating the solution, surrounded by an outer jacket consisting of a much wider tube; and when inserted in a rubber stopper to fit the solution reservoir, this form of base gives the apparatus sufficient stability so that it requires no bracket to hold it upright. The tube *c* is for the attachment of a rubber pressure bulb, and tube *d* is closed with the finger when pumping air into the reservoir. The hole in the outer jacket of the base is to equalize the pressure in the reservoir. The other details of the apparatus require no explanation.



The dimensions of the apparatus are as follows: the burette *c*, including lower stopcock, is 24 in. long; the outlet tube is 4 in. long; jacket *a* is 10.5 in. long, with a diameter of 0.5 in.; tube *c* is 2.25 in. long, and tube *d* is 1 in.; the distance from the top of jacket to the hole *h* is 1.75 in. This hole must be above the level of the liquid in the reservoir.

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LABORATORY APPARATUS FOR RAPID EVAPORATION

By E. C. MERRILL AND CLARE OLIN EWING

Received December 30, 1918

When it is considered that evaporation is a daily proceeding in general laboratory practice, the importance of reducing the time factor in this operation will be at once appreciated. Nevertheless, there seem to be comparatively few analytical chemical laboratories where provision is made for a rapid and effective system of evaporation. The authors have found the following extremely simple apparatus very useful and efficient for this purpose:

The air from the blast is first passed through a screw-capped brass cylinder, *A*, 3 cm. \times 15 cm., packed with cotton, which filters out any scale or particles which might contaminate the residue during the operation; then, before passing to the blowers, it is conducted

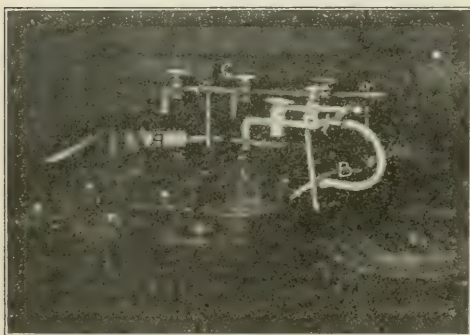


FIG. 1

through a 2-meter coil of 0.6 cm. copper tubing which rests on the steam pipes in an ordinary steam bath and has its terminal, *B*, sufficiently elevated above the top level of the bath to enable rubber connections to be made. The individual blowers, which are supported over the respective holes in the steam bath, are provided with glass stopcocks, so that as many as are desired can be used simultaneously. The heavy bent wires *C* that support the blowers slide within hollow standards by means of which the height of the blowers above the bath can be adjusted as desired. Fig. 1 shows the arrangement of the apparatus.

When the steam is turned on, the air passing out at the orifices of the blowers is heated to approximately 60° C. but can be varied according to the volume of air passing. No doubt a higher temperature could be obtained by using a longer coil. The following tabulation shows how much evaporation may be expedited by the use of this apparatus when other conditions are constant:

TABLE I—RATE OF EVAPORATION OF SEVERAL SOLVENTS ON STEAM BATH, WITH AND WITHOUT BLAST¹

SOLVENT	Volume Cc.	Surface Sq. cm.	TIME IN MINUTES		
			No Blast	Ordinary Blast	Hot Air Blast
Ether.....	50	20	7	5	3
Chloroform.....	50	20	23	11	7
Benzene.....	50	20	55	14	10
Alcohol, 95 per cent.....	50	20	100	24	15
Water.....	50	20	175	100	64

¹ All determinations made in 100 cc. pyrex beakers.

The apparatus has been found especially useful for the rapid top-evaporation of solutions which otherwise are prone to decrepitate, such, for example, as strychnine in chloroform, and also for the rapid drying of wool fibers used in qualitative color analysis. Another advantage of the apparatus is that by insulating the beaker from the bath a rapid evaporation at a low temperature can be made of solution of materials which are apt to volatilize, polymerize, or decompose at higher temperatures. It is useful, for example, in the evaporation of aqueous solutions of glycerin, petroleum-ether solutions of volatile alkalis such as conine, ethereal solutions of volatile oils, chloroform solutions of salicylic acid, etc.

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WASHINGTON, D. C.

A FUSION BOMB FOR SULFUR DETERMINATION IN COAL

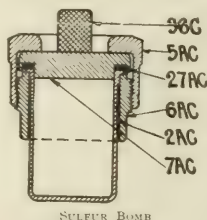
By S. W. PARR

Received January 27, 1919

The determination of sulfur in coal by use of sodium peroxide as an oxidizing medium has met with favor wherever it has been tried. The results have been shown to be in close agreement with those obtained by the Eschka method, hence a reference only to tables already published is sufficient.¹

In this process the need of a suitable device for carrying out the combustion has been evident for some time. It is the purpose of this note to call attention to a simple piece of apparatus which has been found to operate satisfactorily in this connection.

A fusion cup, 2AC of the figure, has a cover, 7AC, which is held in place by a screw cap, 5AC. The fusion cup is removable and by having duplicate cups a number of samples may be made ready at the same time.



The charge consists of 0.5 g. of coal with 9 or 10 g. of sodium peroxide which, after being sealed within the holder, is thoroughly mixed by shaking. Ignition is effected by holding the bottom of the cup for a moment in the flame of a Meker burner or, still better, by having a jet of flame from a blast lamp strike the bottom of the fusion cup. This method avoids the use of a hot slug or fuse wire to be made red hot by an electric current. After ignition, which begins almost immediately, the cup is removed from the flame. Combustion is complete in less than half a minute. After cooling under the tap the cup is removed from the holder and placed on its side in a beaker of about 200 cc. capacity. Solution of the fusion is complete in a few minutes, when the cap may be removed, rinsed, and dried. It is then ready for another charge. The composition of the cup is such

¹ Preliminary Report of Joint Committee on Standard Methods of Coal Analysis, THIS JOURNAL, 5 (1913), 525; also *Ibid.*, 1 (1909), 689.

as to withstand the action of the fused alkali in excellent shape; no roughening or corrosion of the interior can be detected even after some hundreds of fusions have been performed.

The same apparatus has been used with much satisfaction in the determination of the sulfur in pyritic

material, in rubber and other organic combinations. It has a still wider application in the determination of carbonaceous matter in soils, and as a substitute for the Carius method of determining halogens in organic compounds.

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ADDRESSES AND CONTRIBUTED ARTICLES

THE PRESENT STATUS OF NITROGEN FIXATION^{1,2}

By ALFRED H. WHITE, Lt. Colonel, Ordnance Dept., U. S. A.

INTRODUCTION

Fixed nitrogen in some form is an essential constituent of the food of all the higher animal and vegetable organisms. Fixed nitrogen in the form of potassium and sodium nitrates has been of prime importance in warfare since gunpowder came into general use. The ammonia resulting from the destructive distillation of coal has been recovered and used in the chemical industry for more than a century. Free nitrogen forms nearly eighty per cent of the air we breathe, but in the free form it can be utilized neither by the bodily mechanism nor in explosives or fertilizers. The chemist has known for many years how to convert this inert gas into other compounds in his laboratory, but it is only within the last twenty years that the fixation of nitrogen has been recognized as an industrial as well as a scientific problem, and only within the last five years that its importance has become generally recognized.

Sir William Crookes, in 1898, called attention to the diminishing supply of Chilean nitrate, and the need of replacing it with a synthetic product if the world was not to be confronted with possible starvation as a result of shortage of nitrogen fertilizers. But although this stimulated interest and may almost serve as a date for the commencement of industrial research on nitrogen fixation, it was ultimately war and not peace which caused the rapid development of the processes for fixation of atmospheric nitrogen. One of the proofs of Germany's cold-blooded calculation is found in the subsidized development of the nitrogen fixation industry. The sodium nitrate vitally necessary for explosives was found only in Chile, and its supply would almost certainly be cut off in a war with a first-class naval power. The German government did not declare war until it had the Haber, Ostwald, and cyanamide processes developed to the point where it knew it could become independent of Chilean supplies.

Almost all of the military explosives, whether used as propellants or as bursting charges, contain large percentages of the nitrate group. If this is to be supplied from sodium nitrate, there will be needed nearly two pounds of sodium nitrate for each pound of explosive, as shown somewhat more in detail in the following table:

EXPLOSIVE	NITRATE FACTOR
Smokeless powder.....	1.70
Trinitrotoluol.....	1.70
Picric acid.....	2.50
Miscellaneous high explosives.....	1.50

Ammonium nitrate, while not itself an explosive under ordinary conditions, becomes, when mixed with a portion of its weight of TNT, the very satisfactory high explosive amatol, important as a bursting charge for shells. Ammonium nitrate is the richest of all explosives in nitrogen.

SUMMARY OF FIXATION PROCESSES

It is the first step in nitrogen fixation which is the most difficult. The nitrogen molecule as it exists in the air is very inert and becomes active only at high temperatures or in the presence of some activating substance. The processes may be classified as follows:

I—THE ARC PROCESS for the direct combination of the nitrogen and oxygen of the air to form nitric oxide which subsequently by oxidation with air and combination with water forms nitric acid of approximately 35 per cent concentration. There are required about 10.5 h. p.-years electrical energy per ton of nitrogen fixed as nitric acid per annum.

II—THE CYANAMIDE PROCESS, involving:

(1) The production of calcium carbide through reaction between lime and coke in an electric furnace.

(2) The interaction of calcium carbide and pure nitrogen at a red heat to form calcium cyanamide.

(3) The decomposition of cyanamide by steam under pressure, to form ammonia.

(4) The oxidation of ammonia with air and combination with water to form dilute nitric acid of approximately 50 per cent concentration.

The power required by this process is approximately 2.5 h. p.-years per ton of nitrogen converted to nitric acid per annum.

III—NITRIDE PROCESSES. The best developed of these processes is that for making aluminum nitride from aluminum oxide, coke, and nitrogen heated to a temperature of perhaps 1800° C. in an electric furnace. This process has not been developed far enough to show its ultimate power requirements, but it is approximately in the same class as the cyanamide process. The aluminum nitride, after formation, may be decomposed with steam or dilute caustic solutions yielding ammonia and regenerating the alumina.

IV—THE DIRECT SYNTHETIC AMMONIA PROCESS, usually called the Haber process, wherein pure nitrogen and hydrogen are made to combine in the presence of a catalyst, at temperatures which in commercial work have usually approximated 500° to 600° C. and under a pressure of 100 atmospheres or higher. The ammonia made by this process is then oxidized with air and converted to nitric acid. Electrical energy is not necessary for this process and the total power requirements are only about 0.5 h. p.-year per ton of nitrogen fixed as nitric acid per annum.

V—THE CYANIDE PROCESS, wherein a mixture of sodium carbonate and coke with iron in small quantities is heated in a stream of pure nitrogen to a temperature of approximately 1000° C., resulting in the formation of sodium cyanide. This furnace product may be decomposed with steam, yielding ammonia. Power requirements for this process are of the same order as for the Haber process.

It will be seen that all of the above processes, except the arc process, yield ammonia as their initial product. The arc process requires the greatest expenditure of electrical power, the cyanamide and nitride processes rank next, and the direct synthetic ammonia and the cyanide processes require only small amounts of power. In fact, these two latter processes do not necessarily require any electrical power, it being possible to carry out all the heating reactions without the use of electrical energy, although electrical heating may in some cases be more economical. If nitric acid is desired, the ammonia produced by these processes may be oxidized to nitric oxide by air in the presence of a catalyst, usually platinum, working at 750° to 850° C. The nitric oxide resulting is oxidized by cooling, mixing with more air if necessary, and passing through towers, down which water or dilute nitric

¹ Published by permission of the Chief of Ordnance.

² Address delivered at the Chicago Meeting of the American Institute of Chemical Engineers, January 16, 1919.

acid trickles. The resulting product is about 50 per cent nitric acid. This oxidation process requires very little external energy. It may be considered that the principal problem is to get atmospheric nitrogen into a combined form, and that the problem of converting the initial form of combined nitrogen into the final form is distinctly simpler and better elaborated.

NITROGEN FIXATION IN THE UNITED STATES

It was reserved for two Americans, Bradley and Lovejoy, to first place the fixation of nitrogen on an industrial scale in their plant at Niagara Falls, N. Y., in 1902. This historic attempt, though well conceived, failed largely because of the lack of sufficiently cheap electrical power at Niagara to allow the process to be carried to industrial success. Later developments were made mainly in Europe, largely because of the existence there of water power which could be used to generate cheap electrical power necessary for most of the nitrogen fixation processes.

The subject of nitrogen fixation in the United States had been studied by some of the larger corporations prior to the outbreak of the European War in 1914, but no commercial plant had been installed in this country, and only had been actually installed in Canada, that of the American Cyanamid Company, at Niagara Falls, Ontario. The United States Army authorities were alive to the critical situation in which this country would be placed should it enter the war and its connections with Chile be interrupted; but no money for fixation was appropriated until the passage of the National Defense Act of June 3, 1916, which carried as its Section 124 (Nitrate Supply) an appropriation of \$20,000,000 to be placed at the disposal of the President for investigation of "the best, cheapest, and most available means for the production of nitrate and other products for munitions of war and useful in the manufacture of fertilizers, and other useful products, by water power or any other power as is in his judgement the best and cheapest to use." This Act also conferred on the President broad powers in the acquisition of processes and of land, and in the construction of plants and sale of product.

The question of nitrogen fixation with special reference to the use to which this money should be put was studied by several nitrate commissions, the first organized by the National Research Council, and the others by the Secretary of War, but retaining a considerable proportion of the original membership. Their conclusions and the action recommended and taken up to August 1917 have already been published.¹

When this country declared war on Germany on April 6, 1917, no definite program had been approved and no further commercial developments on the manufacturing scale had taken place, although the American Nitrogen Products Company had established at La Grande, near Seattle, Washington, a small experimental arc process plant, which was producing sodium nitrite. On July 7, 1917, the Secretary of War on behalf of the President approved the recommendations of the Nitrate Supply Committee and directed that approximately \$3,900,000 be placed at the disposal of the Chief of Ordnance of the United States Army to carry out the recommendations of the Committee. The Ordnance Department instituted the Nitrate Division on July 25, 1917, with Colonel J. W. Joyes as Chief, to carry out the program of construction and research therein laid down, and to have charge of such other nitrogen fixation projects as should be committed to it.

The files of the Nitrate Division contain confidential reports received from the French and British governments, as well as the records of eighty-four special investigations that have been made in this country. The Nitrate Division corresponded with and in most cases had personal interviews with every person or institution which it could learn was interested in or had worked on nitrogen fixation. It is a great gratification

to be able to record that with hardly an exception all of these individuals and firms placed their information at the disposal of the Government without reservation. They cheerfully allowed the Government to make any tests which it wished at their plants, and many of them went on with the work at their own expense at the request of the Government, in spite of the difficulties of conducting the work in war time, and in spite of their feeling that from their own standpoint they would rather have put their energies into other lines of work. Although the files of the Nitrate Division contain all these reports, it would be manifestly improper to disclose their content, or even to list the names of those who were working in this field, without their permission. Perhaps some day a complete report may be written on this subject. For the present, a brief summary must suffice.

UNITED STATES NITRATE PLANT NO. 1

The Nitrate Supply Committee,¹ on May 11, 1917, made, among others, the following recommendations:

The committee, appreciating the offer of the General Chemical Company, recommends:

1.—That the Government enter into negotiations to acquire the rights to use the synthetic ammonia process of that company.

2.—That contingent upon satisfactory arrangements with the General Chemical Company, out of the \$20,000,000 nitrate supply appropriation, such sum as may be needed, now estimated at \$3,000,000, be placed at the disposal of the War Department to be used in building a synthetic ammonia plant, employing the said process of the General Chemical Company and of a capacity of 60,000 lbs. of ammonia per 24-hr. day, said plant to be located in a region where land, water, coal, and sulfuric acid are cheaply available, where good transportation facilities exist, and where the proposed new powder plant of the Government can be properly located. In the opinion of this committee all of these conditions just enumerated are best fulfilled by a location in southwest Virginia or contiguous region.

3.—That out of the \$20,000,000 nitrate supply appropriation an amount now estimated at \$600,000, or as much as may be needed, be placed at the disposal of the War Department to be used in building a plant for the oxidation of ammonia to nitric acid and the concentration of nitric acid, of a capacity equivalent to 24,000 lbs. of 100 per cent nitric acid in a 24-hr. day, said plant to be located in the neighborhood of the aforesaid synthetic ammonia plant and the proposed new powder plant of the Government.

4.—That the War Department proceed at the earliest practical date with the construction of the oxidation plant and contingent upon a satisfactory arrangement with the General Chemical Company, also with the synthetic ammonia plant, and that the Government give such priority orders as will secure rapid construction of the structure and machinery needed for these plants.

This recommendation, having been approved by the Secretary of War on behalf of the President, constituted the first instructions to the Nitrate Division of the Ordnance Department. The plant built as a result of these instructions is known as United States Nitrate Plant No. 1, and is located at Sheffield, Alabama. This group is composed of four principal parts: the synthetic ammonia plant, the ammonia oxidation plant, the ammonium nitrate plant, and the nitric acid concentrating plant. The synthetic ammonia plant was built in accordance with the designs of the General Chemical Company, and the construction and initial operation were carried out with their active cooperation. It consists of three units, two each of rated capacity of 15,000 lbs. of anhydrous ammonia per day, and one of capacity of 30,000 lbs. per day. The many difficulties in obtaining equipment delayed the completion of this plant, and its first unit did not start into operation until September 15, 1918. As was to have been expected, there were numerous minor troubles in starting this new process, and its operation was still in a somewhat experimental state when the armistice was declared on November 11, 1918. No attempt has as yet been made to start the operation of more than one unit of the plant.

¹ The full report of this committee, together with some other documents, is to be found in THIS JOURNAL, 9 (1917), 829-841.

The ammonia oxidation plant was built to oxidize approximately one-half of the ammonia made in the synthetic process, it being the intention to have as the ultimate product of the plant, ammonium nitrate. The catalytic agent in this plant is a platinum gauze, and the converter is one designed by Capt. G. A. Perley, of the Ordnance Department, after designs made initially by Dr. Charles L. Parsons, of the Bureau of Mines, and Mr. Louis C. Jones, of the Solvay Process Company, as the result of cooperative experiments made at the plant of the Solvay Process Company in Syracuse, N. Y. The oxidation towers and acid system were designed and installed by the Chemical Construction Company, Charlotte, N. C. This oxidation and acid plant has had relatively little opportunity to show its efficiency, and has never been operated up to capacity, but so far as it has been operated, it has shown itself to be satisfactory. The ammonium nitrate plant follows a fairly standard design which has been worked out by various munition manufacturers, and although it has not had much continuous operation, it has worked entirely satisfactorily. The nitric acid concentration plant was built in accordance with the recommendations of the Nitrate Supply Committee, to have a capacity of 24,000 lbs. of nitric acid in a 24-hr. day, calculated as a 100 per cent acid, but being actually delivered as 96 per cent. This plant was designed and erected by the Chemical Construction Company, Charlotte, N. C., but has never been tested.

The present status of United States Nitrate Plant No. 1 is therefore that of many other munition plants throughout the country. It was completed, but had not yet really come into operation, when the armistice was signed. It is hoped to keep this plant in partial operation until its measure of success has been determined. The wording of the Nitrate Supply Section of the National Defense Act indicates that at the time the Act was passed it was contemplated that this plant should be operated for the manufacture of fertilizers. The ultimate disposition of the plant is not yet known.

UNITED STATES NITRATE PLANT NO. 2

U. S. Nitrate Plant No. 1 was built in accordance with the deliberate judgment of the Nitrate Commission that the direct synthetic process of producing ammonia through combination of nitrogen with hydrogen should be tried in this country, because it did not involve the large amounts of electrical power necessitated by the other processes which had proved themselves successful by actual commercial experience. After this country had been in the war a few months and the loss of ships from submarines became a serious factor, and it was seen that a further source of synthetic nitrate should be supplied, the Nitrate Division unreservedly recommended that the cyanamide process be installed, as involving less electrical power than the arc process, and being the only other process which had been fully developed on a manufacturing scale. The only commercial organization in this country which had expert knowledge of this process and the requisite staff thereof was the American Cyanamid Company. Accordingly, this company was called into conference, and on November 16, 1917, contract was made with them for the erection of a plant to produce 110,000 tons ammonium nitrate per year by the cyanamide process. This plant was to be located at Muscle Shoals, Alabama, and it was proposed to have the plant, to one-half the capacity, ready to begin operations within six months from the date of breaking ground and the remaining half ready twelve months from the same date. The American Cyanamid Company organized the Air Nitrates Corporation as a subsidiary to carry on the actual work and operation of this plant under government supervision. The exceptionally severe winter of 1917-1918 and the difficulties of getting the large steam turbo-generator units required for the plant were important factors which delayed construction so that the plant did not furnish its initial product of ammonium nitrate until November, 25, 1918. The first

unit of the plant which was tested behaved satisfactorily except for small minor defects, and there was every expectation that the plant would have rapidly built up to its full rated capacity by the completion of subsequent units. This plant is now being given a careful test on one unit only, which means about one-sixth its rated capacity. It is expected the test will be completed during the month of January and that the plant will be closed about the first of February 1919, pending decision as to its future operation.

UNITED STATES NITRATE PLANTS NOS. 3 AND 4

In the Spring of 1918 when the losses by enemy submarines were becoming increasingly serious and the stocks of sodium nitrate in the country were reduced to alarmingly low levels, it was decided that additional fixation plants should be erected. The question as to the best process was again referred to the Nitrate Commission, who reported unanimously that the cyanamide process was the only one to consider from the standpoint of certainty of operation combined with reasonable cost. A new contract was accordingly made with the Air Nitrates Corporation, and the American Cyanamid Company, for the erection of U. S. Nitrate Plant No. 3 at Toledo, Ohio, and No. 4 at Ancor, Ohio, near Cincinnati. Each of these plants was to have a capacity of 55,000 tons of ammonium nitrate per year. The construction of these plants was well under way when the armistice was declared. Work upon them was at once stopped, and the contracts are now being adjusted and formally cancelled.

CHEMICAL PLANT, SALTVILLE, VA.

The chemical plant at Saltville, Va., was built at the request of the Ordnance Department and with Ordnance money, but through the agency of the Bureau of Mines with Dr. Charles L. Parsons as its representative. This plant was to produce 10 tons of sodium cyanide per day by the Bucher process.¹ The plant was starting initial operation when the armistice was signed. It was given a test run to get information on operating costs, and was then closed down. It is at present under the jurisdiction of the Nitrate Division of the Ordnance Department, but its future is uncertain.

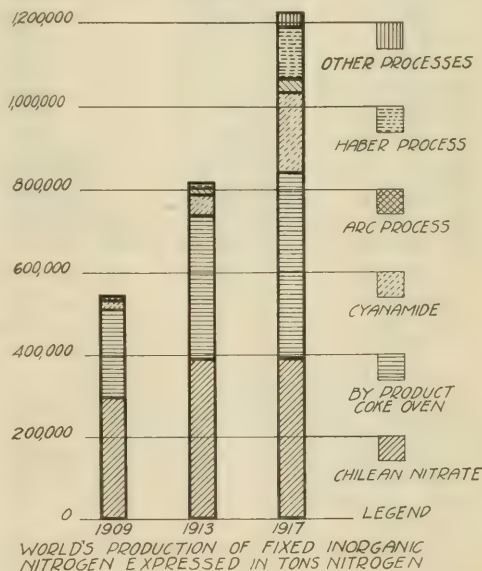


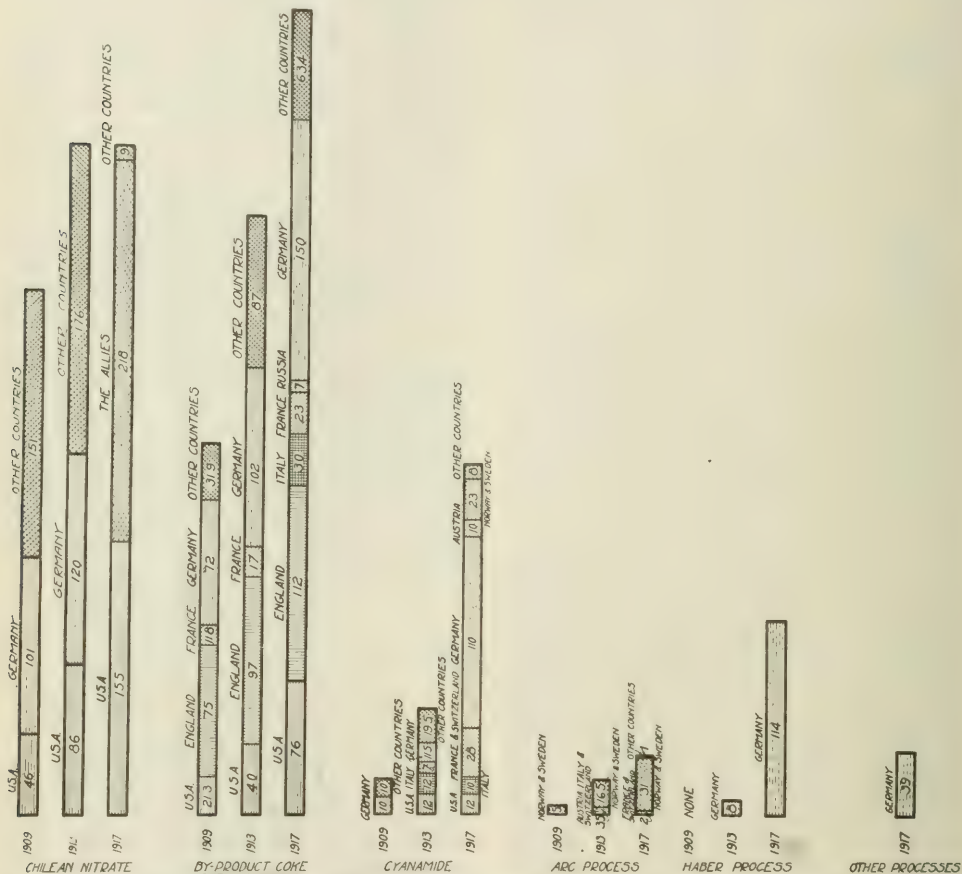
FIG. 1

¹ THIS JOURNAL, 9 (1917), 233-253.

COMMERCIAL DEVELOPMENTS IN THE UNITED STATES

It is felt necessary to speak with considerable reserve about commercial developments, on account of the confidential relation which the writer has sustained to them in his official capacity. The arc process plant of the American Nitrogen Products Company at La Grande, Wash., referred to earlier in this article, has been in successful operation throughout the war and is the single commercial nitrogen fixation plant known to be in operation in the United States proper, although the

so that the clearest way to obtain a view of the world's nitrogen supply is to reduce the figures for the various nitrogenous materials to a common basis of fixed nitrogen. The nitrogen in manure and other organic refuse, while important for agriculture, cannot be estimated with any accuracy. Fig. 1 shows the world's production of fixed inorganic nitrogen expressed in short tons of nitrogen for the years 1909, 1913 and 1917. No great accuracy can be claimed for these figures since some of them are mere estimates. It is believed, however, that the general situa-



WORLDS PRODUCTION & CONSUMPTION OF FIXED INORGANIC NITROGEN DIVIDED BY COUNTRIES & EXPRESSED IN THOUSANDS OF TONS NITROGEN
FIG. 2

American Cyanamid Company at Niagara Falls, Ontario, is still operating with a materially increased capacity. Experimental plants have been in operation testing modifications of all of the five type processes already mentioned. Several of them are adequately backed by capital and it is hoped that successful commercial processes may result. There is a general tendency to go somewhat slowly pending a readjustment of the world's markets.

THE WORLD'S SUPPLY OF FIXED NITROGEN

The world can use almost any form of combined nitrogen, either directly or after conversion into a more desired form,

tion is expressed correctly. Much of the data in Figs. 1, 2 and 3 is due to Mr. Eysten Berg. The first outstanding impression is that of great growth in each period, but on closer analysis the striking fact is that the percentage increase from 1909 to 1913, when the world was at peace, is nearly as great as during the subsequent period when the world was at war. The increase is very closely fifty per cent for each four-year period. The year 1913 shows an increase in production from every source. The year 1917 shows no increase from Chilean nitrate, in spite of the urgent demands of the Allies for greater supply. This was partly due to lack of ships. The greatest increase on the chart for the period 1909-13 is shown by the by-product

coke ovens. In 1917 the increase was mainly due to the cyanamide and Haber processes, so that in this year the world's supply came almost equally from the three sources, Chilean nitrate, coke ovens, and synthetic, the cyanamide process being the most important in the latter group, with the Haber second.

DISTRIBUTION OF FIXED NITROGEN BY PROCESSES

In Fig. 2 an attempt is made to distribute the world's production of fixed nitrogen by countries and processes. Only approximate accuracy can be claimed for the chart, as was the case with Fig. 1, but certain important factors stand out clearly. In 1909 and 1913 Germany received nearly one-third of all Chile's nitrate. After the war broke out, she received none. If the war had continued, it is probable that the

The cyanamide industry more than tripled in each period, and rose in 1917 to a production of more than half of the equivalent in Chilean nitrate. Facilities provided since 1917 make a further increase of twenty-five per cent possible.

The arc process shows a growth, but in spite of the stimulus of high prices, it has not attained prominence and remains centralized in Norway and Sweden, where water power is cheap.

The phenomenal growth of the Haber process in confined to Germany. The 8000 tons production in 1913 represented success on a manufacturing scale and gave the German government assurance that it could go to war, confident that neither foreign navies nor expensive electrical power could keep her armies from an adequate supply of the material most necessary for explosives.

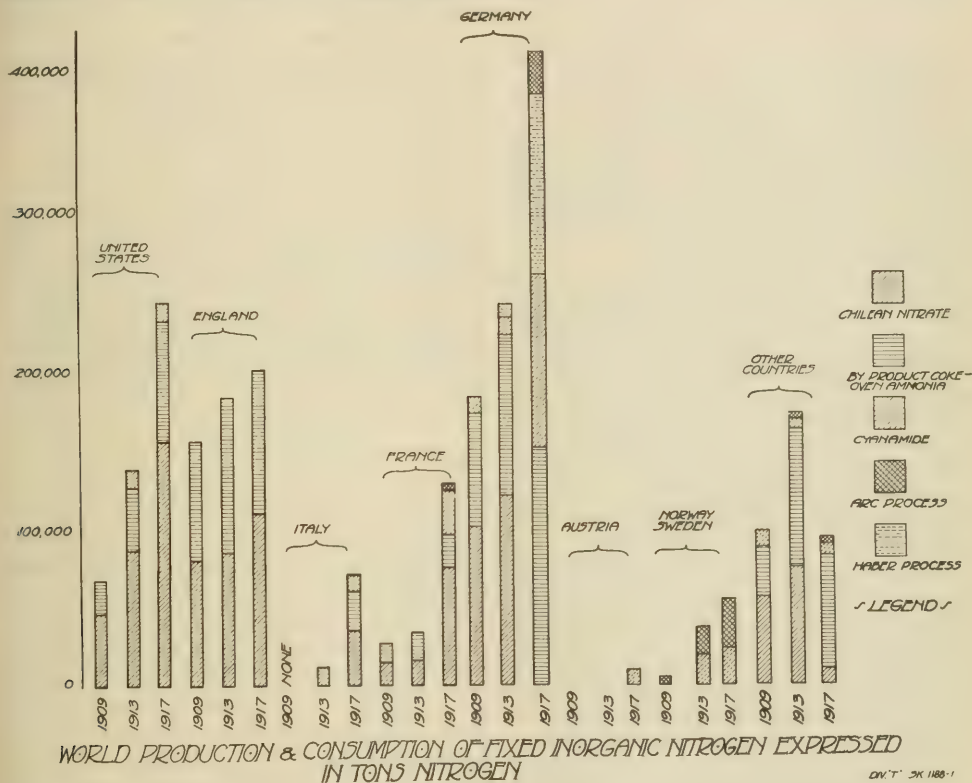


FIG. 3

D.V.T. 3K 1188-1

year 1918 would have seen the Chilean output increased nearly 25 per cent over 1917. This probably represents nearly the maximum output, and it is believed that 500,000 tons of nitrogen as nitrate may be fairly taken as the most that can be expected from Chile.

The figures for ammonia from by-product coke ovens show a steady increase for every country, so that the coke ovens became the largest factor in the world's nitrogen production in 1917. There is every probability that a further increase was registered in 1918. Ovens still under construction, especially in the United States, will afford facilities for further material increase in 1919. In the periods studied, Germany shows the largest absolute as well as the largest relative increase in production from coke ovens.

DISTRIBUTION OF FIXED NITROGEN BY COUNTRIES

The distribution of the world's fixed nitrogen among the various countries is approximately shown in Fig. 3.

The distribution of Chilean nitrate among the European countries is almost entirely an estimate, since much of the nitrate exported from Chile and consigned to Great Britain has been reconsigned, on arrival or en route, to continental countries.

The most interesting column is that which shows Germany's towering total for 1917, in spite of the entire absence of Chilean nitrate. Here again the figures are an estimate. The relatively small production of Norway and Sweden is also interesting and at first disappointing, in view of the large amount of publicity which has been given the installations in that country.

RELATIVE TECHNICAL DEVELOPMENT OF FIXATION PROCESSES

The two processes first commercially established were the arc process and the cyanamide process. Both have had a commercial development of approximately thirteen years in the hands of skilled chemists, chemical engineers, and electrical engineers in countries with high industrial development. There has, moreover, been mutual exchange of information between various groups of plants, both national and international, and the industry has become relatively stabilized along lines which represent the most advantageous process which the combined experts of the various affiliated companies have devised. Improvements will still undoubtedly be made, but the processes are relatively highly developed.

Experts in the arc process state that a commercial proposition to be attractive must have continuous electrical power in large units at not more than \$12.00 per h. p.-year. Others state that power must be as low as \$8.00 per h. p.-year. It gives as its sole primary product dilute nitric acid, or an alkaline nitrate or nitrite. There are attractive theoretical possibilities for increasing the efficiency of the arc process, but none have, so far as we are aware, been developed far enough to hold out the hope that the arc process can ever be successfully operated except where large blocks of cheap electrical power are available. Even the stress of war conditions has failed to bring about the establishment of really large plants anywhere but in Norway and Sweden, and the total output by this process only amounts to about three per cent of the world's total.

The cyanamide process has been studied since 1898 and has grown until in 1917 it furnished approximately one-sixth of the world's total fixed nitrogen. It requires large amounts of electrical power, but only one-fourth as much as the arc process. It also requires as raw materials large amounts of pure limestone and coke. It yields calcium carbide as an intermediate and cyanamide as its primary product, with ammonia, nitric acid, or ammonium nitrate as subsequent products obtained by relatively efficient processes. It stands as an example of a highly developed chemical industry dependent for commercial success upon relatively cheap electrical power in large units. The war has seen one variant of this process receive an extensive test in this country on a semi-industrial scale, with such favorable results that a commercial plant is now being erected.

While many metals yield nitride when heated in nitrogen, the manufacture of aluminum nitride has received most attention because of the possible importance of the alumina obtained as a by-product, for the aluminum industry. It requires large amounts of electrical power and a rather specific raw material, bauxite. The commercial developments of the past have not been successful, and although more is hoped from the two large semi-commercial installations now being tested in this country, it must still be regarded as a rather unproven process.

The cyanide process does not require electrical power and uses as its raw materials sodium carbonate, coke, iron, and pure nitrogen. Of the raw materials the iron is always recoverable and if the cyanide is converted into ammonia under proper conditions, the sodium carbonate is also recoverable, leaving as the only raw materials actually expended nitrogen and coke in the cyanizing reaction, and steam in the ammonia reaction, together with the coal required to furnish the heat. The initial product is cyanide which may be purified and marketed as such or converted into ammonia with a possibility of sodium formate as a by-product. The development has been largely in the United States and since the war broke out. It has been studied carefully by the United States Government and by several private corporations in plants almost large enough to be called commercial plants. The only really large-scale plant is the United States Chemical Plant at Saltville, Va., previously referred to. The commercial possibilities of this process have not yet been established. The present developments have

tended towards an externally heated steel or nichrome retort as the most suitable container for the cyanizing reaction which requires a temperature of 1000° to 1100° C. The retort is necessarily small and the reaction is rather slow. The process attracted the Government during the war because it was certain nitrogen could be fixed without the use of large amounts of electrical energy, which were then almost unobtainable. At present the process involves high capital, labor, and repair costs. The process must not, however, be condemned in its present immature form.

The direct synthesis of ammonia from nitrogen and hydrogen was first developed both from the theoretical and practical side in Germany, and the name most frequently associated with it is that of Haber. The combination of nitrogen and hydrogen according to the reaction



is favored by high pressure and relatively low temperature. Some of the equilibrium values are given in the following table.

Temp. ° C.	Per cent NH_3 in Equilibrium at Pressures (in Atmospheres) of			
	1	30	100	200
300	2.18	31.8	52.1	62.8
500	0.129	3.62	10.4	17.6
700	0.0223	0.66	2.14	4.11

The rate of reaction between the gases is altogether too slow to be commercial unless accelerated by a catalyst. Our knowledge of catalysis is still very vague, and catalysts are discovered only by tedious experiments, largely empiric in their nature. Furthermore, they are extraordinarily susceptible to poisons.

While therefore the reaction between nitrogen and hydrogen is extremely simple to write, it is extremely difficult to carry out economically. The successful solution of the problem involves many problems but they may be divided into the following groups:

- 1—Preparation of pure nitrogen
- 2—Preparation of pure hydrogen
- 3—Preparation of catalyst
- 4—Construction of plant

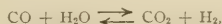
PREPARATION OF PURE NITROGEN

It is unfortunate that the term "fixation of nitrogen" fixes attention so strongly on nitrogen that the lay mind gains the impression that one of the chief difficulties to be overcome is the preparation of the nitrogen. The arc process starts with air but all the other processes require or at least work distinctly better if supplied with nitrogen substantially dry and free from oxygen, carbon dioxide, and carbon monoxide. Argon, helium and other rare gases of the atmosphere interfere only as they dilute the nitrogen slightly. The supply of pure nitrogen is important, but fortunately the liquid air process furnishes it so cheaply and reliably that the problem may be considered as solved. A nitrogen column as delivered to the United States nitrate plants has an hourly capacity of 20,000 cu. ft. of dry nitrogen, with less than 0.1 per cent oxygen for an expenditure of 180 h. p.-hrs. Power is by far the most expensive item, for air is free, only a small amount of caustic is needed for purification of the entering air, and the labor charge is small. The operation is so reliable and the cost so small that efforts to recover waste nitrogen from industrial sources are hardly worth while where a really large installation is being considered.

PREPARATION OF PURE HYDROGEN

Pure hydrogen is needed only for the direct synthetic ammonia process. It forms 17.6 per cent of the theoretical gas mixture by weight, but 75 per cent by volume. Hydrogen is formed as a by-product in the electrolytic manufacture of chlorine, but the expense of collecting it and purifying it is considerable. Hydrogen and oxygen are obtained by electrolysis of caustic solutions, but it is difficult to find a location where both gases

can be used to advantage. It is also made by the action of steam on red-hot iron and by the water-gas reaction wherein steam reacting with coke produces approximately equal volumes of carbon monoxide and hydrogen. By further reaction with steam in the presence of a catalyst, as shown by the following equation,



most of the carbon monoxide may be removed with the formation of an equal volume of hydrogen, but a long and elaborate purification process must be followed to bring the gas to a pure and dry state. The refinement of purity necessary will vary with the different catalysts, but the impurities must certainly be measured only in hundredths of a per cent, if not thousandths. Further research work on the purification of hydrogen is desirable.

FUTURE OF NITROGEN FIXATION PROCESSES

The future of the nitrogen fixation industry can be forecasted only in the most general manner. It depends upon two factors, the demand for fixed nitrogen and its price. These two factors are in part independent and in part linked together, for a lowered price is certain to cause a greater demand. The principal demand of the last few years has been for munitions, and the demand was an insistent one which had to be met regardless of price. The great normal demand for fertilizers has been restricted to a minimum. The largest demand for fixed nitrogen in the future will probably be for fertilizers, and the use of fertilizers will be very largely a matter of price. The diagram, Fig. 1, shows an increase of roughly fifty per cent in output for fixed nitrogen for each four-year period. It is not probable that 1921 will show such a proportionate increase although if all the resources of Chile and all of the facilities in the way of coke ovens now under construction, and fixation plants should be utilized, the year 1920 might well see a possible production of 25 per cent more than 1917. What will be the cost of production? The cheapest source of fixed inorganic nitrogen will undoubtedly be the ammonia from by-product coke ovens because it is a by-product and the cost of collecting and putting it into marketable form is small. The coke ovens of the world can now produce more fixed nitrogen than the world used from all sources ten years ago. It will be a powerful factor tending towards low prices. It is probable that Chilean nitrate could, if necessary, be sold at lower prices than in former years. The fixation processes will therefore have to be prepared to meet possible low prices if they are to be ranked as anything more than emergency reliances.

The cost of nitrogen in the staple raw materials sodium nitrate and ammonium sulfate varied from \$12 to \$16 per hundred pounds in the years 1900-1915. It is manifest that a process which is to produce a large proportion of the world's fixed nitrogen must be able to compete with these staple materials. Smaller factories may produce specialized products such as sodium nitrite and anhydrous ammonia for which there is a demand, large in itself, but small in proportion to the world's total demand.

The necessity and the possibility of independence of Chilean nitrate as a material for munitions has been proved in the past four years. The question as to whether the fixation processes can compete with Chilean nitrate and coke oven ammonia in times of peace, and for the cheapest commercial nitrogenous product—fertilizer—cannot yet be answered.

The cyanamide and arc processes both labor under the handicap of the requirement of large amounts of electrical power. The nitride process has a somewhat similar handicap but possesses a possible advantage in the recovery of alumina as a by-product. The cyanide process labors at present under the disadvantage of small manufacturing units but has the advantage of low-power requirements and the possible recovery of formates as by-products. The direct synthetic ammonia process presents

great engineering and chemical difficulties, but has great possibilities of future development. As will be seen from the table earlier in this paper, if an inventor could find a catalyst active at 300° C., he would have the theoretical possibility of increasing the conversion by one passage through the apparatus at 100 atmospheres pressure to fivefold the conversion at 500° C. Or with such a catalyst, he could work at 30 atmospheres pressure and 300° temperature, eliminating thereby many of the serious engineering difficulties and still obtaining a conversion far better than anything now commercially known to us. There is no theoretical reason why such a catalyst might not be made, and its discovery would offer the possibility of cheaper fixed nitrogen than anything heretofore known.

RESEARCH TECHNICAL DIVISION
NITRATE DIVISION, ORDNANCE DEPARTMENT
WASHINGTON, D. C.

THE NEEDS OF THE U. S. PATENT OFFICE¹

By THOMAS EWING, Former Commissioner of Patents

I believe that one result of this war is going to be that there must be new methods of business introduced, and that the competition for business all over the world will be keener than it has ever been.

All great manufacturing establishments are keenly interested in original and novel developments in their particular lines. I happen to know that the General Electric Company, as one of its activities, maintains a large and superbly kept laboratory of research, and the expenses which are incurred for it are not treated as strictly commercial, but are expected, in a large way, to pay themselves many times over. I have no connection with the General Electric Company in any capacity. I once sold some patents to another great company, the Bell Telephone Company, with which also I have no connection. They paid half a million dollars for them, and before they had a single dollar of return, they had spent one million dollars more in determining the exact conditions of the economical use of the inventions. But there has never been a time since they acquired them, when they could have been bought back from them for ten times what they paid for them. I think it is true of all great enterprises, that if they are not handled in a broad way—I do not care how large the company may be, or how large its business may be—dry rot will set in, competitors with new ideas will enter the field, and they will find the ground cut from under them before they know it. Therefore, all great concerns are interested in original development, and that means that they are interested in patents, or should be; and it also means that it should be a regularly recognized line of development which must be liberally treated, both in acquisition of inventions from the outside and in developments within the company.

I know that everybody who has anything to do with the patent system complains about it, and there is reason for complaint, but the complexity of the questions and the vast field which the patent system covers make it impossible that all of the troubles should be either removed or immediately mitigated.

There is one factor in our patent system which everybody should be interested in and should try to help, without any regard whatsoever to one's general opinion about what the patent system should be, or what it is worth; and that factor is the Patent Office.

We could have a system of registration of patents such as we did have down in 1836, and such as a number of countries have to-day, but in 1836 this Government introduced the system of granting patents on examination—examination not only of the form of the papers, but of the invention, as its novelty; and from that period on, the Patent Office has been an important and constantly growing factor in our system.

¹ Address before the War Emergency Reconstruction Conference held at Atlantic City, December 3 to 6, 1918.

The theory of the Patent Office is that patents will be granted only when they ought to be granted, and that the claims that are allowed will be only such as ought to be allowed; and in view of the fact that there are more than four hundred men engaged constantly in the examination of applications, the courts give great weight to what the Patent Office concludes. They are frequently saying, "Why, there is a finding by the Patent Office; here is something which the experts of the Patent Office have held to be novel over the other patents which are being presented to us;" and the courts will therefore reject arguments for holding a patent invalid, or for limiting it. They rely upon what the Patent Office has decided, and seek to give effect to its conclusions. With such an attitude, which is perfectly proper in view of the theory of the Patent Office, it is the worst sort of business to have a Patent Office that is insufficiently provided with men and facilities for making proper examinations. It becomes dangerous, because weight is given to patents which is not deserved, not that the Patent Office is not industrious, and not that its *esprit de corps* is not high, for the examiners are both industrious and of high character, but because the Office is inadequately supplied with means and with men to make proper searches, and their conclusions are therefore, in many cases, erroneous.

I would like to impress upon you to-day that it is of the utmost importance to all of you, no matter whether you are interested in patenting inventions or are interested in going into new fields which are being developed by other people where you may have to meet hostile patents, it is to your interest, and it is to the interest of every inventor as well, of course, that the Office be efficiently and adequately provided with the means necessary to perform its great labor.

I was in the Patent Office for four years as Commissioner, and previous to that, thirty years ago, as an assistant examiner; and I have practiced before it. I have no personal interest in what may be done for it, or any personal pride of position in it; but it is perfectly apparent to me that the provisions for the Office are inadequate. And it became apparent to me while I was Commissioner that the Office, through the ordinary channels, is not able to influence Congress to give it proper facilities. Only influence from the outside—I mean, of course, influence that is entirely proper and legitimate, of people who are interested in having the thing done right—can bring effective pressure to bear upon Congress. Only in that way will the Office get what it needs.

Let me give you an illustration of the difficulty. The last year I was there I made a recommendation to Congress, asking for an increase in the force which would have cost one hundred thousand dollars a year. I had studied the Office diligently for the three preceding years, and I presented the reasons for the need as strongly as I possibly could. At the end of the deliberations there was not one cent allowed for the things that I asked for. Subsequently we entered the war, and many people who had applications in the Office, which were not being reached for action because we were behind, were writing, asking to have their cases made special. I could not make one man's case special without being guilty of unfair treatment to the others whose cases were awaiting action, and I adopted the method of writing to each one who asked to have his case made special that I was unable to do so, because the facilities and means provided in the Office for acting upon the applications were insufficient, and that my appeal to Congress to increase these means, which I had based particularly upon the probability that we were going into a war, and a dangerous situation might arise, had been entirely fruitless. Some of the letters which I wrote—and I wrote many—came back to the congressmen, and the congressmen went to the appropriation committee, and the committee finally sent for me and said that they would hear me over again; and after a great deal of effort, I succeeded

in getting an increase of about forty thousand dollars where I had asked for one hundred thousand.

What the Patent Office needs is not forty thousand dollars, or one hundred thousand dollars, but about one million dollars; and it is utterly impossible for the Office to get any such increase of appropriation unless some large influence is brought to bear to make Congress look into the matter and see what the situation really is.

Six hundred thousand dollars a year more than is now spent ought to be spent in increasing the examining corps and the clerical force, that is, increasing the personnel. Three hundred thousand dollars more ought to be spent in increasing salaries. The salaries are ridiculously low. The primary examiners, of whom there are forty-five, have the authority to pass out patents, sometimes of enormous value. If one of these primary examiners signs a file wrapper, the patent goes out automatically. It is true that the Commissioner must sign it, but as he has to sign about seven or eight hundred a week, it is entirely impossible for him to examine them; and, therefore, these forty-five men have it in their power to pass out patents which may be worth millions of dollars. Men who are doing work of that sort should be properly paid. The primary examiners who have that authority receive twenty-seven hundred dollars a year. A very large percentage of them are men of college education or technical school education. Most of them have gone through a law school; they are highly educated men; they are, I am happy to say, men of character. It is one of the greatest reasons for pride that we may all have that the Patent Office, the repository of secrets of great value, immense value, is practically above suspicion as to improper dealing. In the four years that I was there as Commissioner my door was open to anybody who chose to come in and complain. I never refused to see a man who called upon me the whole time I was there. I saw everyone alone. I have never had a man come to me and say there had been any improper dealings in the Office. I had letters, a few letters, saying that there was, and I investigated every instance carefully. I never found ground for belief that there was anything of the sort, and in the experience which I have had with the Office, running now over thirty years, only two cases have ever arisen, so far as I have been able to find, where any man was seriously suspected; one man was sent to the penitentiary and the other man died just before the question was brought up for decision. No man who had any disposition to use the Office improperly could live in the atmosphere there. He would be driven out by the other members of the corps. Now, men of such character, men who are serving in the Office as primary examiners—on the average the primary examiners have been in the Office for twenty-five years—devoting all their lives to that work, ought to be paid a salary which will enable them to bring up their families with the same educational advantages that they had themselves; that their place demands of them. Yet this is not possible under present conditions.

And what is true of the primary examiners is also true of the first assistant examiners, and the second assistant examiners. The lower grades of assistant examiners are not so important. Young fellows come in and stay a few years, go through the law school, learn the ropes, and go out to practice. The third and fourth assistant examiners probably get enough, but if a man is willing to stay and make that a life work, becoming, as he does, more valuable every year, because of his knowledge of the arts that he is examining, these men ought to be paid a proper salary, not only as a matter of justice, but as a matter of wisdom.

While there are some men of very fine ability in the Office, it is true that the work suffers seriously because of low salaries. And yet, if you go to Congress, as I went year after year, and ask for an increase of salaries for the primary examiners, and for the assistants, you will meet with this statement: "You

are simply trying to get more money for a lot of men who are there now." Well, I was not. I was trying to build up a great Office, or help to. It is a great Office now, but I was trying to improve it, but that is the spirit that Congress displayed. They treated it exactly as if it were any clerkship that was under discussion; and the Office cannot get by it, but men like you can; if you will give the matter sufficient thought, and make up your minds that it is right, and bring influence to bear upon Congress, the matter can be rectified.

The equipment is also insufficient. For example, there is a library of technical books and technical literature. You gentlemen all know that the technical literature of the world is very large, and constantly increasing. Congress allows three thousand dollars a year for the Patent Office to keep up with all the technical literature of all the arts. It ought to be fifty thousand dollars, and it ought to be whatever is necessary beyond that; and yet it was absolutely impossible for me to get one dollar beyond the three thousand dollars a year while I was there. There was a separate set of German patents, two hundred thousand in number, which we wished to bind by classes according to German classification, so that searches might be made through them by the public who are interested. Instead of making a list of all the patents that dealt with electrical motors, for example, and then going through twenty-one hundred volumes to get at them, we wanted to have four or five volumes of electrical motor patents, and so with the other arts. It took me three years to get an appropriation of twenty thousand dollars to bind them, and during that whole time they were tied in bundles, because we did not dare open the bundles for fear numbers would be lost.

There is another matter of great importance. These young men and these older men, the examiners, instead of being obliged to get knowledge from books only, ought to be able to go out and see what the manufacturers are doing in their establishments. They ought to learn the arts as they are actually practiced, so that their judgment would be sound. I sent out as many as I could; I would have sent all of them out from time to time to make investigations if I had been permitted to do so. I could have raised a fund of fifty thousand dollars easily by voluntary subscription from concerns that had applications pending, but sending the young men out by the use of funds raised in that way would have put the Office under obligations, and it would have placed the assistants in positions where they might be open to suspicion and criticism because they had a pleasant trip to Chicago, or St. Louis, or elsewhere; and Mr. Lane, I think properly, said he would not permit it. But here was a fund which I used for that purpose. It was five hundred dollars. There are now four hundred and nineteen in the corps; this sum was about \$1.25 apiece for these men. I tried my best to get Mr. Lane to agree to ask Congress for thirty thousand dollars for that purpose, and he said it was absolutely useless; he would not do it; he knew it would not be granted. But an appropriation like that, properly presented to their congressmen, by people who know the importance of it, might easily be secured.

I wish to speak also of the position of the Office in the governmental system. The Patent Office is a bureau of the Interior Department. When I went into office I did not know Secretary Lane. He sent for me shortly before I was appointed and I then met him for the first time. I formed an intimate friendship with him, our relations were most cordial, and I regard him as a great man, and yet, in spite of that, I am obliged to say after a four years' experience as Commissioner that the Office gains nothing by being a bureau of the Interior Department, and that it is seriously handicapped by the connection. It ought to be an independent office, answerable to nobody but the President and Congress, just as the Agricultural Bureau was before the present Department of Agriculture was created. The reason is that it is one of eight different bureaus, unrelated,

the work in one not similar to the work in another, the needs of one not similar to the needs of another. But, if an attempt is made to increase the salaries in the Patent Office, or to increase the personnel, immediately the question arises, "What about the Land Office? Won't the Commissioner of Pensions want salaries raised?" Thus a comparison is made between the Patent Office and its needs, and the needs or demands of other offices having no relation to it whatsoever. That comparison the Secretary could not fail to make, no matter how well he might understand the conditions in the offices, because he would arouse jealousy. And if he made up his mind that one office needs better salaries than the others, because it is engaged in a higher class of work, and were to pass that recommendation on to Congress, the Congress itself would make the very same comparison and he would not get anywhere.

If the Office were an independent bureau it could fight its own battles without any such disadvantageous comparisons, and I believe that if that change were made and gentlemen such as you would interest yourselves, and get your local bureaus and your legal departments to interest themselves, in any way you may see fit, in the needs of the Office, we might get the necessary assistance from Congress, and we could build the Office up to the point where it would be, in fact as it should be, the most superb patent office in the world—and its judgments would be far more certain and trustworthy. I think such action would save every year, in the relief of business from the uncertainty of wrongly granted patents, millions of dollars over all that it would cost.

It is constantly said, when the subject of increased appropriations for the Patent Office is raised, that the Office pays its own way. In the last five years it has turned back into the Treasury about one million dollars over the entire appropriation for it, and the building which it occupies was largely built out of surplus which had accumulated in the Treasury from Patent Office fees. But there is no reason why public money should be wasted, no matter where it is drawn from, and the income of the Office is not the measure of its needs, nor of the service it renders to the public. If the Office must be kept self-sustaining, it is an easy matter to increase the fees for patents, and I think that the business interests of the country would stand it. I do not think that is important. The important thing is that the needs of the Office should be intelligently studied by Congress, and when ascertained they should be provided for, without any regard to whether the Office costs one million dollars over what it receives in fees or not.

As I have said, the Office is absolutely unable to help itself. Anybody who as Commissioner starts in to get something for the Office is immediately accused of trying to get something for himself. But intelligent bodies, and influential bodies such as this, can influence and should influence Congress. Here is a field for constructive work, where the results will be to the interest and advantage of all of us. I trust that you will make it a matter of serious thought and concerted action. I thank you very much for the opportunity to bring the subject to your attention.

160 BROADWAY
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THE PHARMACEUTICAL CHEMIST AND THE SCOPE OF HIS WORK¹

By FRANK O. TAYLOR

Each of us is prone to magnify the importance of that particular branch of chemistry in which he is actively engaged, so perhaps I may be pardoned for what, to many of you, may seem a biased and erroneous opinion, or evidence of a dense ignorance concerning other fields of chemical endeavor, when I say that I believe no field of chemistry is of greater scope or more varied character than that of pharmaceutical chemistry. And

¹ Address before the Detroit Section of the American Chemical Society, January 16, 1919.

yet. I hope to give you such reasons for the faith that is in me that, if not fully agreeing, you may at least recognize a measure of justice in this claim and have a better understanding of the reasons back of it.

Pharmacy has to do with the compounding and dispensing of medicinal products and is most frequently thought of in the very narrow sense of mere mixing together of various individual substances, or the extraction of drugs with the proper solvents and dispensing in suitable form for use, the whole process involving only a very moderate degree of chemical knowledge.

It is to this extremely limited scope that the term "pharmaceutical chemistry" is all too frequently confined. I wish to direct your attention, however, to pharmaceutical chemistry in its broadest sense as being the chemistry of medicinal substances, pertaining to their origin, preparation, dispensing, and effects, and the remarkable and varied ramifications of these subdivisions. Far from being a limited and somewhat isolated division of chemical science there is, I believe, no other branch of chemistry that needs for the solution of its diverse problems so many otherwise distantly related portions of chemical knowledge.

The metallurgist, who from the iron ore of northern Michigan produces by reactions in blast furnace and Bessemer converter, iron and steel of varied composition; or from the scarlet cinnabar of southern California wins the mercury for use in physical instruments and amalgams; or from the ores of Missouri obtains in giant smelters the zinc for innumerable industrial uses, may often forget that iron is intimately associated with vital processes as in the red blood corpuscles and plays an important rôle as a curative agent; that the mercury salts are used in combating some of the most deadly and insidious diseases, or as highly effective germicides and antiseptics; that the zinc in one form may be intensely escharotic and in another may be the basis of mild and healing ointments of wide use.

The agricultural chemist, who makes two blades of grass or ears of wheat grow where only one grew before, may also develop digitalis or belladonna or hydrastis or cannabis in greater abundance or of higher potency.

The glass chemist may have his skill taxed to produce ampoules of glass free from excess alkali and easily workable in a blow-pipe flame or free from soluble iron salts that rapidly decompose such substances as hydrogen peroxide or adrenalin.

The coal-tar industry contributes from its cruder products the so-called "dead oils" as a basis for disinfectants of considerable potency; pure cresylic acids, to make antiseptics for surgical or general use; and phenol for use as such or in various compounds such as phenyl salicylate (salol) or the phenolsulfonates of zinc and calcium.

The dye chemist furnishes for medicinal use such things as phenolphthalein, so widely employed as a laxative; phenolsulfonaphthalein as a test for activity of the kidneys; scarlet-red for stimulating healthy and rapid growth of skin over surfaces denuded by burns or other accidents; acriflavine, but recently recommended in solution as a surgical dressing for extensive wounds, to be used in a manner similar to the sodium hypochlorite solution, known as Dakin's Solution, being destructive to bacteria in high dilution and apparently harmless to living tissues; malachite green proposed and widely experimented with for the same purposes; or methylene blue, so extensively used in certain types of urethritis.

Physical chemistry lends its aid in the production of such remedial agents as colloidal solutions of silver, mercury, sulfur, etc., obtained either by direct electrolytic action or in the presence of proteins, and adds to our slowly acquired empirical knowledge of emulsions an understanding of the reasons why, and the conditions under which the best results may be obtained.

Radiochemistry finds its pharmaceutical application in the use of ultra-violet rays for sterilizing water or various solutions, or the employment of radium salts and radioactive solutions in the treatment of various diseases, notably cancer.

The petroleum industry gives to the pharmaceutical chemist solid and liquid petrolatum of varying degrees of purity ranging from cruder petrolatum for veterinary ointments to the most highly purified liquid oil intended for human use as an intestinal lubricant, and paraffin as an ingredient of ointments or base of surgical dressings for application to extensive superficial wounds or burns.

The consideration of oils and fats, both vegetable and animal, applied one way or another to medicinal use, opens up another wide range through which our chemical investigations may lead us, including such things as the familiar castor and cod-liver oils; the intensely active cathartic, croton oil; that relic of old-time pharmacy, citrine ointment, made from lard, nitric acid, and mercury by a process similar to the familiar elaidin test for olive oil; the comparatively little known chaulmoogra oil, which has been used with some measure of success in the treatment of leprosy in India and our own southern states, and was some years ago the subject of extensive chemical investigation; oil of chenopodium or American wormseed, used first as an ordinary anthelmintic and more recently as a highly successful agent in destroying the hookworm, the bane of existence to so many thousands of people in warmer climates; and a great array of other fixed and volatile oils. And these things suggest at once a multitude of gums and resins of more or less interest medically, but which we will pass by.

In that limitless domain to which we refer in general as "organic chemistry," including therein those things particularly connected with physiological and biological chemistry, there exists a tremendous number of substances of great interest to the pharmaceutical chemist and there lie before him untouched fields for investigation that almost stagger the imagination. In this category appear substances of natural origin and of synthetic production—the alkaloids of aconite, opium, belladonna, stramonium, ergot, *nux vomica*; the comparatively innocuous glucosides of cascara or the highly toxic ones from *strophanthus* and digitalis; the digestive ferments such as pepsin, diastase, pancreatin; the endocrine glands and their derivatives, such as the suprarenal whence comes adrenalin, so marvelously potent in its effects on the blood pressure that one-twentieth of a milligram will show pronounced effects on a man; the thyroid, from which but recently an active iodine-bearing substance has been isolated; the pituitary gland of inestimable value in obstetrical practice and in the treatment of surgical shock; and others still less understood. Then we have that formidable and continually increasing array of synthetic substances, some of which, like acetylsalicylic acid (aspirin), or acetphenetidin (phenacetin), are part of the equipment of almost every household medicine cabinet, and others that you and I never heard of and probably never will.

These brief citations give some idea of the infinite variety of work presented to the chemist who deals with medicinal products but do not give any adequate conception of the great number of unsolved and abstruse problems which still lie before us and to which I will refer presently. You can at least see that the chemical knowledge of the man who has to do with pharmaceutical problems in their fullness must be extensive and that he will certainly have no monotonous existence.

Specific examples of some of the interesting questions that arise, which in some instances are very easy of solution and in other cases give us problems that promise to remain unsolved for an indefinite time in the future, will serve to give a more concrete conception of the requirements of the man who has to do with the development and production of medicinal substances in their widest scope.

Remember also that sometimes the solution of the simplest problems may involve the saving of hundreds or even thousands of dollars to the manufacturer who is producing medicinal substances on a very large scale. A question that may be of no particular moment when the quantity involved is only a few

ouces becomes of intense interest when it may mean the difference between entire loss or the satisfactory distribution of hundreds of pounds or thousands of pints of medicinal compounds of properly high quality.

Take so simple a thing as the almost universally used mild tonic, Beef, Iron, and Wine. Why should continual trouble be experienced with the development of pressure in the bottles, the evolution apparently of carbon dioxide, and continual breaking of packages and consequent loss? "Fermentation, of course," will be your first answer, and the fact that carbon dioxide is evolved seems excellent evidence that this supposition is correct, but fermentation is not likely to occur in a product that contains 18 per cent alcohol, and furthermore, this explanation is impossible when the trouble continues after the product has been thoroughly sterilized in an autoclave and proven sterile by bacteriological tests. The solution when found is very simple and is that due to the action of the actinic rays of light the ferric citrate in the slightly acid solution is reduced to a ferrous salt with liberation of carbon dioxide. If a ferrous salt is originally used, there is no such trouble, and if the ferric salt is employed, the product must be carefully protected from bright light, especially direct sunlight.

Take another case: Why should breakage in ampoules containing cacodylates be very much greater than with any other of the solutions usually prepared in this form? There was no pressure developed and no decomposition of the solutions could be detected. The fact that the breakage occurred largely at the extreme end of the capillary tip, where the ampoule is finally sealed in a blowpipe flame, gave a clue, and the solution of the problem was that traces of the cacodylate solution adhering to the glass were decomposed just at the tip where the flame is used for sealing; the arsenic combined with the glass, forming a ring of arsenical glass, which is entirely different in coefficient of expansion from the remainder of the ampoule and very brittle, hence comparatively slight changes in temperature frequently caused the tip to snap off. On putting into effect means for carefully washing out the tip of the ampoule with distilled water before sealing, the trouble disappeared.

Again, in the manufacture of antiseptic tablets containing corrosive sublimate, some suitable diluent is used that will be completely soluble in water and if possible aid in the solution of the mercuric chloride without reacting with it chemically; for this purpose ammonium chloride or citric acid is commonly used. In some few instances both together have been employed. To prevent the material sticking to the dies on a tablet machine, some lubricant is necessary, and as a comparatively soluble substance, antiseptic in itself, boric acid is often employed in a case of this kind. A quantity of tablets began to evolve considerable amounts of hydrochloric acid gas, sufficient to rapidly attack tinned-iron containers shortly after they were made. It was found that the boric acid used as a lubricant, in the presence of citric acid, reacted upon the ammonium chloride with the evolution of hydrochloric acid. The omission of either the boric or citric acid immediately remedied the trouble.

Another problem that seemed on the face of it so simple that it was really no problem at all was the obtaining of material such as sodium chloride, milk sugar, and alkaloidal salts of such purity that they would give a solution in distilled water *completely free* from insoluble floating particles. I would not go so far as to say that it cannot be done; I think that conditions are conceivable under which it might be accomplished; but I have never seen it done, and upon a commercial scale it has, so far as I know, never been accomplished. You must remember, of course, that the floating particles thus referred to are minute, though easily visible to the naked eye. Some years ago it was desired to prepare C. P. sodium chloride in crystalline form suitable for redissolving in distilled water for intravenous injection. No sodium chloride of sufficient purity was obtainable

on the market, and in attempting to make a quantity, it was found that during evaporation of a carefully purified solution, the sodium chloride would attack tinned copper, aluminum, and several grades of special enameled iron to such an extent that the crystals when redissolved in water would show a weighable amount of insoluble matter. The best thing available was one particular grade of resistant enamel, though had it been available on a commercial scale, a pure silver pan would probably have been just as effective.

When it comes to milk sugar or alkaloidal salts, it would seem that all that is necessary is to carefully filter the solution and evaporate, to obtain a product that will redissolve in distilled water without showing any signs of floating particles. When you come, however, to critically examining such solutions, you will discover that the first thing is to get distilled water which under the most rigid tests will show no tiny particles floating in it. So far I have never seen any of the above mentioned substances or distilled water that would show absolutely no signs of tiny floating particles when viewed by the naked eye against a dark background under an electric light. Remember, though, that one liter or even five liters of such a solution will leave no weighable residue on a filter paper; in fact, unless the filter is hard and smooth it is very likely to make the solution worse.

After problems connected with the manufacture are solved, there come up also numerous questions in regard to containers used. For example, glass that contains any trace of alkali soluble in water (and this is the rule rather than the exception) cannot be used in making ampoules containing very delicate substances, for strychnine alkaloid will be precipitated from its salts and a delicate organic preparation like adrenalin will be quite rapidly destroyed. Containers made from coke tin plate cannot be used to hold materials that might slowly attack iron, whereas charcoal tin plate is satisfactory, the difference being that the former has occasional exceedingly minute holes through the tin, while in the latter the tin coating is uniform and unbroken.

When we come to the consideration of the more difficult problems connected with medicinal substances and their development we reach a vast unknown region that has been but most imperfectly explored. We speak glibly oftentimes of relationship between chemical constitution and physiological action, but our actual and definite knowledge of the relationship is at the best extremely limited. We have acquired what seems like a considerable amount of empirical understanding that certain effects are in some way associated with certain combinations of elements or radicals, but we may draw a hasty conclusion merely to find that there are numerous exceptions to our supposed "law." For example, pyrocatechol (ortho-dihydroxy-benzene) is more poisonous than its monomethyl derivative, guaiacol, which in turn is more potent than the dimethyl derivative, veratrol. Apparently we are on the road to prove that alkylation of a hydroxy group in aromatic compounds decreases the toxicity, but presently we find that from resorcinol, which is meta-dihydroxy-benzene, we obtain a dimethyl derivative that is very much more toxic than the parent substance and our interesting theory suffers a rude shock.

If now we cautiously advance along some of the blazed trails in the jungle of organic compounds, hoping fervently that harsh and unrelenting facts will not pounce upon and tear to pieces some of our nicely domesticated pet theories, we discover some rather astonishing things. Take adrenalin, which, as derived from its natural source, is levorotatory. When prepared synthetically it is racemic and much less active than the naturally occurring form. Further investigation shows that the dextro-rotatory form is only about one-twelfth as powerful in increasing the blood pressure as the levorotatory form. The peculiar effect of the atropine group of alkaloids in dilating the pupil of the eye is about fifteen times as great in levohyoscyamine as in its

stereoisomer. Atropine and cocaine are not widely different chemically, both being derivatives of the nucleus tropine, but while some points of likeness may be found in their physiological action, there are many and pronounced differences, for instance, cocaine is a powerful local anesthetic, while atropine is devoid of this effect. Again, cocaine is methyl-benzoyl-ecgonine and ecgonine has no local anesthetic properties, while neither benzoyl-ecgonine nor ecgonine-methyl ester have more than a very slight effect of this kind. And so we go, gradually accumulating a great store of isolated facts and laboriously fitting them together. We are very like the child with a jig-saw picture puzzle: we fit together a few facts here and a few more over there and occasionally have to take apart some which do not fit perfectly, hoping that some day we will get enough of this picture together to find out what it really looks like.

Turning for a moment to other questions, how shall we determine the medicinal activity of aconite preparations? The drug contains one important and highly toxic alkaloid, aconitine, but also varying amounts of related alkaloids which are not only much less toxic but in some cases actually antagonistic in their action to the aconitine. The aconitine itself is very easily affected by heat, especially in the presence of moisture, and decomposes into various other bodies which possess quite different physiological action. One can obtain concordant results on repeated chemical assays, and find that they fail entirely to agree with the physiological activity as determined by tests on animals. Both the physiological test and the chemical assay seem to be affected by the presence of secondary alkaloids. The present situation as regards the determination of the activity of aconitine preparations is in a very unsatisfactory state.

For over 100 years we have known that the most important alkaloid of opium is morphine, but only within the past 10 years have we come to a definite understanding of its chemical constitution, and though at present morphine is worth \$200 per pound, there is no commercially available process for producing it synthetically.

Then there is that class of substances known as enzymes, typified among medicinal agents by pepsin, pancreatin, and diastase. We have for years used these products, particularly pepsin, as an aid to imperfect digestive activity, but do not yet know their exact constitution. Most extensive investigations have been pursued regarding the nature of pepsin, and it has been possible to produce a material under this name of such strength that one part will digest 50,000 parts of coagulated egg albumin, showing a tremendous power of protein digestion. Even here apparently the limit is not reached, and we have not succeeded in isolating any definite substance whose chemical identity we can establish.

Pancreatin is known to be a mixture of several different enzymes, but we are no better acquainted with the constitution of any of them than we are with that of pepsin. Besides these substances there are numerous other enzymes of more or less importance that occur either in vegetable or animal life, and many of which undoubtedly have important rôles to play in connection with vital processes, and as we come to understand them better we may find some of them of great service in dealing with diseases that are now but imperfectly understood.

In investigating enzymes we are struck with the similarity in many respects between catalytic action of these organic substances and those inorganic colloidal solutions of metals that are quite extensively advocated as remedial agents. For instance, both are rendered inactive by boiling and are affected by the reaction of the medium in which they act. The decomposition of hydrogen peroxide by catalase, which reaction may be used for the quantitative determination of this enzyme in the blood or liver, or the similar decomposition by colloidal solution of platinum, both proceed more rapidly in a slightly alkaline medium. The presence of a trace of hydrocyanic acid

acts as a distinct poison, and inhibits the activity both of enzymes and colloidal solutions, though there are some exceptions to this rule. What is the chemical reason back of these resemblances between substances that seem otherwise so dissimilar?

One of the scourges of humanity in Eastern Asia, the Philippines, Borneo, Sumatra, and the Straits Settlement has been a disease known as beri-beri. This through long and laborious investigations was found to be connected with the type of food used, being especially prevalent where polished rice was the main article of diet. It was found that a very remarkable and rapid improvement in the condition of those afflicted with this disease could be produced by extracts from the husks and polishings removed from rice. Continued investigation has led to recognition of certain bodies called "vitamines" present not only in the pericarp of rice but also in other grains, in yeast, and in a number of different plants. The name has been given because it is known that these substances are related to the amines and are so intimately associated with vital processes. They are present in only exceedingly minute amounts and yet their effect is very great. To the presence or absence of the same compounds has been traced the disease quite prevalent in our own southern states, known as "pellagra."

We are just beginning to understand that these vitamins, which all these years we have taken into our systems with our daily food, have in some way a tremendous effect upon our health, but how widely they are distributed or what their chemical constitution is and how they may differ as derived from different sources, and why they are so necessary to our healthful existence, still remains almost a complete mystery. Few, if any, greater fields for chemical investigation of medicinal substances exist at present than that of the vitamins.

Some 400 years ago Paracelsus founded what came to be known as the School of Iatrochemistry, on the assumption that the human body was made up of chemical substances and that illness was caused by chemical changes in the organs and juices of the body, and that to cure these ills chemical compounds must be found that would restore the original healthy condition. This fundamental principle was so obscured by fantastic ideas and was carried to such extremes by overzealous followers that it fell into disrepute and finally disappeared entirely, giving place to a chemistry founded on careful experimentation rather than fanciful theories. Strangely enough we are now returning, but under very different auspices, to something of that older idea. We have come to understand better the limitations of our knowledge and the fact that we must not be too eager to draw conclusions from the isolated facts we know, but as in former days the practice of pharmacy and the art of healing did much to develop chemical knowledge, so to-day must chemistry in its fullest application go far toward improving our means of treatment and control over disease.

PARKER, DAVIS AND COMPANY
DETROIT, MICHIGAN

THE DEOXIDATION OF STEEL BY FERROMANGANESE¹

By ALLEN L. FEILD

In spite of the recent advances in the field of high temperature research, the precise nature of the function which ferromanganese performs in steel manufacture is not yet known with certainty. Owing its discovery to accidental circumstances in the early days of the industry, the addition of a manganese ferro-alloy to molten steel for the purposes of producing a sound product, free from undesirable "blowholes," still remains one of the basic practices in modern steel metallurgy. The question of an adequate supply of manganese ore has been one of the most critical problems of the present war, so that, search where he may, the chemist

¹ Presented before the Division of Industrial Chemists and Chemical Engineers at the 56th Meeting of the American Chemical Society, Cleveland, September 10 to 13, 1918.

can with difficulty find a problem possessed of such fascinating possibilities.

Without bringing forward any new experimental data, it is the purpose of this paper to discuss briefly certain of the more striking features of the work of other investigators, and in the light of this to consider the evidence in the case.

It may be said in advance that the statements regarding the action of manganese alloys on molten steel which are found in the various texts are so confusing when taken singly and so contradictory when examined collectively that a detailed discussion is not possible here.

COMMON THEORY REGARDING DEOXIDATION

It has been commonly stated that the reactions between manganese and the metal bath can be represented by the equation

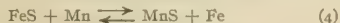


and that because the free energy, or affinity, of the oxidation of manganese at this temperature is considerably greater than that of iron, the reaction goes practically to completion from left to right, being assisted by the very low solubility of manganese oxide in molten steel. Furthermore, it is postulated that the manganese oxide thus formed is not as readily acted upon by the carbon contained in the steel, after recarburization, as is ferrous oxide over that temperature interval during which solidification occurs, thereby avoiding the liberation of carbon monoxide, through the mechanism of any such reaction as one of the following:



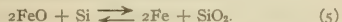
The corresponding reactions with manganese oxide are, according to this view, also opposed to a considerable degree by the ease with which the manganese oxide formed according to Equation 1 rises to the surface of the bath and enters the slag layer.

This supposedly deoxidizing effect on manganese should not be confused with its well-known effect on the sulfur content of the metal bath. The desulfurizing reaction



seems to be firmly established experimentally.

It has not, however, been universally customary to ascribe deoxidizing properties to manganese, and the older writers on the subject were inclined to regard it preëminently as a recarburizer, and, of course, at the same time a desulfurizer. In such cases ferrosilicon was named as the principal agent in ridding the bath of oxide and gaseous impurities. Its action on ferrous oxide was represented by the equation



It has been customary to explain the absence of practice wherein only a single deoxidizer, such as ferrosilicon, is used by calling attention to the fact that such a steel, while possibly free from "blowholes," undergoes cracking in passing between the rolls. Such a phenomenon is explained by assuming that the particles of silica resulting from Reaction 5 are perfectly solid at the rolling temperatures and not sufficiently plastic for the needs of the process, whereas, in case manganese is added at the same time, the manganese oxide formed in accordance with Equation 1 unites with the silica to form a plastic manganese silicate which does not seriously impair the strength of the metal. Then, too, a smaller amount of slag material actually remains in the steel, since the manganese silicate is very fluid at the temperature of the bath and forms liquid globules which coalesce into larger droplets and rise rapidly to the surface into the slag layer.

Finally it has been suggested that the ferro-alloys increase the solubility, as such, of the gases dissolved in the metal, or else form stable compounds with them, suppressing thereby the evolution of gas while solidification takes place.

OXYGEN CONTENT OF STEEL

Oxygen in steel does not refer to the presence of elemental oxygen but to the oxygen content of those oxides which are reduced by the action of hydrogen at a temperature of 850°–950° C. The method by which it is usually determined is that of Ledebur¹ as modified by Cushman.² Since it is agreed that at this temperature only the oxides of iron would be reduced, it ought to be possible to detect by analysis whether Reaction 1 actually occurs. Having this in mind, Shimer and Kichline³ investigated samples of severely "over-oxidized" steel and of the same metal to which ferromanganese and ferrosilicon had been added. They found that the oxygen content of the deoxidized steel was just as high as that of the undeoxidized steel.

The importance of this fact does not seem hitherto to have been given sufficient attention. Until these results of Shimer and Kichline can be satisfactorily explained on grounds other than that the iron oxide content of the two steels is the same, the entire theory outlined above regarding not only the action of ferromanganese, but of ferrosilicon as well, must be regarded as extremely doubtful. So far as I have been able to ascertain, the vital point regarding the entire deoxidation theory has never received any direct experimental proof, and the only existing evidence is directly contradictory.

GAS CONTENT OF SOLID AND LIQUID STEEL

Baraduc-Muller⁴ has found that a steel, in the molten condition, 5 min. after being poured from the Bessemer converter, and after additions of ferromanganese had been made, liberated, on cooling under a vacuum, 22.4 times its own volume of gas of the following average composition:

Gases	Per cent by vol.
CO ₂	3.6
O ₂	9.9
CO.....	30.8
H ₂	52.1
CH ₄	0.2
N ₂	12.7

Until the surface setting of the steel occurred during the cooling, the percentage of carbon monoxide exceeded that of hydrogen in the issuing gases, reaching a maximum value of 56.8 per cent. Hydrogen liberation predominated at low temperatures.

Whatever, then, the nature of the deoxidation process, it must certainly be connected with the equilibria between these various gases, the carbon of the bath, and the metals and their respective oxides. It is undoubtedly a very complex process, involving a number of reversible gaseous reactions operating over a wide range of temperature. It would be surprising, indeed, if the simple reactions given above could adequately describe the processes occurring in the metal bath.

Goerens and Paquet⁵ have recently analyzed cold samples of basic Bessemer and open-hearth steel for the presence of gases. Their observations were as follows:

BASIC BESSEMER	Carbon monoxide Per cent by wt.
Before deoxidation.....	0.010
After deoxidation.....	0.059
After rolling.....	0.025
OPEN HEARTH	
Before melting down.....	0.0775
After deoxidation.....	0.0665
After deoxidation.....	0.0770
After rolling.....	0.0550

The changes in the percentages of the other gases were slight, and no particular importance could be attached thereto.

These results indicate that there may be important differences in the exact procedure of the deoxidation process in the case of steel made by the basic Bessemer and open-hearth method,

¹ *Stahl und Eisen*, 2 (1882), 193–198.

² *THIS JOURNAL*, 3 (1911), 372–4.

³ *Trans. Am. Inst. Min. Eng.*, 47 (1913), 436–463.

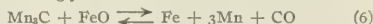
⁴ *Iron and Steel Inst., Carnegie Scholarship Memoir*, 6 (1914), 216–40.

⁵ *Ferrum*, 12 (1915), 57–64 and 73–81.

and it is certain that the results of the analyses given above are exactly the reverse of what most metallurgists would have expected.

FERROMANGANESE CONSIDERED AS A CARBIDE

The composition of ordinary commercial 80 per cent ferromanganese corresponds very closely to what would be theoretically the case for manganese carbide, Mn_3C . The extreme difficulty of preparing carbon-free manganese by any of the ordinary methods indicates that the affinity of manganese for carbon is very great, and there is no very good reason to suppose that it does not persist in the liquid state. The experience of Wright¹ in attempting to prepare manganese free from carbon points strongly to the conclusion that such a reaction as



would not be expected to proceed from left to right appreciably during the deoxidation process.

This viewpoint appears even more reasonable when we examine the extensive researches of Boylston² who found that ferromanganese when added without ferrosilicon decreases the number of blowholes in a steel ingot to no appreciable extent, whereas ferrosilicon alone produced a very marked effect.

Whatever may be the exact nature of the process, it seems that manganese carbide, *i. e.*, ferromanganese, does not take a prominent part, due probably to the difficulty with which it parts with its carbon content.

QUESTION OF THE IDENTITY OF FERROUS OXIDE

It has been assumed in the foregoing discussion that the compound ferrous oxide exists as such in equilibrium with iron. However, there is conclusive proof³ given by Sosman that at

¹ Iron and Steel Inst., *Carnegie Scholarship Memoir*, 1 (1909), 143-60.

² *Ibid.*, 7 (1916), 102-171.

³ *J. Wash. Acad. Sci.*, 7 (1917), 55-72.

ordinary temperatures the compound usually referred to as ferrous oxide is in reality a mixture of iron (or iron carbide) with magnetite or with some oxide intermediate in composition between FeO and Fe_3O_4 . It goes without saying that in this light our interpretation of the well-known equilibria between iron and its oxides, carbon and its oxides as described by Bauer and Glaessner¹ and Preuner,² as well as the equilibrium between iron and its oxides, hydrogen and water vapor as reported by Chaudron³ must be revised in order to accord with the facts.

CONCLUSIONS

It is obvious then that our present knowledge regarding the true function of ferromanganese, ferrosilicon, and the other deoxidizers is insufficient to explain the observed facts. Furthermore, the current theory has been shown to be contradicted each time by those few experimental facts which investigators have been able to gather.

In such a situation it is difficult to refrain from offering a new theory regarding the process, since it would be hard to devise any reasonable kind of hypothesis which would not fit experience at least as well as our present one.

It can be predicted, however, with considerable certainty, that this most important industrial problem, and by this I would include the general question of substitutes, will be solved not by postulates and theories, but by painstaking measurements of equilibria at high temperatures, and by the accumulation of a more adequate supply of data concerning the specific heats and stability relations of the elements and compounds concerned.

NATIONAL CARBON COMPANY, INC.
CLEVELAND, OHIO

¹ *Z. phys. Chem.*, 43 (1903), 354.

² *Ibid.*, 47 (1904), 385-417.

³ *Compt. Rend.*, 159 (1914), 237-39.

FOREIGN INDUSTRIAL NEWS

By A. McMILLAN, 24 Westend Park St., Glasgow, Scotland

A NEW TEXTILE FIBER

According to the *Z. angew. Chem.* for June 14, 1918, a manufacturing company in Chemnitz has succeeded in producing a useful substitute for cotton and jute from pine tree needles. These needles are treated chemically and then prepared by machinery. The finished material can be spun on any cotton spinning machine. The spun yarn breaks less easily than paper yarn and is also more elastic. This company also manufactures a very serviceable watertight and pliable substitute for shoe leather.

ANNEALING OF GLASS

The *Proc. Tokyo Physic. Soc.* for September 1918 contains an interesting paper on the annealing of glass. In the first case a newly drawn glass fiber is heated slowly in an electric furnace and its length observed. It was found that it increases as the temperature rises but at a temperature about 400° C. it begins to contract and at 500° C. it becomes elastic. Again, when a short cylinder of the glass between crossed Nicols is heated, the interference rings show little change until a temperature of 400° C. is reached. They then widen and disappear at about 500° C. Lastly, when the glass is slowly heated or cooled, the curve of temperature change shows that over the plastic range of temperature there are absorption and liberation of heat, proving that some change of state of a constituent of the glass takes place at that temperature. The first two effects vary with the nature of the glass and are not exhibited by annealed specimens. The third effect is found in both annealed and unannealed glass.

TETRAPHOSPHATE

The new Italian fertilizer known as tetraphosphate is produced by mixing natural phosphate rock powder with 6 per cent of a powder containing equal parts of carbonates of calcium, sodium, and magnesium with a little sodium sulfate. According to a report in the *Chem. Trade J.*, 63 (1918), 406, the mixture is roasted several hours at 600° to 800° C. in special furnaces. After treatment with cold phosphoric acid the product is reduced to required strength by mixing with dry earth and sand. In tests by the Italian commission, the new fertilizer has been applied to wheat, rice, potatoes, oats, beans, and clover, and the results are said to have equalled or surpassed those from superphosphate. It was found to have special advantages in freedom from acidity, causticity, and deterioration, while it can be made from phosphate rock of much lower than usual percentage.

JUTE SUBSTITUTE

Paper yarn, says *Nature* quoting from the *Z. angew. Chem.* for August 2, 1918, of from 1 to 5 mm. diameter is in use in Germany as a substitute for jute, while paper yarn from parchment paper is woven into belts for driving light machinery. The yarn, when treated with 1 per cent solution of tannin, is rendered soft and flexible to the touch and its strength increased by 49 per cent. The addition of gelatin gives a hard, firm touch to the yarn and an increased strength of 25 per cent. When wet its strength is reduced by only 15 per cent. Neutralized aluminum acetate added to the tannin gives the yarn a strong, elastic touch and increases its strength 44 per cent. The average water content of the yarn is about 38 per cent.

COMBINED RAIL AND ROAD TRUCKS

A scheme of which particulars are issued by Mr. T. Bennett, St. Albans, England, contemplates the use of combined rail and road trucks. He would collect and deliver goods in containers or "loaders" provided with wheels which would permit them to be hauled over ordinary roads. On arriving at a station by road these loaders would be taken to a bank or platform raised to such a height as to be level with the flat tops of wagons or "chassis" running on the railway track. On this bank each of their wheels would be placed on "laterals" furnished with four small wheels or rollers, and then they would be moved upon the chassis and secured in place. On reaching its destination the train would be taken alongside a similar bank, and the loaders would be pulled off the chassis and removed from the laterals to be subsequently delivered by road. Mr. Bennett claims advantages for his plan, including saving of shunting and of handling goods, but whether or not these could be realized in practice, the permissible height of the loads he could carry would be less than at present owing to the limitations used vertically on the landing gauge by overbridges and tunnels, and probably also the gross weight of the trains would be greater in relation to the paying load.

TWO-CYCLE PARAFFIN OIL ENGINE

In accordance with the requirements of the government department by which it was ordered, a 50-h. p., 2-cycle internal combustion engine made at Manchester by the Record Engineering Company was recently subjected to an endurance test of five days. During that time, says the *Times Engineering Supplement*, it ran continuously night and day at full load under paraffin oil, without attention or adjustment of any kind beyond the usual filling up of the fuel tanks and the supply of lubricating oil. None of the plugs was changed, and when the engine which is of the V type, with 4 cylinders and 2 cranks, giving 4 impulses per revolution, was dismantled at the end of the test, it is stated that no appreciable signs of wear were visible and that the cylinders were practically free from deposit. In the design adopted by the company, the two-to-one gears with the camshafts, cams, tappets, and poppets found in the ordinary 4-cycle engine, are eliminated and are replaced by a simple piston valve generally for each pair of cylinders worked by an eccentric on the main shaft. As a valve merely controls the distribution of the gaseous fuel to the pump cylinders it is not subject to a pressure exceeding a few pounds per sq. in. nor to the high temperatures of the working cylinders. The crank case is used only as a reservoir for lubricating oil, and not for handling the fuel mixture, so that the deposition of carbon and soot on the bearings is avoided, as also is the mixture of fuel oil with the lubricating oil. As the cylinder heads are made loose, both piston tops and combustion chambers can be cleaned without dismantling.

PRESENT STATE OF RUSSIAN INDUSTRY

According to the *Z. angew. Chem.* the latest information concerning the industries of Russia is of a pessimistic description. The *Sarja Rossijii* affirms the complete destruction of the starch industry in the government department of Rjasan. The factories which were in part destroyed remain idle, and the peasants have taken possession of the stocks of materials. All industry in the Urals is carried on under great difficulties. In the district of Bogeslewsk the monthly output of iron ore has dropped from 4017 to 3570 tons. In the Hylswenski district, where 21,000 workmen were employed, not more than 4000 are now working. At Tschusowslosawod, an iron-producing district, all the furnaces are out of blast. In Werchnisetzke likewise all the factories are idle. State help has been given to the industries of the Urals without, however, any visible effect in improving the situation.

ELECTRIC MELTING OF BRASS

In the *J. du Four Electrique* some notes on electric brass furnaces are given, the advantages of which are summarized as follows: Hand labor a minimum, because the capacity can be raised to 3-4 tons and the application of the heat does not involve manual labor; no crucible and maintenance running costs, except the renewal of electrodes which requires determination by long experience; loss in zinc probably little different from that in small covered crucibles as the furnace is a closed one; insignificant oxidation; no dross requiring treatment. It is convenient that if combustibles are replaced by electric power, the furnace will require about the same number of kilowatts per 100 kg. of metal turned out as the kilograms of coke consumed by the ordinary furnace for the same output. Theoretically, the electric furnace is the ideal but its practical development is contingent on a sufficiently low price of energy.

AUSTRALIAN EUCALYPTUS OIL TRADE

Considering the great variety of the Australian eucalyptus trees, it is not astonishing, says the *Oil and Color Trade J.*, that there are many kinds of eucalyptus oils which already find varied applications but which certainly could be more fully utilized. In 1917 Australia exported to the United States \$24,145 and to Canada \$6,120 worth of such oils, the figures for 1916 being, respectively, \$12,170 and \$700, and the production and trade in these oils could be largely increased, no doubt. It is said that of the 300 specimens of eucalyptus not more than 15 can be utilized for their oils but that estimate may be too low. So far, the oils of 160 specimens of eucalyptus have been examined for their products. The leaf oil of *Eucalyptus macarthurii*, a tree of very rapid growth, contains 60 per cent of geraniol and geranyl acetate, valuable in the preparation of perfumes. *Eucalyptus citriodora* and *stageriana* yield substitutes for lemon oil only in small percentages but yet in industrially paying quantities. Eucalyptus trees flourish also in other countries into which they have been introduced, notably in swampy districts, and the oil industry is, therefore, not of interest to Australia alone.

PAPER-MAKING MATERIALS

As the results of the tests made by the Imperial Institute, London, on South African grasses as paper-making materials, a grass called "thatching grass" or "Dek grass" is said to have proved a promising material. It gives a satisfactory yield of long-fibered pulp of good quality suitable, in the unbleached state, for the manufacture of brown paper or, after bleaching, for the manufacture of fairly good cream-colored or white paper. According to report, however, the export of South African grass would scarcely be possible, as it would probably have the same value as Algerian exports, i. e., \$12 to \$14 in the United Kingdom in normal times. It may be possible, however, to convert the grass into "half-stuff" or paper in South Africa for export.

TREATMENT OF PEAT

In the improved Ekenberg process of treating peat, says the *Chem. Trade J.*, 63 (1918), 406, as being tested at Chateaufneuf, France, the raw material is first compressed to reduce the water from 90 to 60 per cent. It is then subjected to the action of superheated steam at 160° C. for 25 min. and is afterwards again compressed or at once dried in special chambers or in the open air. Turbon, as the product is called, still retains 20 to 25 per cent moisture. It yields 61 per cent volatile matter and its calorific value is 10 per cent higher than that for ordinary peat. It is recommended for direct firing where ammonia can be recovered and especially for power gas for internal combustion engines.

FUTURE OF GERMAN IRON INDUSTRY

In the *Berliner Tageblatt* of October 19, 1918, Dr. F. Pinner discusses the relation which Alsace-Lorraine has hitherto borne to German industries and the effects which might result from the loss of these provinces. The point which is most worthy of notice is that the cession of Alsace-Lorraine would mean the cutting off of sources of raw materials with which Germany is not too well supplied. Manufacturing industries can be set up anywhere but the loss of raw material is irreparable. Three words suffice to describe what Alsace-Lorraine means to Germany—iron ore, potash, petroleum. While the loss of Alsace petroleum deprives Germany of 42 per cent of her total petroleum production and while, with the cession of Alsace, Germany loses also her world monopoly of potash, the question of the iron production affects her most of all. It cannot be doubted that the enormous rise in the German iron trade was due to the acquisition of the Lorraine mines in 1871. From a few million tons, the production has risen to 19 million tons and Germany has outstripped all other countries in the iron trade except the United States. In 1913, out of a total ore production of 35.9 million tons for the whole of Germany, Lorraine and Luxemburg contributed 28.5 million tons, and of a total iron content of 10.54 million tons, Lorraine and Luxemburg represented 8.15 million tons, or 77 per cent. When Lorraine is lost, Germany will have to go abroad for iron ore. She may get supplies from Sweden, Spain, Russia, and even from France, but the ore basis of the German iron industry will be so restricted that its maintenance and continuation will, in the opinion of the *British Board of Trade Journal*, become a matter of question.

LIQUID CRYSTALS

Evidence has been accumulating during the last few decades that there is justification for speaking of liquid crystals. The term, says *Engineering*, certainly does not appear to accord with the time-honored distinction of the three states of aggregation—solid, liquid, and gaseous—and, besides, bodies like pitch and wax, which gradually soften and have no definite melting point do not exactly fit into this classification. But crystals, substances which in solidifying assume definite though varying shapes with straight edges and plane surfaces and which are characterized by optical and other physical properties not found in either amorphous or in liquid substances, seem to be solids *par excellence*, and it is difficult to imagine such substances to partake simultaneously of the characteristic properties of solids and of liquids. Yet we know now a large number of crystal-like bodies of more or less constant shapes which unite when they meet, forming twins which may split again or be distorted into spirals and which not only possess some of the specific properties of crystals to an enhanced degree but which actually display certain optical properties for which scientists have so far been looking in vain in solid crystals. These liquid crystals may drift in a trough across which wires are stretched and float right through the wires to close up again and to re-assume their original shape and properties, very much as the proverbial ghosts float through walls and are left unharmed by bullets and sword thrusts. These liquid crystals are real though they are best studied under the microscope or polariscope.

POTASH DISCOVERY IN SICILY

An important message has been received from Rome in connection with the supply of potash. It is stated that in the province of Cattanielsa in the Island of Sicily, immense deposits of potash have been discovered and the preliminary investigations are said to establish these as the richest in the world. The exploitation of these deposits, if the first reports receive the confirmation hoped for, would make it quite unnecessary to have recourse to the German supplies.

MINERAL WEALTH OF THE UKRAINE

The important bearing on the food supply of artificial manures containing phosphorus, says a writer in an Austrian contemporary, makes the mineral wealth of the Ukraine of some account at the present time. Phosphorite is found in many districts, in some parts in great abundance, and large quantities can even be obtained from open-cast workings at low cost. Before the war Austria obtained phosphorite in considerable quantity in ground condition. The mineral on analysis is found to contain a high percentage of calcium phosphate and no less than 27.5 per cent of phosphoric acid. In order to produce the best results, the deposits would require to be worked systematically and not by the antiquated methods which were formerly employed.

IRON TRADE IN SWEDEN

According to official statistics for 1917 now available, the financial result of the Swedish iron trade is, on the whole, satisfactory on account of the higher rate of prices although the production in several cases is smaller than during the preceding year. The production of iron ore amounted to an aggregate of 6,217,172 tons against 6,986,298 tons for the preceding year, but the value rose from \$17,250,000 in 1916 to \$21,000,000 in 1917. The production in pig iron showed an increase, the total for last year being 828,969 tons as against 732,734 tons in 1916. The value of the pig iron rose even more than the production, being nearly doubled. The figures for 1917 were \$58,450,000 as against \$28,675,000 for 1916. The production of bar iron and steel receded some 29,000 tons; band, nail, and other fine iron, 14,000 tons; and solid tube material, some 8,700 tons. The total aggregate value of production of Swedish iron and steel work during 1917 is put at \$95,425,000 against \$60,975,000 for the preceding year.

SEA-ANIMAL OIL

In 1915 and 1916 a large number of samples of sea leopard oil, seal oil, and penguin oil, prepared at Adélie Land during the Australasian-Antarctic Expedition in 1912-13, were forwarded to the Imperial Institute, London, for examination. The results found were interesting. An eminent authority on the subject considers that there is an assured future for penguin, seal, and whale industries in Antarctic regions, but that any plans for developing them would require to be very carefully considered before action is taken, and several years preliminary work might be required before such industries could be started on proper lines. It would also, in the opinion of this authority, be necessary to introduce some form of protection for these animals.

AGRICULTURAL IMPLEMENTS

Before the war Austria-Hungary supplied Rumania with 40 per cent of her requirements in agricultural implements. This supply has ceased since 1914 and, as Rumania had a large stock of agricultural machines sufficient to last her up to the present time, only various spare parts had to be furnished. The supply is now giving out and Rumania offers an excellent market for agricultural implements, especially for tractors and fodder-cutters which are little known in that country. Again, Russia used 6,000,000 scythes annually, of which one-half were for Siberia. About 4,500,000 were imported and those which came from Austria were most in demand because of light weight and cheapness. At present, there are hardly any scythes in Russia as the native industry is at a standstill and import is closed. Before the war the price for scythes ranged from one to two roubles (\$0.76 to \$1.50). Here, again, a good market could be found, as large numbers of scythes will soon be required.

LARGEST OIL-TANK STEAMER

A notable addition to the oil-tank fleet of the Eagle Oil Transport Company was successfully launched on December 3, 1918, from a yard at Wallsend-on-Tyne, England. The vessel, *San Fiorentino*, is constructed to carry a total weight of 18,000 tons and is the largest oil-tanker afloat. She is 346 ft. in length, 68 ft. 7 in. in width, with a moulded depth of $42\frac{1}{4}$ ft. The hull of the ship is divided into 13 oil-tight compartments and fitted with $4\frac{1}{2}$ miles of oil pipes. The system of piping is so arranged that the pumps can discharge the vessel by grouping together a given number of oil-holds in every conceivable way. Four different grades of oil can be either loaded or discharged simultaneously without getting mixed. The engines consist of a set of compound geared turbines.

SOCIALIZATION OF GERMAN INDUSTRIES

The socialization of certain German industries, notably mining, the steel and iron, and textile industries, for which the extreme wing clamors, says *Engineer*, is not likely to materialize at present. The government does not find the time convenient and fears that German industry cannot stand any further disturbance lest its foundation should be entirely shaken. The Bavarian shares the view of the Berlin government and deems it inopportune to transfer the industries to the state at a time when it is entirely exhausted. In the meantime, industrial circles are alarmed at the prospects of immediate higher taxation.

MAGNETIC PROPERTIES OF IRON ALLOYS

The results of some investigations by Gumlich are quoted in *Elektrotechnik und Maschinenbau* for September 1, 1918, on the magnetic properties and resistance of iron alloys. The materials used in the investigation consisted of pure electrolytic iron and four series of alloys with increasing carbon content (up to 1.8 per cent). The density and specific resistance vary with the percentage of added material. According to the results given, it would seem that the addition of silicon or aluminum do not improve to any extent the magnetic properties of iron, and any benefit derived by their presence is due to secondary causes as oxygen is removed and the effect of the carbon somewhat neutralized. Eddy-current losses are reduced by the addition of silicon and aluminum. Results are also given showing the effect of the added materials on the coercive force and from them it would appear that good permanent magnets may be produced by adding tungsten, chromium, or molybdenum.

LUBRICANTS

Various forms of lubricating oils and greases are described in a list issued by Messrs. Sterns, Limited, of 16 Finsbury Square, London, E. C. 2. Of solidified lubricants it is said that their use secures economy and cleanliness, reduces friction to a minimum, and diminishes the risk of fire, owing to the non-combustibility of the solid matter. Oil leads to dirtiness and waste through dripping from bearings, upsetting, and leakage of containing vessels, and overfilling of lubricators, and is very susceptible to changes of temperature by which solid lubricants are not affected. The employment of the latter is stated to mean, in almost every instance, simpler construction of machinery and economy of lubricating material, 11 to 16 lbs. of solid being equal to 1 cwt. of liquid oil. The list also refers to lubricating oils for machinery, oil and gas engines, steam engine cylinders, motor cars, and marine purposes, to belting bricks for leather, balata and textile belts, to pastes for piston rods, and for cog wheels and driving chains, to soluble cutting oil, and to various other oil preparations.

THE GERMAN DYE INDUSTRY

The *Morning Post*, London, states that German chemical and dye works are being rapidly readapted to the manufacture of peace-time products, and the future is regarded as by no means unpromising. Manufacturers realize that they will not be able to export for some time to come 70 to 75 per cent of their total output, but they are already resuming the production of dyes from coal tar, and the manufacture of pharmaceutical products has been carried on at full pressure during the war. A German contemporary points out that the demand for pharmaceutical products, which is imperative everywhere, can be at once met, while the stocks of dyes must be greatly reduced both in Germany and throughout the world. Manufacturers rely on the excellence of the German products being able to open up doors at present closed to them. They further state that they do not underestimate the efforts which have been made in England and the United States to create a chemical industry of their own, particularly for dye manufacture, and are conscious of the fact that considerable success has attended their efforts, especially in the case of the United States, but consider that serious importance should not be attached to these foreign efforts as German industry has the great advantage of long experience. Germany admits that she may feel the competition in the simpler products but not in the more complicated products which are a specialty of German manufacture. In this latter department, she fears greater competition from the Swiss, who have made great advances and succeeded in gaining entry into a market which was formerly held by German industry.

SOURCES OF ALCOHOL

Particulars are given in *Z. angew. Chem.* for September 13, 1918, regarding a process at present largely used in Germany, for the manufacture of alcohol from sawdust, chips, and shavings. It is estimated that from a half to one million tons of such waste material are produced annually in that country. Four distilleries are at present being run on these raw materials, each having fifty-one autoclaves of 1000 kg. capacity. The cost of production is said to be high when the residue cannot be used as cattle fodder or the waste liquors used for other products. The material is heated in an autoclave with either sulfurous or hydrochloric acid for from 20 to 40 min. at 265° C. at a pressure of 7 atmospheres, then quickly drawn off, neutralized, and run into the fermenting vat, beer yeast being used.

GERMAN SYNTHETIC RUBBER

The full story of the efforts of German chemists and engineers, says *Chem. Trade J.*, 64 (1919), 26, to produce substitute materials during the four years' war scarcity will be an interesting one. Synthetic rubber, one of the most important of these substances, was more or less successfully made by Frantz Hoffmann, as early as 1912, but his experiments were partially abandoned on account of the lower cost of the natural rubber at the time. With the stimulation of the industry by the war demand, the process was improved and such difficulties as ready oxidation in the air and imperfect vulcanization were overcome. At a recent meeting of the Bunsen Society, in Berlin, it was stated that, in spite of the trouble in obtaining new materials, the production of methyl rubber had reached 165 tons per month, and a large factory at Leverkusen has a capacity of 2,000 tons yearly. The hard rubber, claimed to be a 20 per cent better electrical insulator than the natural rubber, was used for the accumulator boxes on submarines. The soft rubber, less easy to develop, is leather-like and inelastic at ordinary temperatures, but is given increased elasticity in manufactured articles by the addition of dimethylaniline and toluidine. It now serves for tires for heavy road motors.

SCIENTIFIC SOCIETIES

THE NAVAL CONSULTING BOARD OF THE UNITED STATES

The Naval Consulting Board of the United States was called into existence through the Secretary of the Navy in September 1915 to establish a link between the Navy of the United States and civilian technologists, inventors, and scientists. It was the first one of the so-called civilian war boards which were created later on, after our country had entered the war, and consists of 22 members.

The AMERICAN CHEMICAL SOCIETY was one of the several technical and scientific organizations which were asked to designate their two representatives.

It soon became obvious, and more so after the United States entered the war, that it was undesirable, except in special cases and to a limited extent, to divulge the program or the detailed activities of this Board. Several of its members became also active members in other war boards created later on. Others were just as active as members of the National Research Council, so that the activities of the Board, in many cases, ramified through and intertwined with those of the many departments of the Council of National Defense. Frequent cases occurred where the collaboration of members of the AMERICAN CHEMICAL SOCIETY and of the other engineering or scientific societies of the United States was requested, to serve as aids or advisers in the many committees or subcommittees. The enthusiasm with which, in each case, such cooperation was furnished, without desire or hope of reward, and frequently at the sacrifice of personal interests or private occupations, was one of the many symptoms of that great wave of patriotism and devotion to a great cause, which swept over our whole country. Several officers of the Army, as well as of the Navy, were adjoined to the Board and furnished most valuable collaboration.

The Naval Consulting Board has not yet been dissolved, and some of its committees are still actively busy with some of its unfinished problems. Some of these subjects are of such a delicate nature that, even to-day, it would be reckless to speak about them, especially in view of the fact that conditions of peace, or future disarmament are far from settled at this moment. But a provisional statement, not involving details, seems desirable, especially in view of the fact that the members of the AMERICAN CHEMICAL SOCIETY are entitled to know something about a Board with which many of them have so heartily cooperated.

The present brief statement seems particularly justified in view of the publication of the Annual Report for 1918 of the Secretary of the Navy. A copy of this report can be obtained from the Government Printing Office, Washington, D. C. It is one of the most interesting documents ever published by the United States Government. The information contained therein should reassure anybody who has ever doubted the organization and efficiency of our Navy, and ought to be a source of pride to every American citizen. The volume comprises 380 pages and covers a great diversity of subjects. In it, occasional references are made to the Naval Consulting Board, of which we beg to quote as follows:

**** The work of the Naval Consulting Board has increased greatly in both importance and volume during the past years. In addition to work especially adapted to naval uses, the members have assisted in almost every field of research, and Mr. Thomas A. Edison, president of the Board, is still devoting his entire time and his laboratory to war work.

More than 110,000 ideas, inventions, and devices have been considered by this Board and the department, either separately or conjointly; there have been 4,200 interviews on inventions and upwards of 700 models have been examined. In addition, at the Chicago branch office 2,300 interviews have been granted

and 2,500 communications investigated. This gives an idea of the volume of this work and the care that is taken in considering and investigating every invention or suggestion that gives promise of being of any value.

A very complete bulletin on the enemy submarine has been prepared, after the most careful study and compilation of all data, and was issued under date of May 1, 1918. This gave all but the most confidential information on the subject and has served as a guide to the country-at-large in making suggestions. A second bulletin on the subject of aeronautics, composed of articles prepared by a number of the best authorities on the subject, was issued on August 1, 1918. This pamphlet included a carefully prepared bibliography that is complete and exhaustive and gives the student in aviation a most valuable fund of information.

During the past year the war committee of the technical societies, composed of representatives of the great engineering societies, associated themselves with the Naval Consulting Board, and their chairman, Mr. David W. Brunton, was elected a member of the Board.

With the erection and occupancy of the new Navy building space was provided for the resident member and a staff of examiners directly connected with the office of the Secretary of the Navy, and all the files and correspondence have been concentrated in one location, bringing the examination and consideration of ideas and inventions in closer touch with the Navy Department. The office of the Board is in charge of Mr. Brunton, who is also a member of the advisory committee to the inventions section of the General Staff of the Army, and there is established a close working basis of handling all ideas presented to the attention of the proper authorities with the least effort and by a very direct route. This has not only resulted in increased efficiency, but in a reduction of expenditure of funds and time consumed.

Among the subjects studied by the board were: aeronautics, propellers for airplanes, stabilizing and controlling devices, and an instruction machine that has been adopted for use; optical glass, improvements in quality and production; ordnance equipment; anti-submarine defensive devices and offensive instruments; internal combustion engines, refined hydrocarbon fuel for airplane engines giving greater efficiency and longer life to machines, and method of coal combustion looking to higher economy.

When the department called for classes of electrical and mechanical engineers from which to select a number of commissioned officers for active service, the Board was a material assistance in its prompt and efficient handling of the situation, and as a result the Navy was enabled to obtain an excellent selection of able and experienced officers.

The officers and members of this Board give their time and talents, many of them to the exclusion of their private business, from a desire to render a patriotic and disinterested service. They are entitled not only to the thanks of the department, but of the large number of other agencies and individuals that have benefited by their counsel and advice. ****

**** The department has been keenly appreciative of the necessity of employing every effort to develop devices with which to combat the enemy's submarine operations. Advice and suggestions were freely requested and carefully considered by the department, the Naval Consulting Board, the National Research Council, the various bureaus and departments, the General Board of the Navy, and other boards in Washington.

In order to coordinate the efforts in this matter the department appointed a special board of officers to have complete charge of carrying out experiments on anti-submarine devices. The General Electric Company, the Western Electric Company, and the Submarine Signal Company patriotically offered every assistance in this work, and with a fine spirit of cooperation have rendered valuable service.

An experimental station was established at New London, Conn., under the supervision of the special board, and many scientists of unusual attainments were assembled there in connection with the experiments and development of devices for detecting submarines.

The naval activities at New London, Conn., embrace also a station for assembling and installing various devices developed and training the personnel for the efficient employment of such devices afloat. The results achieved by these methods have been most gratifying; and the operation of vessels fitted with these devices, both abroad and in home waters, has had a marked effect in restricting submarine operations.

**** The most striking engineering accomplishment during the year was the completion of the electrically propelled battleship *New Mexico*, the results of whose trials confirm the judgment of the department in adopting this type of machinery for the battle cruisers, and mark an engineering advance which will affect battleship construction the world over. Electric propulsion had its inception in the Navy, having first been applied in the collier *Jupiter*, where its superior advantages were so clearly demonstrated that the Bureau of Steam Engineering recommended it for adoption in the *New Mexico* and subsequent battleships, and still later in the higher-powered battle cruisers. It will be recalled that this decision of the Department led to the bitterest criticism not only from engineers peculiarly interested in other types of machinery but also from others eminent in their profession who had no pecuniary interest, but who feared that we were embarking upon an experiment that would be fraught with national calamity. Despite the criticism of these eminent engineers, the decision of the Navy Department, supported by the judgment of the best electrical engineers in the country, was followed in the full conviction that no mistake was being made.

The wisdom of this decision has been amply vindicated by the performance of the *New Mexico*, which has been tested in every way, her trials including many more than those specified in the contract. She has failed in none of them; the operation of her machinery has been highly satisfactory in every respect; and today, in this unique vessel the United States Navy has a battleship which has no peer in the world's navies, not only for economic propulsion and less liability to serious derangement, but for her military superiority in greater maneuvering power and increased underwater protection. As so often before, American ingenuity and inventive skill now lead the world in the propelling machinery of battleships. To the vision and the wisdom of Rear Admiral Griffin, Chief of the Bureau of Steam Engineering, and his able assistants, who gave approval to this new method of propulsion, the idea first fully tried in the *Jupiter* upon plans of Mr. W. L. R. Emmett, a naval academy graduate and member of the Naval Consulting Board, the world owes this successful revolution in the propulsion of the biggest fighting ships. This is one of the biggest achievements of this generation in engineering. ****

After complete order shall have been restored to the present disturbed conditions of the world, and when non-observance of secrecy seems no longer dangerous, your representatives on this Board may be in a condition to give further information about many interesting details of the subjects which were undertaken.

W. R. WHITNEY AND L. H. BAEKELAND
Members, Naval Consulting Board of the United States

WASHINGTON, D. C.
February 1, 1919

SPRING MEETING AMERICAN CHEMICAL SOCIETY

The Spring Meeting of the AMERICAN CHEMICAL SOCIETY will be held in Buffalo, N. Y., April 8 to 11, 1919. The secretary of the local committee, Mr. E. K. Strachan, writes as follows concerning plans for the meeting:

The local committee desires to make the "Victory Meeting" one of the most famous that the AMERICAN CHEMICAL SOCIETY has ever held.

The headquarters of the meeting will be in Hotel Statler, which is centrally located and furnishes ample space for the general meeting, smoker, and banquet. This hotel can furnish lodging for several hundred members and in addition, we have three or four other excellent hotels within a few blocks.

Scientific meetings will be held at the Technical High School which is but a short distance from the hotel. Mr. Childs, the principal of the school, is working enthusiastically to provide us with the very best accommodations. The school building is of the very finest kind of modern construction and equipment. It is large enough so that the meetings will in no way interfere with the classes. The school is equipped to furnish a cafeteria or buffet luncheon at noon and will do so on the days we hold sectional meetings there. It has every convenience in the way

of intercommunication, telephones, projection lanterns, coat rooms, etc.

The public meeting will be held at the Hutchinson High School, which is another building of fine modern construction and equipment. This is located nearer to the residential section and has been chosen because we are making every effort to draw a large local audience. The Engineering Society of Buffalo, an organization of about one thousand members, is being interested in this event as well as in the meeting as a whole.

The smoker will be conducted under the able direction of Mr. Lidbury. Those who know him need no further guarantee that this affair will be a great success.

Our program includes an all-day trip to Niagara Falls. During the morning, the party will visit the various power plants and will be shown the location of the chemical industries. Luncheon will be provided at the Chamber of Commerce, and a comprehensive exhibit of Niagara Falls products will be shown, as well as many moving pictures. Those who prefer to do so may visit the Falls and take the scenic railroad trips down the Gorge and to the various places in the neighborhood. There will also be industrial excursions in Buffalo. Some of the largest chemical and other industries in the country will open their plants to the visitors.

We are in hope of arranging with Dr. Parsons for a general symposium on Tuesday afternoon, which will deal with some prominent, vital subjects, preferably chemical reconstruction problems. During the entire meeting we aim to place the chemist before the public in the most favorable way possible.

We should strike while the iron is hot and while the war is still a live subject. We hope to give the local public and the people of the country-at-large a new knowledge of the chemist and his works.

A delightful program for the visiting ladies is in course of preparation and we feel that all of them who come will enjoy a memorable occasion.

The following committee has charge of the local arrangements:

- C. G. DERRICK, National Aniline and Chemical Company, Buffalo
Chairman, Executive Committee; Chairman, Program Committee
- J. F. SCHOLLEKOFF, JR., 1429 Marine Bank Building, Buffalo
Treasurer, Executive Committee; Chairman, Finance Committee
- E. K. STRACHAN, National Aniline and Chemical Company, Buffalo
Secretary, Executive Committee; Chairman, Registration and Information Committee
- D. H. CHILDS, Technical High School, Buffalo
Chairman, Committee on Arrangements for Meetings
- W. H. WATKINS, National Aniline and Chemical Company, Buffalo
Chairman, Excursions Committee; Chairman, Exhibits Committee
- A. M. WILLIAMSON, International Acheson Graphite Co., Niagara Falls
Chairman, Niagara Falls Excursions Committee
- JOHN A. MILLER, 45 Lewis Block, Buffalo
Chairman, Hotels Committee
- F. A. LIDBURY, Oldbury Electrochemical Company, Niagara Falls
Chairman, Smoker Committee
- WALTER WALLACE, Oldbury Electrochemical Company, Niagara Falls
Chairman, Banquet Committee
- F. S. LOW, Niagara Alkali Company, Niagara Falls
Chairman, Niagara Falls Exhibits Committee
- H. B. SAUNDERS, Chamber of Commerce, Buffalo
Chairman, Publicity Committee
- D. C. HOWARD, 160 Park St., Buffalo
Chairman, Clubs Committee
- D. W. SOWERS, Sowers Manufacturing Company, Buffalo
Chairman, Invitations Committee
- MRS. J. F. SCHOLLEKOFF, JR.
Chairman, Ladies' Entertainment Committee
- G. P. FULLER, National Electrolytic Company, Niagara Falls
- L. E. CHAMBERLAIN, Hoppenstedt Laboratories, Buffalo
- H. S. LICHTENBERG, Richardson, Beebe Co., North Aurora
- A. C. PARSONS, Lackawanna Steel Co., Buffalo
- R. E. FOWLER, National Electrolytic Co., Niagara Falls
- A. P. SV, University of Buffalo
- E. B. STEVENS, Wood Products Co., Buffalo
- A. H. HOOKER, Hooker Electrochemical Co., Niagara Falls
- F. J. TONE, 328 Buffalo Ave., Niagara Falls
- L. E. SAUNDERS, 123 Buffalo Ave., Niagara Falls

CALENDAR OF MEETINGS

American Drug Manufacturers Association—Eighty Annual Meeting, Waldorf-Astoria, New York City, March 24 to 27, 1919.
American Electrochemical Society—Thirty-fifth General Meeting, Rumford Hall, Chemists' Club, New York City, April 3 to 5, 1919.

American Chemical Society—Spring Meeting, Hotel Statler, Buffalo, N. Y., April 8 to 11, 1919.

National Foreign Trade Council—Sixth National Foreign Trade Convention, Congress Hotel, Chicago, Ill., April 24 to 26, 1919.

NOTES AND CORRESPONDENCE

REPORT OF THE PATENT COMMITTEE TO THE NATIONAL RESEARCH COUNCIL¹

The Commissioner of Patents in 1917, with the approval of the Secretary of the Interior, requested the National Research Council to appoint a committee to investigate the Patent Office and patent system, with a view to increasing their effectiveness, and to consider what might be done to make the Patent Office more of a national institution and more vitally useful to the industrial life of the country.

Mr. Thomas Ewing, who is a member of your Patent Committee, was the Commissioner of Patents who took that action.

The National Research Council, complying with the request, appointed a Patent Committee, consisting of: Dr. William F. Durand, *Chairman*; Drs. L. H. Baekeland and M. I. Pupin, scientists and inventors; Drs. R. A. Millikan and S. W. Stratton, scientists; Dr. Reid Hunt, physician; and Messrs. Frederick P. Fish, Thomas Ewing, and Edwin J. Prindle, patent lawyers. On the departure of Dr. Durand for Europe, Dr. Baekeland was appointed acting chairman of the Committee.

Your Committee has approached its work in the belief that the American patent system has been one of the most potent factors in the development of the prosperity of our country. Americans, being descendants of the European races, are not naturally more inventive than are Europeans, but under the incentives of the American patent system they have produced many more inventions and been able to pay higher wages and live on a better scale than Europeans.

American inventions have played a vital part in the war. There is hardly any implement or explosive that our Army and Navy has used which is not more or less the result of American invention. The Patent Office is keeping secret and withholding for publication many inventions made since the beginning of the war and which are useful in war. After the war, it will be imperative that American inventors continuously improve American products and the manufacture of them, and make basically new inventions to meet and keep ahead of the strenuous efforts which Germany and other nations will make to attain supremacy by these methods.

Your Committee has, therefore, carefully investigated the Patent Office and the patent system, with a view to increasing their effectiveness, and, based on its investigation and the experience of its members, makes the following recommendations:

The Committee has concluded to propose a program consisting of but four features, because it believes those features are of such fundamental importance that their enactment into law would strengthen the entire system and directly and indirectly establish it upon a new and much more advantageous footing before Congress and the public; and because with a simple program, presenting comparatively little opportunity for difference of opinion as to the desirability of the changes proposed, there would be a unanimity of opinion in support of it which could not be obtained if the program were more extended.

A SINGLE COURT OF PATENT APPEALS

The first proposal which your Committee recommends is the establishment of a single Court of Patent Appeals that will have jurisdiction of appeals in patent cases from all the United

States District Courts throughout the country, in place of the nine independent Circuit Courts of Appeals in which appellate jurisdiction is now vested.

Until 1891 the Supreme Court of the United States was the appellate court in patent cases for all the lower courts. At that time the right of appeal to the Supreme Court in patent cases was taken away, and that court now hears patent cases only upon writs of *certiorari*, which are never granted unless certain very unusual conditions exist.

The existence of nine appellate courts of concurrent jurisdiction in patent cases works serious hardships. While, theoretically, the law is the same in all of these courts, there has been an irresistible tendency to drift apart in the application of the law. It has even happened in a substantial number of cases that two of the appellate courts have taken a different view of one and the same patent. It is, of course, very important that the questions which always exist as to the validity and scope of a patent should be settled once and for all at the earliest possible date in the life of the patent, for, as a practical matter, seventeen years (the term of a patent) is a comparatively short time in which to reduce the invention to a thoroughly commercial form to prepare for its manufacture, and to introduce it upon the market, and it is usually necessary to determine the validity and scope of the patent in order to determine the amount of money which it is safe to invest in exploiting the invention. As things are now, whichever party succeeds in the first suit that is tried on the patent, the other party is very likely to feel that in a second trial before another court he might have better luck. He, therefore, is inclined to insist upon a second litigation. Meantime, he advertises that the questions involved were not settled in the first case. This means uncertainty on the part of the owners of the patent as to their rights and uncertainty on the part of the public as to its rights to use the invention or to determine what it must avoid in working in the same field—a really intolerable situation.

Moreover, we shall never have a uniform and definite patent law, consistently applied, until we have a single Court of Patent Appeals independent of local sentiment, realizing a responsibility to fix the principles of the law and enforcing an harmonious application of these principles on the lower courts. It would be of the utmost value to those in the United States who are engaged in industry if the present confused condition could be corrected and a single tribunal devote itself to crystallizing the fundamentals of the patent law and to educating the courts throughout the land to uniformity in applying these principles in special cases.

Attached hereto is a copy of a bill¹ for the establishment of such a court, which has been advocated for many years by the American Bar Association, and is No. 5011, of the House of Representatives, 65th Congress, 1st Session. It provides for a court of seven members, which would sit in Washington, with a Chief Justice appointed for life by the President. The appointment of the Chief Justice for life is in order that there may be an element of continuity in the court. The other judges are to be selected by the Chief Justice of the United States Supreme Court from the various district and circuit judges throughout the land, and each is to sit on the Court of Patent Appeals for a period of six years, or longer, if reappointed.

¹ Submitted December 13, 1918. Approved January 14, 1919.

¹ The proposed bills are not printed with this report.

There are many advantages in this plan. Among them are the following:

The judges would not be men who were appointed as judges primarily to deal with patent matters. There could be no charge that special interests had a hand in their selection or that they were chosen to promote special views as to the patent law and its application. They would be men who had been primarily selected by the President as fit to be federal judges in the localities where they live. Federal judges are men of a high type, and many of them are broad-minded men, much respected in the communities which they serve. They would take up the work of the Court of Patent Appeals with a breadth coming from the performance of their general duties of judges in their own circuits or districts and would, therefore, escape the narrowing which so often comes from continuous work in a specialized field.

The Chief Justice of the United States Supreme Court would select from the district and circuit judges throughout the land men whom he thought most competent to serve for a term on the Court of Patent Appeals. He would seldom, if ever, take more than one judge at a time from any one circuit. The Court, therefore, would be made up of men who were primarily judges and who would be recognized as bringing to the Court of Patent Appeals the instincts and feelings, on the subject of the interpretation of the patent law, of the courts and of the people in the communities in which they live.

Undoubtedly many of them would be on the appellate court for one term only and after that they would go back to their circuits or district with a training as patent judges such as could be obtained only by sitting for a period of years in such an appellate court. They would not only be qualified as patent judges, but they would reflect the atmosphere of the appellate court and cause that atmosphere to pervade their own neighborhood. They would thereafter undoubtedly be selected to hear patent cases in the lower courts in preference to judges who had not had training in the Court of Patent Appeals. The courts throughout the country would, in time, become educated to the high and definite standards established by the Court of Patent Appeals, not only by study of the decisions of that court, but by the presence in the lower courts of men who had had this special training in the upper court.

It is of the utmost importance that these judges in the Court of Patent Appeals should be well paid. Otherwise they might not be willing to break up their homes and go to Washington for a limited term. We think that their salaries should be higher than those of the judges of any court in the United States except the United States Supreme Court.

The increased expense due to such a court would be small. The aggregate amount of work to be done by the judges of the United States courts as a whole would not be changed to any substantial extent, because all appeals must now be heard by the present courts and judges and, if there were a single Court of Patent Appeals, the Court of Appeal in the nine circuits would be relieved of just as many appeals as were heard by it. The judges in some of the circuits are much overworked, but this is not true of many of the circuits. The Chief Justice of the United States Supreme Court, in selecting these judges, could, if he chose, take into account the work of the different circuits and whether one circuit or another could best spare a judge.

As the law now stands, judges from one circuit may be called upon, and not infrequently are called upon, to go into other circuits which are short-handed. In this way, any undue pressure upon the judges in any particular circuit, by reason of the loss of any single judge who went to the Court of Patent Appeals for six years, could be relieved.

Moreover, it is no hardship to increase the number of judges where necessary. The whole judicial system of the United States is said not to cost as much as it does to run one first-

class battleship, and the addition of a few judges would be a negligible burden upon the Treasury.

A further advantage of a single Court of Patent Appeals would be that it would see clearly where there were defects in the statute and in the conditions and practice in the Patent Office, and could speak with authority on all matters which affect the theory and practical working of the patent system.

THE PATENT OFFICE A SEPARATE INSTITUTION AND INDEPENDENT OF THE DEPARTMENT OF THE INTERIOR

The second proposal which your Committee recommends is that the Patent Office be made a separate institution, independent of the Interior or any other department.

The Patent Office was originally in the State Department, but, on the formation of the Interior Department in 1849, it was made a bureau of that department and has been so ever since.

The only matters connected with the Patent Office with which the Secretary of the Interior has anything to do are the following: The Secretary of the Interior must submit to Congress all estimates for appropriations. All appointments, excepting those of the Commissioner, two Assistant Commissioners, and five Examiners-in-Chief, are made by the Secretary but only on the recommendation of the Commissioner. The eight places named are presidential appointments, but the Secretary makes recommendations to the President. All matters of disbarment or reinstatement after disbarment of attorneys are passed upon finally by the Secretary. All matters of discipline are under the Secretary's jurisdiction. The Secretary of the Interior must approve all changes in the Rules of Practice of the Patent Office, but he cannot compel the Commissioner to make any change whatsoever.

No appeal lies to the Secretary from any decisions of the Commissioner, either in matters of merit or practice. All such matters, as far as they are reviewable, rest with the courts of the District of Columbia.

The Secretary of the Interior no longer signs the patents, and has no jurisdiction to grant or refuse them.

Thus, it will be seen that the Secretary of the Interior is not required to know anything about patents or patent law. He is not selected because of any qualifications for the granting of patents or supervision over the Patent Office. The Secretary of the Interior has less influence over the Patent Office than over any other bureau of the Interior Department, because there are appeals to him from all the other bureaus. Nor is the Patent Office related to any other bureau of the Interior Department.

The Secretary of the Interior has recently moved out of the Patent Office building, thus severing physical contact with the Patent Office, which is but a type of the lack of mental contact between the office of the Secretary of the Interior and the Patent Office.

The experience of many commissioners over a period of several generations has shown that, no matter how pleasant the personal relations may be, the Commissioner of Patents cannot expect any real benefit to the Patent Office to flow from its connection with the Interior Department. There is nothing in common between the interests of the Interior Department and those of the Patent Office, and, consequently, nothing to produce any advantage from the amalgamation of the Patent Office with the Interior Department.

Your Committee believes that to make the Patent Office an independent bureau would greatly increase the respect of the public and Congress and the courts for it, and would make it easier to procure enlarged appropriations and better salaries than under present conditions.

As to appropriations, under present conditions the demands of the Patent Office for equipment, personnel, and salaries are necessarily subjected to comparison both by the Secretary of the Interior and by Congress with those of several other unrelated bureaus, each pressing its own demands and criticizing

any apparent preference. In the opinion of your Committee, this operates as a severe handicap. In estimating the needs of the Patent Office there should be no discussion of the demands, for example, of the Pension Office or the General Land Office. As an independent institution, the needs of the Patent Office would be judged on their necessity and the appropriations be determined by consideration of general policy.

As to personnel: the enhanced dignity and independence of the Patent Office would render all positions of importance in it more attractive, and particularly would make it easier to secure and retain in office men of the necessary qualifications to fill the difficult office of Commissioner.

A copy of a proposed bill for making the Patent Office an independent bureau is annexed to this report and its enactment is recommended by your Committee.

INCREASE IN FORCE AND SALARIES OF THE PATENT OFFICE

The third proposal which your Committee recommends is a substantial increase in the force and salaries of the Patent Office. The patents granted by the United States Patent Office are of less average probable validity than formerly, because the number of applications for patent and the field of search are constantly increasing, while the examining force for many years has been insufficiently large and has not been increased proportionately. The inducements are so unattractive that 25 per cent of the examining force has resigned within the past three years. Your Committee finds that the Patent Office is suffering both from lack of examiners and from inadequate compensation.

The salaries of the Patent Office examiners have been increased only 10 per cent since they were fixed in 1848, when they were approximately the same as those of members of Congress. At the time the salaries of the Examiners-in-Chief were fixed, they were the same as those of Federal District Judges. During the past 70 years, the compensation for technical service in almost all other directions has been increased very largely. Congress, in creating new positions, is willing to pay technical men salaries more nearly approximating the usual compensation of such men in private service, but, having started a position at a given salary, is very loath to increase the salary. A Principal Examiner, to pass the entrance examination for the Patent Office, must himself have an education equivalent to that of a college graduate, and yet his salary is so low (\$2,700 a year) that it is practically impossible for him to give his own sons a college education.

Your Committee believes that salaries should be paid to the examiners proportionate to those paid for equally high technical work in other departments created recently; such, for example, as are paid in the Army and Navy and in the office of the Attorney General. The examiners are passing upon questions often involving millions of dollars, and they cannot be at their best in this vitally important work unless their salaries are large enough for them to live comfortably and without strain. The chances of making mistakes in the granting of patents are great enough even under the most favorable circumstances, and they should not be increased by compelling the examiners to work for inadequate salaries. The inducements should be such as to present compensation and a career which would attract and hold men of the highest ability. The payment of adequate salaries and the creation of provisions tending to hold out attractive prospects to the examiners would also tend to raise the dignity of the Patent Office and to increase its standing in the estimation of the public and of Congress and the courts, and so would tend to enhance the value to the public of the patent system.

The work of the Patent Office has grown so much more rapidly than has the examining force that the examination to determine whether or not the invention claimed in an application for patent is novel is imperatively restricted to the field of search

where it is most likely that the invention will be found. Many patents are granted which would not be granted if the examiner had time to make a thorough search. One of the Assistant Commissioners of Patents is compelled to devote a large amount of his time to speeding the work of the examiners in order to prevent further falling behind in the number of unexamined cases. Money is often invested on the strength of patents, only to find later that the patent is upset in the courts, because the Patent Office search did not go far enough to discover that the invention had already been disclosed in some earlier patent or publication. The granting of a patent with invalid claims or claims which are too broad or which are nebulous is a menace to the art to which it relates, and until such a patent has been adjudicated and its effect judicially determined, it tends to prevent manufacturing and commerce in that art. Such a patent may, in this way, cost the public many millions of dollars beside the cost of establishing its invalidity or its true breadth or meaning by litigation, and the prevention of the granting of such patents by any reasonable increase in the examining force of the Patent Office would, in many cases, be a very large saving. The inducement to inventors and investors in patents is consequently lessened, the standing of patents before the courts and the public is impaired, and the production of inventions discouraged.

Your Committee accordingly recommends a substantial increase in the salaries of the Patent Office officials, and in the number and salaries of the Examiners, as provided in the draft of a bill for that purpose which is attached hereto.

While your Committee believes the Patent Office so fully justifies its existence that it would be an exceedingly profitable investment, even though all expenses were paid from the public income, the Patent Office has always been self-supporting and the increase in salaries and examining force which the Committee recommends can easily be entirely taken care of by the Patent Office income, if necessary.

COMPENSATION FOR INFRINGEMENT OF PATENTS

While an injunction can ordinarily be obtained against an infringer in a case where a patent is adjudged valid, except where it would interfere with government work, a money recovery had not heretofore been generally possible except under most favorable circumstances. In a case where it cannot be said that the entire salability of the article depends upon the invention, it has been necessary to show just how much of the price of the article is attributable to the invention, and as it is ordinarily impossible to make such a separation, and as most patent cases are ones in which it cannot be said that the whole salability of the article depended upon the invention, it has resulted that recovery of money is seldom obtained in a patent suit.

Recently there have been two or three decisions in which the courts have taken a more liberal attitude, holding in effect that where an invention has been used by an infringer a reasonable royalty may be awarded to the patentee based on a mere estimation or on opinion evidence, even though no exact computation can be made. This is analogous to the attitude of the courts in personal injury cases and is entirely just and reasonable. While, as stated, there have been two or three decisions to this effect, it may take a generation to induce United States courts generally to adopt this position, if at all, and the Committee therefore proposes that the law be amended to provide, that as damages to the complainant, the court, on due proceedings had, may adjudge and decree to the owner payment of a reasonable royalty or other form of general damages. Such an amendment has been provided in the attached bill amending Section 4921, the Revised Statutes of the United States, and reading as follows:

If proof is not offered or, in the absence of adequate proof of the amount that should be awarded as damages or profits, the

court, on due proceedings had, may adjudge and decree to the owner payment of a reasonable royalty or other form of general damages.

This proposed amendment would enable the patentee in all suits where the patent has been found valid and infringed to recover at least a reasonable royalty, and would provide a money recovery in the great majority of patent suits where no recovery would otherwise be possible. The Committee believes that the comparative certainty of financial return would answer one of the most common and strongest reproaches against the patent system, namely, that a patent does not ordinarily pay the inventor any money, and it believes that the incentive to invent would accordingly be greatly increased.

There are some cases in which it seems to many who are familiar with such matters as though the courts were inclined to go to the other extreme and award damages out of all proportion. Where a complainant has shown that profits have been made by the use of an article patented as an entirety, the infringer is liable for all the profits unless he can show—and the burden of proof is on him to show—that a portion of them is a result of some other invention used by him. If the infringer cannot show what proportion of the profits is due to such other invention, then all his profits must go to the complainant. Any rule by which the entire profits are given to a patentee in the absence of proof that they are all due to the invention of the patent sued upon, is unfortunate and sometimes very unjust. The proposed amendment to the statute would permit a court under these circumstances to do substantial justice even though it could not be mathematically exact. In other words, the amendment to the statute would enable a court to avoid awarding either too much or too little.

CONCLUSION

Your Committee, believing that the American patent system is vitally useful in our system of Government, therefore recommends that the reforms herein discussed be enacted into law.

Your Committee also recommends that this report be approved by the National Research Council and that the Committee be continued for the purpose of arousing and coordinating interest in and support for the necessary legislation of various national societies, manufacturing interests, bar associations, and other elements of the public.

L. H. BARELAND, Acting Chairman
WILLIAM F. DURAND, Chairman
(absent in France)
M. I. PUPIN
R. A. MILLIKAN

S. W. STRATTON (see reservation below)
REID HUNT
FREDERICK P. FISH (see reservation below)
THOMAS EWING

Approved: JAMES T. NEWTON, Commissioner of Patents

RESERVATION BY DR. STRATTON

I agree to the terms of the report with the exception of that portion which refers to the establishment of the Patent Office as a separate government institution. It is not quite clear in my own mind that this would be the best thing to do since in general it is best for all government establishments to be represented in the Cabinet.

(Signed) S. W. STRATTON

RESERVATION BY MR. FISH

I entirely concur in the substance of the conclusions set out in the above report.

I think, however, that the words "if proof is not offered, or" in that portion of proposed Section 4921 which deals with damages and profits, should be omitted so that the sentence in which those words appear should read:

In the absence of adequate proof of the amount that should be awarded as damages or profits, the Court, on due proceedings had, may adjudge and decree to the owner payment of a reasonable royalty or other form of general damages.

I do not think that a statute should directly or indirectly contemplate a condition in litigation in which "proof is not offered." I believe that the clause which I suggest would

accomplish the desired purpose and that the courts in applying the clause would be embarrassed if the phrase "if proof is not offered" were in the statute.

I think also that general damages by way of a reasonable royalty or otherwise should not be awarded unless it appeared that actual damages or actual profits due to the unlawful use of the invention could not be determined and that there should not be any language in the statute which implied that no effort be made to determine such actual damages and profits.

(Signed) FREDERICK P. FISH

PROMPT ACTION BY CHEMISTS NEEDED ON PROHIBITION LEGISLATION

Editor of the Journal of Industrial and Engineering Chemistry:

The passage of the prohibition amendment relegated to the category of history most discussions of morals connected with this subject. With this passage, however, two kinds of chemical responsibility present themselves. We should concern ourselves at once with both of them. They deal with effective enforcement of the will of the people and neither of them can be shouldered by any one but the chemist.

The first responsibility is that of watchful care over both national and state legislation so that those in charge of this legislation may be supplied with honest information which will prevent its lack bringing unnecessary hardship upon chemistry and those utilizing it, by unwise restrictions.

The other responsibility is involved in the importance of every chemist eliminating, as rapidly as may be, the need for un-denatured alcohol in every laboratory and manufacturing operation.

Most legislative bodies now in session have under consideration bills to put into effective operation prohibition of the manufacture, sale, possession, and use of intoxicants or intoxicating liquors. Many of these bills will be enacted. These bills are necessarily drastic in character because of the evasions which they anticipate. The legislative committees in charge of these bills are usually selected because of their interest in prohibition rather than with a view to protecting the toes of science or industry. If the present Ohio legislature is any guide, however, these committees are unusual in their willingness to listen to citation of unnecessary interference with scientific work or with the manufacture of non-beverage products. This does not mean that the committees are in any sense lax. They are not. They do not hesitate to ask a petitioner, for instance, if he is "aware that Ohio is dry," and to tell him that "this bill is going to keep it dry."

This latter is the keynote or purpose of the legislation. The Ohio Senate Bill No. 4 and House Bill No. 24, for instance, are entitled "A bill to prohibit the liquor traffic and to provide for the enforcement of such prohibition." This bill is an emergency act made necessary to provide enforcement of the prohibition amendment to the Constitution of Ohio adopted by vote of the people November 5, 1918, which becomes effective May 27, 1919. The Ohio bill is very carefully drawn, very simple, and comparatively brief. It makes a very obvious effort to protect non-beverage industry.

The authors of the bill, however, did not have chemical knowledge or advice, and were unacquainted with the extent to which ethyl alcohol is used in chemical and other scientific work. For this reason, careful inspection of such bills by chemists and chemical manufacturers is imperative to avoid irritation in the working of the acts. There are, doubtless, those who would not be displeased at irritating operation of these acts but those of us who must act as the sand in the gears do not care to officiate if we can retrieve ourselves in advance. Whether prohibition has come to stay or not is a matter for debate or watchful waiting. Chemistry must not suffer in the interim or it is our fault as chemists.

Taking an active part personally in hearings on the Ohio bill makes it simple as an illustration in point to furnish warnings. The bill, as presented, contained the following undesirable features:

1—No provision was made for the manufacture, sale, and use of "unmedicated" ethyl alcohol for scientific or any other purpose. In fact, ethyl alcohol as such ceased to exist in Ohio under the provisions of the bill. Provision was made for "medicated" alcohol only.

2—No machinery was provided for the dispensing of alcohol in any form "medicated" or "unmedicated" to scientific workers and students in chemical and other scientific laboratories in universities or other organizations.

3—The possession of "any equipment for the manufacture of intoxicating liquor" was forbidden, except as therein provided. Provision was then made for the non-interference of the act with a number of items omitting, however, the ordinary distillation equipment of scientific laboratories or of dye, chemical, and other manufacturing plants not engaged in beverage preparation.

4—The words "medicated alcohol" were used and not clearly coordinated with "denatured alcohol."

5—Alcohol manufacture in Ohio was permitted by the bill but it could actually not be manufactured in the state for the reason that it was "unlawful * * * to possess any equipment for the manufacture of intoxicating liquors * * * except as herein provided." The provision was subsequently made for permission to manufacture but no provision was made for "possession" of the "unlawful" equipment.

6—General permission only and no explicit permission was given for the use of alcohol in the manufacture of "chemicals, dyes, and other preparations" of a non-beverage character. Since the administration of the act is to repose in a commissioner, all ostensible latitude allowed him in general terms obviously gives him power to tighten the operation of the act but it is doubtful whether he is thereby empowered to do things not specifically permitted, especially in an act whose effects rest on permissions and omissions.

7—The fixing of affidavits to record books and labels of containers provided for retail drug dispensing becomes highly cumbersome in a scientific or educational laboratory and the required variation was not provided.

8—The bond assessed for "other persons" not physicians and druggists, which would include chemists and other scientific workers in educational and plant laboratories, because of no other provision for them, was excessive. It was aimed to cover irresponsible users. It was not less than \$2000 and not more than \$3000, as against the manufacturer of patent medicines, toilet articles, flavoring extracts of \$100 to \$5000, and physicians \$200 to \$1000. It should be omitted entirely or applied to directors of laboratories and then on at least as favorable terms as the petty manufacturer or physician.

It is important that those in charge of such bills as we are discussing should scrutinize carefully every effort at amendment to avoid accidental or deliberate interference with its effectiveness. It is evident, however, that any assistance which chemists and others can give to those in charge of such bills will tend to prevent unnecessary irritation in chemical and manufacturing work, thus helping ourselves and assisting in an honest effectiveness of the legislation.

The second point emphasized herein is at once a responsibility and an opportunity. We, as chemists, should eliminate all unnecessary use of un-denatured ethyl alcohol. We have for years been pleading with the internal revenue bureau for a sane policy in the denaturing of alcohol for use in the arts because of the otherwise dead load thrown upon certain manufactures. There are probably few, if any, chemical manufactures which really require un-denatured alcohol or alcohol usable as a beverage or which cannot find a suitable denaturant. We

now have the need for reducing cumbersome tape in the hands of "prohibition commissioners" in the operation of our laboratories. This is the need and our responsibility. The opportunity lies in the field for research thus opened up in analytical and other forms of chemistry for the replacement of ethyl alcohol by a denatured product or a substitute. If our chemists attack the question of the influence of these other mixtures and substances on our chemical methods and operations, we will likely eliminate entirely the need for un-denatured ethyl alcohol and our laboratories will be thus largely removed from the field of law enforcement tedium. To a lesser extent these ideas also apply in industry. The ultimate beneficial influence of irritating or adverse legislation on chemical manufactures is well known and was ably handled but recently by Dr. T. B. Wagner in THIS JOURNAL, 6 (1914), 71.

Without wishing to enter the prohibition controversy as such, it is the opinion of the writer that in the interest of the public welfare, chemists everywhere should interest themselves in making these prohibitory laws cover such frightful intoxicants as ether which the unscrupulous will pander in the absence of alcohol. Bills should cover all "liquid intoxicants" at least. The tendency is to mention alcohols solely.

If we are concerned about the opportunities of the chemist for public service this whole matter is a case where we must help ourselves and where we will be rendering useful service.

JAMES R. WITHEROW

LABORATORY OF INDUSTRIAL CHEMISTRY
THE OHIO STATE UNIVERSITY
COLUMBUS, OHIO
February 12, 1919

AMERICAN DYES INSTITUTE

At the meeting on February 7, 1919, of the American Dyes Institute, the association formed recently by the combination of the American Dyestuff Manufacturers Association and the American Dyes Institute, announcement was made of the election and appointment of the following officers and committees:

President: W. H. Cottingham, The Sherwin-Williams Company.

Secretary-Treasurer: H. E. Danner.

Counsel: Arthur J. Eddy.

Executive Committee: L. A. Ault, The Ault & Wiborg Company; J. Merritt Matthews, The Grasselli Chemical Company; Frank Hemingway, Frank Hemingway, Inc.; August Merz, The Heller & Merz Company; R. C. Jeffcott, Marden, Orth & Hastings Corporation; W. T. Miller, National Aniline & Chemical Company; M. R. Poucher, E. I. du Pont de Nemours & Company.

Board of Governors: C. S. Althouse, The Althouse Chemical Co., Reading, Pa.; B. R. Armour, American Aniline Products, Inc., New York City; L. A. Ault, The Ault & Wiborg Co., Cincinnati, Ohio; R. P. Dicks, Dicks, David Co., Inc., New York City; B. P. Donnelly, Holland Aniline Co., Holland, Mich.; Frank Hemingway, Frank Hemingway, Inc., New York City; R. C. Jeffcott, Marden, Orth & Hastings Corp., New York City; R. W. Kemp, Holliday-Kemp Co., New York City; G. A. Martin, The Sherwin-Williams Co., Cleveland, Ohio; J. M. Matthews, The Grasselli Chemical Co., Cleveland, Ohio; August Merz, The Heller & Merz Co., Newark, N. J.; W. T. Miller, National Aniline & Chemical Co., Inc., New York City; J. T. Pardee, Dow Chemical Company, Inc., Midland, Mich.; E. W. Pierce, Zobel Color Works, Inc., New York City; M. R. Poucher, E. I. du Pont de Nemours & Co., Wilmington, Del.; G. S. Whaley, John Campbell & Co., New York City; S. W. Wilder, Merrimac Chemical Co., Boston, Mass.

CHEMICAL WARFARE SERVICE ASSISTS IN SECURING EMPLOYMENT

An invitation is extended to civilian chemists of the Ordnance and Quartermaster Departments to make use of the services of the Chemical Warfare Service for securing employment.

MARSTON T. BOGERT

Colonel, C. W. S., U. S. A.

Chief, Relations Section

WASHINGTON, D. C.
January 24, 1919

BACK TO THE COLLEGES AND UNIVERSITIES

Editor of the Journal of Industrial and Engineering Chemistry:

Your educational editorial in the February number of *THIS JOURNAL* leads me to think that you may be interested in the following estimation of the value to the chemical industries of men having had graduate training as compared with those having only the bachelor's training in chemistry.

Some four years ago I attempted to arrive at an estimate of the value to the industries of men with graduate chemical training. The estimates were made in various terms by men experienced in the chemical industries. Consideration was limited to chemically trained men of equal age but of less than 45 years, as too few men over 45 have had graduate work to permit a fair comparison. In considering a man's value to an industry, responsibility for the advances of that industry, and the occupation of a position of influence in the industry were given the highest consideration.

The results finally arrived at were: that a man with one year of graduate training is of approximately double the value of a man having only the bachelor's degree, that with two years of graduate training he is three times as valuable, and that with the doctor's degree, ordinarily representing three years graduate training, he is on an average five times as valuable as the man with only the bachelor's degree.

Also it was the general opinion that for a given age the salaries paid, beyond that necessary for a bare living (about \$800 a year then), were not far from those indicated in the ratio just mentioned.

RALPH H. MCKEE

DEPARTMENT OF CHEMICAL ENGINEERING
COLUMBIA UNIVERSITY, NEW YORK CITY
February 10, 1919

Editor of the Journal of Industrial and Engineering Chemistry:

Permit me to congratulate you on the editorial "Back to the Colleges and Universities." It would be a most unfortunate proceeding for the younger chemists, and one which would later on cause them much regret, were they to leave their studies unfinished and seek employment in the industries at this time. The chemical industries are in a most unsettled state, and while the readjustment is going on the supply of junior chemists ought not to be increased by those who, because of their anxiety to secure an income, are willing to forego the completion of their interrupted education; if these young men will turn back to their old colleges and universities, complete their studies, and leave these institutions with an appropriate degree bearing testimony to their attainments they will the better be able to meet the demands of the chemical industries and in that way contribute their share toward our goal—the building up of a great chemical industry in this country.

T. B. WAGNER

CORN PRODUCT REFINING COMPANY
17 BATTERY PLACE, NEW YORK CITY
February 13, 1919

Editor of the Journal of Industrial and Engineering Chemistry:

I want to thank you for your editorial "Back to the Colleges and Universities." It is very timely and much needed. I know of no profession where there is so much room at the top as in that of chemistry, and I know of no other way of getting there than the way you so well suggest in your editorial. Any young man who has started in chemistry, and has been called away to serve his country, and who can in any way get the opportunity now to go on with his work, would make the mistake of his life if he doesn't do what is necessary to make that push for the top. I hope that many young men will take advantage of the splendid advice you have given.

GENERAL CHEMICAL COMPANY
NEW YORK CITY
February 11, 1919

WM. H. NICHOLS

Editor of the Journal of Industrial and Engineering Chemistry:

I have read your editorial in the February issue of the *JOURNAL*, and wish to say that I heartily agree with you in your advice to young chemists to return to the colleges and universities, in case they are unable to find industrial employment. I am convinced that our country needs completely trained chemists and chemical engineers, and that the future for men of this profession is most promising. At this juncture many of them will find difficulty in securing employment. In my opinion the demand for thoroughly trained research chemists in this country will grow very rapidly, and no better advice can be given to the large number of men with the bachelor's or chemical engineer's degree than to utilize their time in further education, or even in teaching, until suitable opportunities come to them for other employment. I cannot emphasize too strongly the importance of a certain amount of teaching experience for chemists, as many of the successful men not only in this, but in other professions, have been greatly benefited by such experience. For those who have been successfully trained to enter the teaching profession, and are suited for such work, there is no nobler work, and we must not forget that unless our teaching force is well manned, the chemical industries of this country will not be able to secure men of sufficient training to carry on the great work which the future of this country demands.

CHEMICAL DEPARTMENT
E. I. DU PONT DE NEMOURS & COMPANY
WILMINGTON, DELAWARE
February 11, 1919

CHAS. L. REESE

ORDNANCE DEPARTMENT

SALE OF SURPLUS MATERIALS AND SCRAP

1—All surplus, unused, or obsolete construction and manufacturing materials, semifinished and completed parts, miscellaneous supplies, etc., left over at time of cancellation or termination of Ordnance contracts, or surplus, at arsenals and supply depots, will be ordered sold or stored as conditions require, by the subcommittee on sale of material of the Salvage Board. The actual sale of this material will be handled by the Material Branch of the Stores and Scrap Section of the Ordnance Department, through the District Stores and Scrap Managers, located in each District Ordnance Office.

2—Capt. Ralph C. Shaw, Chief, Material Branch, located in Group B, Section 1, Room 303, of the Ordnance Building at Seventh and B Streets, Washington, D. C., is compiling lists of the materials to be disposed of as promptly as these materials are reported for sale. Likewise, he is compiling lists of buyers of given classifications of materials. This information is being imparted to the District Managers. Any government agencies, or others interested in the purchase of any materials having been or to be ordered sold by the Salvage Board, should communicate with the Material Branch.

3—All scrap left over from the operation of Ordnance contracts will be sold by the Scrap Branch of the Stores and Scrap Section, operating through the Stores and Scrap Managers of the District Ordnance Offices. This scrap consists of different kinds of steel in sheets, billets and turnings, scrap steel parts, cupro-nickel scrap, antimonial lead dross, silk and cotton waste, burlap, spent acids, etc.

4—District representatives of the Stores and Scrap Section can give information as to scrap available. Likewise, Lt. Schleck, Chief, Scrap Branch, Group B, Section 1, Room 305, will be glad to advise as to amount of scrap on hand at any point, price at which it is being held, etc. Likewise, he will be glad to receive names of government agencies or other possible buyers of these materials.

GASES USED IN WARFARE

REFERENCES TO THE STANDARD REFERENCE BOOKS¹

By D. D. BEROLZHEIMER, Assistant Technical Editor, The Chemical Catalog Company, New York City

ABBREVIATIONS

Acad. Belg.
Beilstein
Beilstein Suppl.
Ber.
Chem. Zentr.
Mayer and Jacobson

Bulletin de l'Académie royale de Belgique
Handbuch der organischen Chemie
Supplementary volumes to Beilstein
(Ergänzungsbande)

Berichte der deutschen chemischen Gesellschaft
Chemisches Zentralblatt
Lehrbuch der organischen Chemie

ABBREVIATIONS

Molinari
Moissan
Richter
Stelzner
Thorpe
Ullmann

General and Industrial Chemistry: Inorganic
Traité de chimie minérale
Lexikon der Kohlenstoffverbindungen
Literatur-Register der organischen Chemie 1910-11
Dictionary of Applied Chemistry
Enzyklopaedie der technischen Chemie

Allyl isothiocyanate (C_3H_5CNS)

Beilstein, 1, p. 1283
Beilstein Suppl., 1, p. 725
Richter, 1, p. 167
Stelzner, p. 148

Allyl mustard oil

See allyl isothiocyanate

Arsine (AsH_3)

Molinari, p. 330
Thorpe, 1, p. 296

Benzyl bromide ($C_6H_5CH_2Br$)

Beilstein, 2, p. 60
Richter, 1, p. 549
Stelzner, p. 320

Brominated methyl-ethyl ketone

($CH_3BrCOCH_2CH_3$ or $CH_3COCHBrCH_3$)
Acad. Belg., 1900, p. 724
Chem. Zentr., 1901, (I), p. 95
Richter, 1, p. 177
Stelzner, p. 152

Bromoacetone ($CH_3BrCOCH_3$)

Beilstein, 1, p. 989
Beilstein Suppl., 1, p. 502
Richter, 1, p. 100

***o*-Bromobenzyl cyanide** ($C_6H_4CH_2CNBr$)

Beilstein, 2, p. 1316
Ber., 43 (1910), 2234
Chem. Zentr., 1910, (II), p. 643
Stelzner, p. 433.

Bromoketone

See brominated methyl-ethyl ketone

***o*-Bromo-2-phenyl-acetonitrile**

See bromobenzyl cyanide

Butyl mercaptan (C_4H_9SH)

Beilstein, 1, p. 350
Richter, 1, p. 148
Meyer and Jacobson, 1, p. 221

Carbonyl chloride¹ ($COCl_2$)

Beilstein, 1, p. 546
Beilstein Suppl., 1, p. 219
Richter, 1, p. 36
Stelzner, p. 26

Chloroacetone ($CH_3ClCOCH_3$)

Beilstein, 1, p. 986
Beilstein Suppl., 1, p. 502
Richter, 1, p. 100
Stelzner, p. 107

Chloromethyl chloroformate ($ClCOOCH_2Cl$)

Beilstein, 1, p. 469
Beilstein Suppl., 1, p. 168
Richter, 1, p. 53

Chloropicrin

See nitrotrichloromethane

Chlorosulfonic acid (SO_3ClOH)

Moissan, 1, p. 401
Molinari, p. 284
Ullmann, 2, p. 350

Dibromoketone ($CH_3COCHBrCH_2Br$)

Ber., 42 (1909), 2563
Chem. Zentr., 1909 (II), p. 507
Richter, 1, p. 169
Stelzner, p. 149

Dichlorodiethyl sulfide ($(CH_2ClCH_2)_2S$)

Beilstein, 1, p. 358
Ber., 19 (1886), 630, 3260
Meyer and Jacobson, 1, p. 621
Richter, 1, p. 190

Dichloroethylarsine ($As(C_2H_5)_2Cl_2$)

Beilstein, 1, p. 1512
Richter, 1, p. 64

Dichloromethyl ether ($(CH_2Cl)_2O$)

Beilstein, 1, p. 292
Beilstein Suppl., 1, p. 108
Richter, 1, p. 58
Stelzner, p. 74

Dimethyl sulfate ($(CH_3)_2SO_4$)

Beilstein, 1, p. 331
Richter, 1, p. 66
Stelzner, p. 80

Dimethyltrithiocarbonate ($CS_3(CH_3)_2$)

Beilstein, 1, p. 887
Richter, 1, p. 86

Diphenylchloroarsine ($(C_6H_5)_2AsCl$)

Beilstein, 4, p. 1687
Beilstein Suppl., 4, p. 1188
Richter, 2, p. 2192

Diphenylcyanarsine ($(C_6H_5)_2AsCN$)

Not in the literature

Diphosgene

See trichloromethyl chloroformate

Methyl chlorosulfonate (CH_3ClSO_3H)

Beilstein, 1, p. 370
Richter, 1, p. 42

Methyldichloroarsine (CH_3AsCl_2)

Beilstein, 1, p. 1510
Meyer and Jacobson, 1, p. 270
Richter, 1, p. 38
J. Ind. Eng. Chem., 11 (1919), p. 105

Mustard gas

See dichlorodiethyl sulfide

Nitrochloroform

See nitrotrichloromethane

Nitrochloromethane (CCl_3NO_2)

Beilstein, 1, p. 203
Beilstein Suppl., 1, p. 61
Richter, 1, p. 41
Stelzner, p. 36

Palite

See chloromethyl chloroformate

Phenylcarbamylamine chloride ($C_6H_5NCCl_2$)

Beilstein, 2, p. 360
Beilstein Suppl., 2, p. 169
Richter, 1, p. 621

Phosgene

See carbonyl chloride

Superalite

See trichloromethyl chloroformate

Tolyl bromide

See xylol bromide

Trichloromethyl chloroformate ($ClCOOCCl_3$)

Beilstein, 1, p. 465
Richter, 1, p. 50

Xylol bromide ($CH_3C_6H_4CH_2Br$ (*o*-, *m*-, *p*-))

Beilstein, 2, p. 63, 64, 65
Richter, 1, p. 805
Stelzner, p. 406, 407

¹ Bromine, chlorine, and hydrocyanic acid are not included, references to these being readily available.

² For bibliography covering production, properties, reactions, and uses, see p. 263, this issue.

AMERICAN DRUG MANUFACTURERS ASSOCIATION

The eighth annual meeting of the American Drug Manufacturers Association will be held at the Waldorf-Astoria, New York City, March 24 to 27, 1919. Monday, March 24, will be given over to the Committee on Standards and Deterioration, and the morning of March 25 to the Biological Section, the regular sessions of the Association beginning on the afternoon of the 25th.

There will be a series of round tables for the discussion of fire insurance, returned goods, credit matters, elimination of monthly statements, etc., and a debate by authorities of national reputation on the question of trade acceptances as applied specifically to drug manufacturers.

Dr. Charles H. Herty will speak on the proposed national institute for drug research.

Consideration will be given the problem of the future of alcoholic medicinal preparations, which, with national prohibition, will become the subject of regulation in practically every

state and, in many cases, of regulations so drastic as to seriously embarrass their legitimate manufacture and sale.

BUREAU OF MINES MISSION TO EUROPE

The U. S. Bureau of Mines has sent a special mission to Europe to collect information on matters pertaining to mining, minerals, chemicals, conservation of natural resources, etc. The members of the mission are F. G. Cottrell, chief metallurgist; G. S. Rice, chief mining engineer; W. Perdue, petroleum technologist; and F. S. Probert, dean of the School of Mining of the University of California, who goes as consulting mining engineer. The mission will operate from headquarters in London.

Dr. Cottrell will investigate the matter of international helium requirements, will probably confer with the mining experts of France and Alsace-Lorraine regarding the potash supply, and is prepared to negotiate with the authorities of the countries visited regarding patent rights on mechanical and scientific inventions and discoveries made by employees of the United States Government during the war.

MORE DETAILED STATISTICS OF CHEMICAL COMMODITIES

Report of a Committee on Reclassification of Commodities Imported and Exported

The war has made evident the need of more detailed statistics of imports and exports both from the point of view of the Government and of private business men. An attempt is being made to reclassify commodities for this purpose by a committee composed of representatives from the Bureau of Foreign and Domestic Commerce, the Census of Manufactures, the Treasury, the Shipping Board, the Tariff Commission and the War Trade Board. Mr. G. B. Roorbach of the Shipping Board is chairman of this committee.

The committee expects to recommend a definite plan which, if approved by the Secretary of Commerce and the Secretary of the Treasury, will be put into effect on January 1, 1920. It is also expected that beginning on the same date all import and export statistics will be based on the calendar year instead of the fiscal year as at present.

Although this plan of classification is made primarily for

exports although there is provision under the scheme for showing imports in much greater detail than exports. More detailed import classification is necessary to meet the requirements of the tariff act and the wishes of business men.

The proposed classification is based upon a decimal system which is expected to greatly facilitate the collection and tabulation of the statistics by the use of mechanical tabulating machines, and will also give elasticity to the classification, allowing additions and eliminations of items as trade conditions change.

In order to show the general scheme of the whole classification, the 10 main groups and the first subdivisions are given below.

The subdivision in the classification is carried to five figures. Individual commodities may be listed in either a "four-figure" class or in a "five-figure" class depending on their relative importance, or whether or not they are of interest only in imports. Space

CLASSIFICATION OF COMMODITIES

FOR USE IN FOREIGN TRADE STATISTICS

MAIN GROUPINGS

0—VEGETABLE PRODUCTS, PRINCIPALLY FOODS, AND BEVERAGES

- 00 Grains, flours, and starches
- 01 Vegetables
- 02 Fruits and nuts
- 03 Vegetable oils, and fats, and oil seeds
- 04 Tea, coffee, cocoa, and spices
- 05 Sugar, molasses, syrups, and confectionery
- 06 Fodders
- 08 Beverages
- 09 Miscellaneous vegetable food products

1—ANIMALS AND ANIMAL PRODUCTS (except fibers)

- 10 Live animals
- 11 Meats and meat products including poultry
- 12 Milk and milk products
- 13 Fish and fish products
- 14 Animal oils, fats, waxes, and greases
- 15 Hides and skins
- 16 Leather, and manufactures of
- 17 Furs and fur skins
- 18 Hair, bristles, and manufactures of
- 19 Other animal products

2—FIBERS AND TEXTILE PRODUCTS

- 20 Cotton and cotton manufactures
- 21 Flax and linen
- 22 Hemp and ramie
- 23 Jute and jute products
- 24 Other vegetable fibers, manufactures of
- 26 Wools, and manufactures of
- 27 Silk, and manufactures of
- 28 Other animal fibers
- 29 Miscellaneous textile products

3—WOOD, WOOD PRODUCTS, AND PAPER

- 30 Timber: Logs, hewn and sawed timber, etc.
- 31 Lumber: Lumber, lath, shingles, and veneers
- 32 Manufactures of wood
- 36 Paper base stocks
- 37 Paper and paper products
- 38 Books and all printed matter

4—PLANT PRODUCTS OTHER THAN FOODS, FIBERS, AND WOODS

- 40 Rubber, guttas, chicle, and manufactures of
- 41 Gums, n. e. s., resins, and balsams (including naval stores and camphor)
- 42 Crude drugs, n. e. s., and essential oils
- 43 Dyestuffs and tanning materials of vegetable origin
- 44 Seeds for sowing
- 45 Plants, trees, shrubs, and vines
- 46 Tobacco
- 49 Other plant products and manufactures

5—NON-METALLIC MINERALS AND PRODUCTS

- 50 Coal, petroleum, asphalt and products
- 51 Stone, sand, cement, lime, and plaster
- 52 Glass and glass products
- 53 Clays, pottery, brick tile, and other ceramic products
- 54 Abrasive materials and products
- 55 Chemical and fertilizer raw materials
- 56 Precious and semi-precious stones, rare minerals and products
- 59 Graphite, asbestos, magnesite, and all other non-metallic minerals

6—ORES, METALS, AND METAL MANUFACTURES

- 60 Iron and steel ores and crude or semi-crude forms
- 61 Iron and steel, manufactures of, except machinery and vehicles
- 62 Manganese, chromium, vanadium, tungsten, molybdenum, and other ferro-alloying metals and their ores
- 63 Aluminum, tin, and antimony
- 64 Nickel, cobalt, bismuth, and cadmium
- 65 Lead and zinc
- 66 Copper
- 67 Brass and bronze and all other alloys of metals, n. e. s.
- 68 Precious metals and manufactures of, including jewelry
- 69 Mercury and all other metals, n. e. s.

7—MACHINERY AND VEHICLES

- 70 Farm equipment
- 71 Metal working machinery
- 72 Electrical machinery and electrical apparatus
- 73 Engines and parts
- 74 Mining, excavating, and road machinery
- 75 Textile machinery and shoe
- 76 Factory and other industrial machinery
- 77 Office machinery, printing machinery, clocks and watches
- 78 All other machinery
- 79 Vehicles (carriages, automobiles, cars, airplanes, boats, etc.)

8—CHEMICALS AND CHEMICAL PRODUCTS

- 80 Inorganic chemicals (except minerals, 55 and 56; and pigments, 84)
- 81 Inorganic chemicals (continued)
- 82 Coal-tar chemicals
- 83 Organic chemicals (except coal tar)
- 84 Pigments, paints, and varnishes
- 85 Pharmaceutical preparations and medicines
- 86 Soaps, perfumery, cosmetics, and other toilet preparations
- 87 Fertilizers
- 88 Explosives
- 89 Other chemical products (inks, cellulose, etc.)

9—MISCELLANEOUS

- 90 Toys, games, athletic and sporting goods
- 91 Musical instruments
- 92 Photographic apparatus and supplies
- 93 Optical instruments (other than photographic) and accessories
- 94 Professional, educational, and scientific instruments and apparatus, n. e. s.
- 95 Firearms and ammunition
- 99 All other

statistics of imports and exports it is hoped that it may be used, as far as possible, in other statistical studies dealing with commodities or industries, such as statistics of domestic production. It is proposed to use the same classification for both imports and

is provided in the classification so that commodities can be transferred from the five- to the four-figure classification, as their importance changes from time to time. A commodity given a four-figure classification will appear in (1) the tables of

General Imports which show countries of origin and are published monthly and annually, (2) the tables of Domestic Exports showing countries of destination which are published monthly and annually, (3) the tables of Imports for Consumption which are published quarterly and annually showing quantity, value, and revenue collected without showing the country of origin. A commodity given a five-figure classification will appear only in the table of Imports for Consumption. The details for the five-figure headings will not be asked for exports.

The classification of the main grouping, "8—Chemicals and Chemical Products," here given is strictly provisional. Many of the items may be eliminated from the final revision, or others added. The detail is now published for the purpose of obtaining constructive criticisms and suggestions from the chemists,

chemical manufacturers, importers, and exporters of the country. Any suggestions will be fully considered that will aid in making the classification itself more serviceable as a means of grouping chemical commodities; that will give additional items that are of sufficient importance to be included either in our export or import statistics; or that will eliminate items that are not of enough importance to be recorded in our trade returns. It is important that any suggestions should be submitted at once. All communications should be addressed to Mr. G. B. Roorbach, U. S. Shipping Board, Room 714, Munsey Building, Washington, D. C. In addition to the chemical group there are also published details from other main groupings which are closely allied to the chemical industry but which appear under other headings as given in the classification printed above.

4—PLANT PRODUCTS, OTHER THAN FOODS, FIBERS AND WOODS

41 Gums, Resins and Balsams, n. e. s. (including naval stores and camphor)

410 Varnish gums, resins, copals, and lac

- 4100 Damar
- 4101 Kauri
- 4102 East India gum
- 4105 Lac
 - 41050 Stick lac
 - 41051 Seed or grain lac
 - 41052 Button lac
 - 41053 Shell lac
 - 41054 Crude lac
 - 41059 All other lacs
- 4109 Other
 - 41090 Pontianack
 - 41091 Congo gum
 - 41092 Sandarac
 - 41093 Manila
 - 41099 All other copals and varnish gums

411 Naval stores

- 4110 Turpentine, spirits of
- 4111 Turpentine, crude
- 4112 Tar and pitch of wood
- 4113 Rosin, crude
- 4119 Other
 - 41191 Burgundy pitch
 - 41192 Turpentine, Venice
 - 41193 Candle pitch or tar
 - 41194 Marine glue pitch

412 Balsams

- 4120 Copaiba
 - 41200 Crude
 - 41201 Advanced in value
- 4121 Canada
 - 41210 Crude
 - 41211 Advanced in value
- 4122 Spruce gum
 - 41220 Crude
 - 41221 Advanced in value
- 4129 Other
 - 41290 Peru, crude
 - 41291 Peru, advanced in value
 - 41292 Tolu, crude
 - 41293 Tolu, advanced in value
 - 41294 Storax, crude
 - 41295 Storax, advanced in value
 - 41299 Other

413 Camphor

- 4130 Crude, natural
- 4131 Refined natural
- 4132 Synthetic camphor

414 Other gums, n. e. s.

- 4140 Acacia (Arabic or senegal)
- 4141 Aloes
- 4142 Agar-agar
- 4143 Amber
 - 41430 Amber, crude
 - 41431 Amber chips, valued at not more than 50 cents per lb.
 - 41432 Manufactures of amber
- 4144 Karaya
- 4145 Tragacanth

414—Other Gums (Concluded)

- 4148 All other gums and resins
 - 41480 Asafetida
 - 41481 Benzoin
 - 41482 Dragon's blood
 - 41483 Gamboge
 - 41484 Jalap
 - 41485 Lupulin
 - 41486 Mastic
 - 41487 Myrrh
 - 41488 Salep
 - 41489 Tragasol

42 DRUGS, CRUDE, AND ESSENTIAL OILS

420-421 Drugs (herbs, leaves, roots, etc., crude or partly advanced)

- 4200 Cascara sagrada bark
- 4201 Cinchona bark
- 4202 Ginseng
- 4203 Goldenseal root
- 4204 Insect flowers (insecticide flowers or pyrethrum)
- 4205 Licorice root
- 4206 Nux vomica
- 4207 Opium
 - 42070 Crude, over 9 per cent morphine
 - 42071 Dried, powdered or otherwise advanced, over 9 per cent morphine
 - 42072 Crude, less than 9 per cent morphine (for aqueous solutions of opium, see Pharmaceuticals, 8699)

4210 All other crude drugs of vegetable origin

- 42100 Aconite
- 42102 Althea
- 42104 Area nut
- 42106 Arnica
- 42108 Belladonna
- 42110 Buchu
- 42112 Cannabiss
- 42114 Chamomile
- 42116 Coca
- 42118 Colchicum
- 42120 Colocynth
- 42122 Conium
- 42124 Cubeb
- 42126 Dandelion
- 42128 Digitalis
- 42130 Ergot
- 42132 Gentian
- 42134 Hellebore
- 42136 Henbane
- 42138 Ipecac
- 42140 Jaborandi
- 42146 Lavender
- 42148 Manna
- 42150 Orris
- 42152 Rhubarb
- 42154 Rose
- 42156 Sarsaparilla
- 42158 Scammony
- 42160 Senna
- 42162 Soap bark
- 42164 Stramonium

420-421—Drugs (herbs, etc.) (Concluded)

- 42166 Valerian
- 42168 Wormseed, Levant
- 42180 All other drugs of vegetable origin, crude, n. s. p. f.
- 42190 All other drugs of vegetable origin, advanced, n. s. f. p.

(For medicinal and pharmaceutical preparations see Chemicals, 86)

425 Essential oils and essences

- 4260 Lemon (not containing alcohol)
- 4261 Peppermint (not containing alcohol)
- 4265 Others, not containing alcohol
 - 42650 Birch tar
 - 42651 Cajuput
 - 42652 Bitter almond
 - 42653 Anise
 - 42654 Bergamot
 - 42655 Camomile
 - 42656 Camphor
 - 42657 Caraway
 - 42658 Cassia and cinnamon
 - 42659 Cedrat
 - 42660 Citronella
 - 42661 Lemon grass
 - 42662 Fennel
 - 42663 Jasmine
 - 42664 Juniper
 - 42665 Lavender
 - 42666 Limes
 - 42667 Mace
 - 42668 Orange flower or neroli
 - 42669 Orange
 - 42670 Origanum
 - 42671 Rosemary
 - 42672 Roses, attar of
 - 42673 Thyme
 - 42674 Valerian
 - 42690 All other, not containing alcohol

- 4269 Essential oil and essences containing alcohol
 - 42690 20 per cent or less alcohol
 - 42691 More than 20 per cent and not more than 50 per cent
 - 42692 More than 50 per cent alcohol

43 DYES AND TANNING MATERIALS OF NATURAL ORIGIN

430 Dye materials, crude

- 4300 Annatto
- 4301 Fustic or Cuba wood
- 4302 Logwood
- 4303 Osage orange
- 4304 Quercitron bark
- 4308 Others
 - 43080 Brazil wood
 - 43081 Camwood
 - 43082 Cudbear
 - 43083 Cochineal
 - 43084 Lac dye
 - 43085 Litmus
 - 43086 Orchil
 - 43087 Madder
 - 43088 Saffron
 - 43089 Turmeric
 - 43099 Others

481 Dye extracts, and decoctions for dyeing, not medicinal

- 4310 Logwood extract
- 4318 Other extracts
 - 43180 Persian berries
 - 43181 Cutch (used exclusively for dyeing)
 - 43188 All extracts containing alcohol
 - 43189 Others (not containing alcohol)

482 Tanning materials, crude

- 4320 Divi-divi
- 4321 Mangrove bark
- 4322 Myrabolans fruit
- 4323 Nuts and nutgalls
- 4324 Quebracho
- 4325 Sumac
- 4329 Others
 - 43290 Bate
 - 43291 Gambier
 - 43292 Valonia

483 Tanning extracts (not containing alcohol)

- 4330 Gambier
- 4331 Quebracho
- 4332 Gambier
- 4339 Others
 - 43390 Mangrove bark
 - 43391 Myrabolans

55 CHEMICAL AND FERTILIZER RAW MATERIALS**550 Sulfides and sulfur**

- 5500 Pyrites, sulfur ore, or sulfuret of iron, crude, containing in excess of 25 per cent sulfur
- 5501 Sulfur or brimstone
 - 55010 Precipitated sulfur
 - 55011 Flowers of sulfur or sublimed
 - 55019 All other forms

(See Chemicals for other sulfur compounds)

551 Nitrate and potash-bearing materials

- 5510 Crude nitrate of sodium, including Chile nitrate
- 5511 Potash fertilizer materials
 - 55110 Kainite
 - 55111 Manure salts
 - 55112 Hard salts
 - 55113 Potash-bearing dusts used as such for fertilizers
- 5519 All other nitrate or potash materials
- 55190 Other potash-bearing substances such as alunite, leucite, etc.

(For other potash and nitrate chemicals see Chemicals, 80)

- 55191 Other crude nitrate-bearing materials

(For guano, see Fertilizers, 870)

(For crude nitrate of potassium (saltpeter) see Chemicals, Inorganic)

552 Phosphate-bearing materials

- 5530 Phosphate rock, high-grade, ground or unground
- 5531 Phosphate rock, land pebble, ground or unground
- 5532 Phosphate rock, all other, ground or unground
- 5534 All other phosphate-bearing materials
 - 55340 Apatite, crude
 - 55341 Apatite, ground
 - 55342 Wavellite

554 Salt, borax, and all other

- 5540 Common salt
- (For borax, boric acid, all other compounds, see Chemicals, 80)
- (For ferroboron, see 62)
- 5549 All others
 - 55490 Strontium ores
 - 55491 Witherite, crude or ground (natural barium carbonate)
 - 55492 Lithium ores, crude or ground

8—CHEMICALS AND CHEMICAL PRODUCTS**80 and 81 CHEMICALS, INORGANIC (except minerals and pigments)****800 Acids**

- 8000 Sulfuric acid (oil of vitriol)
 - 80000 Sulfuric
 - 80001 Fuming sulfuric (oleum)
- 8001 Arsenic and arsenious acid (white arsenic)
- 8002 Boric or boracic acid
- 8003 Phosphoric acid
- 8008 Other inorganic acids
 - 80080 Nitric acid
 - 80081 Hydrochloric acid (muriatic)
 - 80082 Mixed acid
 - 80083 Fluoric or hydrofluoric
 - 80084 Chromic
 - 80085 Prussic
 - 80086 Silicic
 - 80089 All other inorganic acids

801 Ammonia and compounds

- 8010 Ammoniacal liquor
- 8011 Nitrate of ammonia
- 8012 Muriate of ammonia (sal ammoniac)
- 8015 Other ammonia compounds
 - 80150 Phosphate of ammonia
 - 80151 Bromide of ammonia
 - 80152 Fluoride of ammonia
 - 80153 Persulfate of ammonia
 - 80154 Perchlorate of ammonia
 - 80155 Bifluoride of ammonia
 - 80156 Liquid anhydrous ammonia

802 Cyanogen compounds

- 8026 Cyanide of soda
- 8027 Prussiate of soda (yellow)
- 8028 Prussiate of potash (yellow)
- 8029 Other cyanogen compounds
 - 80290 Potassium cyanide
 - 80291 Potassium thiocyanate
 - 80292 Ammonium thiocyanate
 - 80293 Potassium ferricyanide (red prussiate)
 - 80294 Calcium ferrocyanide
 - 80295 Barium sulfocyanide
 - 80296 Lead sulfocyanide

(For ferro-ferricyanide blues, see Pigments, 84)

803 and 804 Sodas and sodium compounds

- 8030 Soda ash
- 8031 Caustic soda
- 8032 Silicate of soda
- 8033 Sulfide of soda
- 8034 Borate of soda (borax)
 - 80340 Crude
 - 80341 Refined
- 8035 Nitrite of soda
- 8036 Phosphate of soda
- 8045 Other sodium compounds
 - 80450 Sal soda (washing soda)
 - 80451 Bicarbonate of soda (baking soda)
 - 80452 Sodium sulfate, crystallized (Glauber's salt)
 - 80453 Sodium sulfate, anhydrous
 - 80454 Sulfite of soda
 - 80455 Thiosulfate of soda ("hypo" or hyposulfite)
 - 80456 Hydrosulfite of soda
 - 80457 Bisulfite of soda
 - 80458 Crystal carbonate
 - 80459 Perborate of soda
 - 80460 Fluoride of soda
 - 80461 Sesquicarbonate of soda
 - 80462 Perchlorate of soda
 - 80463 Silicofluoride of soda
 - 80464 Bisulfate of soda
 - 80465 Sodium aluminum silicate

(For sodium nitrate, see Minerals, 55)

805 Potash and potassium compounds

- 8050 Caustic potash (hydrate of)
- 8051 Nitrate of potash
- 80510 Nitrate of potash, crude or saltpeter

805—Potash, etc. (Concluded)

- 80511 Nitrate of potash, refined
- 8052 Potash, crude or "black salts"
- 8053 Carbonate of potash, crude
- 8054 Carbonate of potash, refined
- 8055 Chloride of potash, refined
- 8058 Other potassium compounds
 - 80580 Chlorate of potash
 - 80581 Bicarbonate
 - 80582 Silicate
 - 80583 Sulfite
 - 80584 Bisulfite
 - 80585 Perchlorate
 - 80586 Iodide
 - 80587 Nitrite
 - 80588 Persulfate

(For muriate of potash, crude; sulfate of potash, crude, see Fertilizers, 87; for kainite, manure salts, and hard salts, see Minerals, 55)

806 Bromine, iodine, chlorine, and compressed or liquefied gases (other than hydrocarbons)

- 8060 Iodine
 - 80600 Iodine, crude
 - 80601 Iodine, resublimed
- 8067 Others
 - 80670 Carbonic acid (carbon dioxide)
 - 80671 Nitrous oxide (laughing gas)
 - 80672 Oxygen
 - 80673 Sulfur dioxide
 - 80674 Phosgene (carbonyl chloride)
 - 80675 Bromine
 - 80676 Chlorine

807 and 808 Compounds of calcium, barium, strontium, and magnesium

- 8070 Chloride of lime (bleaching powder)
- 8071 Calcium carbide
- 8075 Other calcium chemicals
 - 80750 Calcium oxide (other than quicklime)
 - 80751 Calcium hydroxide (other than hydrated lime)

(For quicklime and hydrated lime, see 51)

- 80752 Calcium carbonate (precipitated)
- 80753 Calcium chloride, crude
- 80754 Calcium chloride, purified
- 80755 Calcium sulfate (pure, precipitated)
- 80756 Calcium sulfide
- 80757 Calcium phosphate (tribasic)
- 80759 Calcium hypophosphate
- 80760 Calcium hypophosphate
- 8077 Barium chloride
- 8078 Barium carbonate (precipitated)

(Witherite, mineral carbonate of barium, see 55)

- 8079 Barium dioxide (peroxide or bin-oxide)

8080 All other barium chemicals

- 80820 Barium nitrate, crystals
- 80821 Barium hydroxide
- 80822 Barium chlorate
- 80823 Barium sulfide, crude lumps
- 80824 Barium sulfide, pure

(For barytes, or barium sulfate, see Pigments, 84)

- 8083 Strontium nitrate
- 8085 All other strontium salts
 - 80850 Strontium sulfate (precipitated)
 - 80851 Strontium carbonate (commercial)
 - 80852 Strontium carbonate (precipitated)
 - 80853 Strontium bromide
- 8086 Magnesium sulfate (Epsom salts)
- 8087 Magnesium chloride
- 80870 Commercial crystals
- 80871 Pure, crystal
- 80872 Anhydrous

807 and 808 Compounds of calcium, etc.
(Concluded)

- 8089 Other magnesium salts
80890 Magnesia, calcined, purified
(For magnesite or magnesia, crude, see Minerals, 59)
80891 Carbonate (precipitated)
80892 Nitrate
80893 Fluoride

809 Alums and compounds of aluminum, iron, and chromium

- 8090 Sulfate of alumina
8094 Other alums and aluminum salts
80940 Soda alum
80941 Potash alum
80942 Iron alum
80943 Ammonia alum
80944 Aluminum chloride
8095 Compounds of iron
80950 Ferrous sulfate (copperas)
80951 Ferrous sulfide
80952 Iron perchloride (ferric chloride)
80953 Iron protochloride (ferrous chloride)
8097 Compounds of chromium
80970 Chromate and bichromate of potash
80971 Chromate and bichromate of soda
80972 Chromium hydroxide
80973 Chromium sulfate (liquid)

810 Compounds of bismuth, lead, and manganese

- 8100 Compounds of bismuth
81000 Subnitrate
81001 Oxide (powder)
81002 Oxide (hydrated)
81003 Chloride
81004 Nitrate
81005 Subcarbonate
8102 Lead compounds (not ores or pigments)
81020 Nitrate
81021 Peroxide
81022 Sulfide
81023 Hyposulfite (thiosulfate)
(See also Ores and Pigments)
8104 Permanganate of potash
8109 Other manganese compounds
81090 Permanganate of soda
81091 Manganese chloride
81092 Manganese oxide (hydrated)
81093 Manganese oxide (other than ore)
81094 Manganese sulfate

811 Compounds of cobalt, nickel, copper, and silver

- 8111 Compounds of cobalt
81110 Oxide
81111 Sulfate
81112 Carbonate
81113 Nitrate
8113 Compounds of nickel
81130 Nickel sulfate
81131 Nickel nitrate
81132 Nickel oxide
81133 Nickel phosphate
8114 Sulfate of copper (blue vitriol)
8116 Other copper compounds
81160 Copper oxide
81161 Copper chloride
81162 Copper carbonate
81163 Copper sulfide
8119 Compounds of silver
81190 Silver nitrate
81191 Silver bromide
81192 Silver chloride

812 Compounds of mercury, zinc, cadmium, arsenic, antimony, and tin

- 8121 Compounds of mercury
81210 Mercuric chloride (corrosive sublimate)

812 Compounds of mercury, etc. (Concluded)

- 81211 Mercurous chloride (calomel)
81212 Mercury iodide
81213 Mercuric oxide (red precipitate)
81214 Mercury ammonium chloride (white precipitate)
81215 Mercury nitrate
8122 Zinc chloride
8123 Other zinc compounds
81230 Zinc oxide, U. S. P. (See Pigments, 84, for other)
81231 Zinc sulfate (white vitriol)
81232 Zinc carbonate (precipitated)
81233 Zinc ammonium chloride
8124 Compounds of cadmium
81240 Cadmium sulfate
81241 Cadmium chloride
81242 Cadmium carbonate
8127 Antimony oxide
8128 Other antimony compounds
81280 Antimony sulfide, red
81281 Antimony pentasulfide, golden
81282 Antimony chloride (solution)
81283 Antimony sulfate
81284 Antimony sulfite
8129 Compounds of tin
81290 Tetrachloride of tin
81291 Bichloride of tin
81292 Tin oxide (other than ore)
81299 All other

818 All other inorganic chemicals, n. e. s.

- 8180 Phosphorus, phosphorus compounds, and sulfur compounds
81800 Phosphorus
81801 Phosphorus chloride
81806 Sulfur chloride
81807 Sulfur bromide
8181 Salts of gold and platinum group of metals
81810 Gold chloride
81813 All other gold salts
81814 Platinic chloride, solution (chloro-platinic acid)
81816 All other platinum compounds
81817 Osmium compounds
8183 Thorium nitrate
8184 Other thorium salts
81840 Thorium oxide (thoria)
(For thorium ores, monazite sand, etc., see Minerals, 55)
8186 Cerium and other rare earths
81860 Cerium sulfate
81861 Cerium nitrate
8187 Radium and radium salts
8188 Other radioactive substances
81880 Mesothorium
8189 Uranium salts
81890 Uranium oxide
81891 Uranium nitrate
8198 All other inorganic compounds
81980 Beryllium nitrate
81982 Titanium chloride
81983 Titanium sulfate
81985 Hydrogen peroxide
81986 Lithium carbonate
81987 Lithium iodide
81999 All other inorganic compounds, n. s. p. f.

82 COAL-TAR CHEMICALS**820 Coal-tar crudes (Group I, Free List)**

- 8200 Benzol
8201 Cresol (cresylic acid)
8202 Crude tar
8203 Dead or creosote oil
8204 Naphthalene (solidifying at less than 79° C.)
8205 Tar pitches
8206 Toluol
8207 Distillates
82070 Anthracene oil
82071 Solvent naphtha

820 Coal-tar crudes (Concluded)

- 82079 All other distillates which or being subjected to distillation yield in the portion distilling below 200° C. a quantity of tar acids less than 5 per cent of the original distillate
8208 All other products that are found naturally in coal tar, whether produced or obtained from coal tar or other source
82080 Acenaphthene
82081 Anthracene having a purity of less than 25 per cent
82082 Carbazol having a purity of less than 25 per cent
82083 Cumol
82084 Ortho cresol having a purity of less than 90 per cent
82085 Meta cresol having a purity of less than 90 per cent
82086 Para cresol having a purity of less than 90 per cent
82087 Methyl anthracene
82088 Methyl naphthalene
82089 Pyridine
82090 Quinoline
82091 Xylenols
82092 Xylol
82099 All others

821-824 Coal-tar intermediates (Group II, Dutiable)

- 8210 Aniline oil
8211 Aniline salt
8212 Anthracene (having a purity of 25 per cent or more)
8213 Beta naphthol
8214 Carbazol (having a purity of 25 per cent or more)
8215 Dinitrotoluol
8216 Naphthalene (solidifying at 79° C. or above)
8217 Naphthylamine monosulfonic acids and salts (Tobias and Cleves)
8218 Nitrobenzol (oil of myrbane)
8219 Phenol
82190 Crude
82191 Refined
8239 Other intermediates
82390 Acetanilide, technical
82391 Alpha naphthylamine
82392 Amidophenol
82393 Amidonaphthol
82394 Anthraquinone
82395 Benzidine and benzidine sulfate
82396 Benzyl chloride
82397 Benzal chloride
82398 Benzoyl chloride
82399 Benzaldehyde
82400 Benzoic acid
82401 Benzanthrone
82402 Benzoquinone
82403 Beta naphthol monosulfonic acid and salts (Schaeffer and Crocein)
82404 Beta naphthol disulfonic acids and salts (R and G)
82405 Cinnamic acid
82406 Chlorphthalic acid
82407 Ortho cresol, 90 per cent pure or above
82408 Meta cresol, 90 per cent pure or above
82409 Para cresol, 90 per cent pure or above
82410 Cumidine
82411 Dinitrobenzol
82412 Dinitrochlorbenzol
82413 Dimethylanthiline
82414 Dinitrophenol
82415 Dimethylanthiline
82416 Diphenylamine
82417 Dimethylphenylenediamine
82418 Dianisidine

831-834 Coal-tar intermediates (Concluded)

- 82419 Diamidostilbene
- 82420 Dichlorophthalic acid
- 82421 Dichlorophthalic acid
- 82422 Ethylbenzylamine
- 82423 H-acid (amido naphthol disulfonic acid)
- 82424 Monochlorobenzol
- 82425 Monobromobenzol
- 82426 Methylanthraquinone
- 82427 Nitrophenol
- 82428 Nitrophenylenediamine
- 82429 Nitrotoluol
- 82430 Naphthylenediamine
- 82431 Nitroanthroquinone
- 82432 Nitroresol
- 82433 Para nitraniline
- 82434 Meta phenylenediamine
- 82435 Picramic acid
- 82436 Phenylglycine
- 82437 Phenylhydrazine
- 82438 Phthalic acid or anhydride
- 82439 Phenylglycol ortho-carboxylic acid
- 82440 Phthalimide
- 82441 Phenyl-naphthylamine
- 82442 Resorcin, technical
- 82443 Salicylic acid
- 82444 Sulfanilic acid
- 82445 Tolidine
- 82446 Tribromphenol
- 82447 Tetramethyldiamidobenzophenone
- 82448 Tetramethyldiamidodiphenylmethane
- 82449 Thiocarbonyl
- 82450 Tolidine
- 82451 Meta toluenylenediamine
- 82452 Toluolsulfamide
- 82453 Toluolsulfochloride
- 82454 Tetrachlorophthalic acid
- 82455 Xylidine
- 8249 All others
- 82490 Any sulfonic acid or sulfonic acid salt of any of the foregoing, n. e. s.
- 82491 All similar products obtained, derived, or manufactured in whole or in part from the products provided for in Group I
- 82492 All distillates which on being subjected to distillation yield in the portion distilling below 200° C. a quantity of tar acids equal to or more than 5 per cent of the original distillate

825 Coal-tar colors, dyes, stains whether soluble or not in water, color acids, color bases, color lakes (Group III, Dutiable)

- 8250 Alizarin and alizarins
- 82500 Natural alizarin
- 82501 Synthetic alizarin
- 82502 Colors derived or manufactured in whole or in part from alizarin
- 8251 Anthracene and carbazol derivatives (other than alizarin)
- 8252 Indigo
- 82520 Natural
- 82521 Synthetic
- 82522 Indigoids, whether or not obtained from indigo
- 8253 Color lakes
- 82530 Yellow
- 82531 Orange
- 82532 Red
- 82533 Violet
- 82534 Blue
- 82535 Green
- 82539 All other color lakes
- 8259 All other colors, dyes, stains, color acids, and color bases

826 Photographic chemicals and medicinalals

- 8260 Medicinals (Par. 18, Act of 1913)
- 82600 Acetanilide
- 82601 Acetphenetidin (phenacetin)
- 82602 Acetylsalicylic acid (aspirin)
- 82603 Antipyrine
- 82604 Phenolphthalein
- 82605 Salol
- 82606 Arsphenamine (salvarsan and neo-arsphenamine)
- 82609 All other coal-tar medicinalals
- 8262 Photographic chemicals
- 82620 Hydroquinone
- 82621 Metol
- 82629 All other coal-tar photographic chemicals
- 829 All other finished coal-tar products
- 8290 Disinfectants
- 8291 Flavors
- 82910 Saccharin
- 82911 Coumarin (synthetic)
- 82912 Methyl salicylate (artificial oil of wintergreen)
- 8292 Synthetic perfume bases
- 8293 Synthetic phenolic resins
- 8294 Synthetic tanning materials
- 8299 All other finished coal-tar products

83 ORGANIC CHEMICALS (exclusive of coal-tar)**830 and 831 Acids, acid anhydrides, and salts of organic acids**

- 8300 Acetic or pyroigneous acid (common)
- 8301 Formic acid
- 8302 Oxalic acid
- 8305 and 8306 Other organic acids and acid anhydrides
- 83050 Acetic acid, glacial
- 83051 Acetic anhydride
- 83052 Barbituric or diethylbarbituric acid
- 83053 Butyric acid
- 83054 Citric acid
- 83055 Gallic acid
- 83056 Glycerophosphoric acid
- 83057 Lactic acid
- 83058 Oleic acid
- 83059 Pyrogallol or pyrogallic acid
- 83060 Ricinoleic acid
- 83061 Sulfuric acid
- 83062 Stearic acid
- 83063 Tartaric acid
- 83064 Tannic acid
- 83069 All other
- 8307 Argols (crude tartar or wine lees)
- 83070 Containing not more than 90 per cent potassium bitartrate
- 83071 Containing more than 90 per cent potassium bitartrate
- 8308 Calcium acetate (acetate of lime)
- 8309 Calcium citrate (citrate of lime)
- 8310 Sodium formate
- 8316 All other salts of organic acids
- 83160 Acetate of soda
- 83161 Acetate of lead, white
- 83162 Acetate of lead, brown, gray, or yellow
- 83163 Acetate and subacetate of copper (verdigris)
- 83165 Citrate of magnesia
- 83166 Citrate of soda
- 83167 Citrates of iron and iron-ammonium
- 83169 Tartrate, potassium acid (cream of tartar)
- 83170 Tartrate, sodium potassium (Rochelle salts)
- 83171 Tartrate of calcium
- 83172 Tartrate, antimony potassium (tartar emetic)
- 83174 Potassium oxalate
- 83175 Potassium titanium oxalate
- 83176 Potassium binoxalate

830 and 831 -Acids, acid anhydrides, etc. (Concluded)

- 83178 Manganese resinate
- 83179 Lead resinate
- 83180 Manganese linoleate
- 83181 Lead linolate
- 83182 Manganese oleate
- 83199 All other salts of organic acids

832 Hydrocarbons and derivatives

- 8320 Hydrocarbons
- 83200 Acetylene
- 83201 Ethylene
- 83209 All other hydrocarbons
- 8321 Halogen derivatives of hydrocarbons
- 83210 Acetylene tetrachloride
- 83211 Carbon tetrachloride
- 83212 Chloroform
- 83213 Dichloroethylene (Dutch liquor)
- 83214 Iodoform
- 83215 Methyl chloride
- 83216 Trichloroethylene

833 Alcohols

- 8330 Alcohol, denatured
- 8331 Alcohol, ethyl (grain)
- 8332 Alcohol, methyl (wood)
- 8333 Fusel oil or amyl alcohol
- 8334 Glycerin, crude
- 8335 Glycerin, refined
- 8338 Other alcohols
- 83380 Butyl alcohol
- 83381 Propyl alcohol
- 83382 Glycol alcohol
- 83383 Cetyl alcohol

834 Aldehydes and ketones

- 8340 Formaldehyde or formalin
- 8342 Other aldehydes
- 83420 Acetaldehydes
- 83421 Chloral and chloral hydrate
- 83422 Paraldehyde
- 8343 Acetone
- 8344 Other ketones
- 83440 Acetone oil
- 83441 Methyl acetone
- 83442 Methyl ethyl ketone (ketone)

835 Ethers and esters

- 8350 Ethers
- 83500 Ethyl ether (ether or sulfuric ether)
- 83501 Ethyl chloride
- 83502 Ethyl bromide
- 83503 Ethyl iodide
- 83504 Methyl ether
- 83505 Methyl iodide
- 8351 Esters
- 83510 Amyl acetate
- 83511 Amyl nitrite
- 83512 Dimethyl sulfate
- 83513 Ethyl nitrate
- 83514 Ethyl nitrite (sweet spirits of niter)
- 83515 Ethyl acetate
- 83516 Ethyl formate
- 83517 Ethyl butyrate
- 83518 Ethyl hydrogen sulfate
- 83519 Others

839 Other organic chemicals (except coal-tar)

- 83900 Camphene
- 83901 Cacodylates
- 83902 Dimethylamine
- 83903 Ethylamine
- 83904 Eucalyptol
- 83905 Guaiacol
- 83906 Guaiacol carbonate
- 83907 Ichthyol
- 83908 Methylamine
- 83909 Menthol
- 83910 Pinene
- 83911 Pinene hydrochloride
- 83912 Sulfone methanes (sulfonal, trional, etc.)
- 83913 Terpin hydrate
- 83914 Terpinene

839 Other organic chemicals (Concluded)

- 83915 Terpineol
- 83916 Thymol
- 83917 Urea and derivatives
- 83918 Vanillin
- 83919 Wood creosote

84 PIGMENTS, PAINTS, AND VARNISHES**840 Mineral earth pigments**

- 8400 Ocher
- 8401 Sienna
- 8402 Umber
- 8403 Cassel brown and Vandyke brown
- 8404 Whiting (calcium carbonate)
- 84040 Dry
- 84041 Ground in oil (putty)
- 8405 Zaffer
- 8406 Indian red, Venetian red, or cochthar
- 8407 Silica and silicate pigments

841 Chemical pigments

- 8410 Zinc oxide
 - 84100 Ground dry
 - 84101 Ground in or mixed with oil or water
- 8411 Lithopone
- 8412 Barium sulfate (barytes)
 - 84120 Crude, natural
 - 84121 Ground barytes
 - 84122 Blanc fixe (artificial)
- 8413 Lead pigments
 - 84130 Litharge
 - 84131 Orange mineral
 - 84132 Red lead
 - 84133 White lead (basic carbonate)
 - 84134 Sublimed lead (basic sulfate)
 - 84139 Other lead pigments
- 8414 Chrome colors
 - 84140 Chrome yellow
 - 84141 Chrome scarlet (basic chromate of lead)
 - 84142 Chrome greens
- 8415 Vermilion (mercuric sulfide) and vermilionettes
 - 84150 Mercuric sulfide
 - 84151 Eosine vermilions
 - 84152 Scarlet vermilions
- 8416 American blue, Prussian blue, Chinese blue, Berlin blue, Paris blue (ferriferrocyanide)
 - 84160 In pulp, dry, or ground in oil or water
- 8417 Carbon blacks (this includes lamp-black, boneblack, or ivoryblack, and other blacks of similar origin)
- 8419 Other chemical pigments
 - 84190 Zinc sulfide
 - 84191 Cadmium sulfide
 - 84192 Ultramarine
 - 84193 Wash blue (containing ultramarine)

843 Paints, stains and enamels

- 8430 Ready, mixed paints
 - 84300 Lead pigments in oil
 - 84301 Zinc pigments in oil
 - 84302 Other pigments in oil
- 8439 Other prepared paints
 - 84390 Artists' paints
 - 84391 Enamel paints
 - 84392 Wood stains, fillers, and polishes
 - 84393 Glazes, fluxes, enamels, and colors, ceramic and glass

844 Varnishes

- 8440 Spirit varnishes
 - 84400 Containing less than 10 per cent of methyl alcohol
 - 84401 Containing 10 per cent or more of methyl alcohol
- 8441 Oil varnishes
 - 84410 Gold size
 - 84411 Japans
 - 84419 Others
- 8449 Other varnishes

85 MEDICINAL AND PHARMACEUTICAL PREPARATIONS**850 Medicinal and pharmaceutical preparations: alkaloids, glucosides, and other active principles of vegetable origin**

- 8500 Caffeine, and salts of caffeine
 - 85001 Caffeine
 - 85002 Salts and derivatives of caffeine
- 8501 Cocaine, ecgonine, and salts of cocaine
 - 85010 Crude cocaine
 - 85011 Ecgonine
 - 85012 Cocaine hydrochloride
 - 85013 Cocaine alkaloid
 - 85019 Other salts and derivatives of cocaine
- 8502 Morphine and its salts and derivatives, and other alkaloids and salts of alkaloids derived from opium
 - 85020 Morphine alkaloid
 - 85021 Morphine sulfate
 - 85022 Diacetylmorphine or heroin
 - 85023 All other salts or derivatives of morphine
 - 85024 Codeine and its salts
 - 85025 Apomorphine and its salts
 - 85029 All other alkaloids and salts and derivatives of alkaloids derived from opium
- 8503 Quinine and other alkaloids and salts of alkaloids derived from cinchona bark
 - 85030 Crude quinine
 - 85031 Quinine alkaloid
 - 85032 Quinine sulfate
 - 85033 Other salts and derivatives of quinine
 - 85034 Cinchonidine and its salts
 - 85035 Cinchonine and its salts
 - 85036 Quinidine and its salts
 - 85039 Other alkaloids and salts of other alkaloids of cinchona
- 8504 Strychnine and salts and derivatives of strychnine
 - 85040 Strychnine alkaloid
 - 85041 Strychnine sulfate
 - 85049 Other salts and derivatives of strychnine
- 8507 All other alkaloids and salts and derivatives of
 - 85070 Aconitine and its salts and derivatives
 - 85071 Atropine and its salts
 - 85072 Ergotine and other ergot extractives
 - 85073 Hyoscyne or scopolamine and its salts
 - 85074 Hyoscyamine and its salts
 - 85075 Pilocarpine and its salts and derivatives
 - 85076 Theobromine, theophylline, and their salts and derivatives
 - 85079 All other alkaloids, salts and derivatives of alkaloids
- 8508 Glucosides and compounds and derivatives of glucosides and extracted glucosidal principles of vegetable drugs
 - 85080 Digitalis glucosides and active principles of digitalis
 - 85081 Salicin and compounds of salicin
 - 85082 Strophanthus glucosides and active principles of strophanthus
 - 85089 All other glucosidal principles of vegetable drugs
- 8509 All other active principles of vegetable drugs, n. e. s.
 - 85090 Chrysarobin and its salts
 - 85091 Eucalyptol and its salts
 - 85092 Santonin and its salts

850 Medicinal preparations (Concluded)

- 85093 Thymol and its salts
- 85099 All other active principles of vegetable drugs, n. s. p. f.

851 Medicinal and pharmaceutical preparations: biological medicines all others, n. e. s.

- 8510 Antitoxins, serums, and vaccines
 - 8511 Enzyme preparations
 - 85110 Pepsin and preparations of
 - 85111 Papain and preparations of
 - 85112 Trypsin and preparations of
 - 85113 Pancreatin and preparations of
 - 85114 Rennin and preparations of (technical)
 - 85119 Other enzyme preparations
 - 8518 All other biological medicinals or medicinals of animal origin
 - 85180 Epinephrine and other suprarenal preparations
 - 85181 Thyroid
 - 85182 Hypophyses and other gland extracts
 - 85183 Ox gall bile salts and bile compounds
 - 85184 Leeches
 - 85185 Cantharis and other blistering beetles
 - 85189 All others, n. e. p. f.
 - 8519 All other preparations, n. e. s.
 - 85190 Preparations not containing alcohol
 - 85191 Preparations containing less than 20 per cent alcohol
 - 85192 Preparations containing 20 per cent to 50 per cent
 - 85193 Preparations containing over 50 per cent
 - 85194 Liquid preparations of opium, as laudanum
 - 85195 Preparations in small packages (Par. 17)
 - 85196 Preparations in capsules, pills, tablets, etc. (Par. 17)
 - 85199 All other, n. s. p. f.
- (For synthetic and other medicinal chemicals see Chemicals 80, 81, 82, 83)

86 SOAPS, PERFUMERY, COSMETICS, AND OTHER TOILET PREPARATIONS**860 Soaps**

- 8600 Toilet or fancy soaps
 - 86000 Perfumed
 - 86001 Unperfumed
- 8609 All other soaps
 - 86090 Castile soap
 - 86091 Medicinal
 - 86092 Soap powders
 - 86099 All other, n. s. p. f. (Includes laundry soap, shaving soaps and creams, soft and liquid soaps, soap chips, scouring soaps, textile soaps, and all others)

861 Perfumery, cosmetics, and other toilet preparations

- 8610 Perfumery, cosmetics, and other toilet preparations
 - 86100 Bay rum or bay water
 - 86101 Floral waters containing no alcohol
 - 86102 Floral essences containing no alcohol
 - 86104 Perfumery and other toilet waters, including sachets
 - 86105 Perfumery and other toilet waters, including sachets, not containing alcohol
 - 86106 Cosmetics and all other toilet preparations, n. e. s., containing alcohol

861 Perfumery, etc. (Concluded)

86107 Cosmetics and all other toilet preparations, n. e. s., not containing alcohol. (Includes tooth pastes and powders, face powders, toilet creams, theatrical greases, paints, pomades and pastes, hair tonics, pomades, powders, etc.)

86108 Substances used in preparation of perfumes and cosmetics, n. s. p. f., not containing alcohol

87 FERTILIZERS AND FERTILIZER MATERIALS (other than crude minerals)**870 Nitrogenous fertilizer materials**

8700 Calcium cyanamide or lime-nitrogen

8701 Calcium nitrate (nitrate of lime)

8702 Guano

8703 Sulfate of ammonia

8708 Other nitrogenous materials (this includes dried blood, tankage, garbage, fish scrap, hoof meal, animal manures, and castor bean pomace)

871 Phosphate materials (except crude phosphate rock and land pebble)

8710 Superphosphate (acid phosphates)

8711 Basic slag, ground or unground (Thomas slag)

8712 Bone phosphates (bone-ash, bone-dust, bone-meal)

871 Phosphate materials (Concluded)

8719 Other phosphate materials (such as spent boneblack)

(Phosphate rock and land pebble are classified under Minerals, 5)

872 Potash fertilizer materials (except crude minerals)

8720 Muriate of potash, crude

8721 Sulfate of potash, crude

8729 Other potash fertilizer materials

(Kainite, manure, and hard salts are classified under Minerals, 5)

875 Mixed fertilizers

8750 Special proprietary mixtures

8759 Other fertilizers

88 EXPLOSIVES (other than coal-tar explosives)**880 Powder**

8800 Gunpowder

8801 Smokeless powder

8802 Blasting powder

8809 Other powders

881 Dynamite, nitrocellulose, and other nitric esters

8810 Dynamite

8811 Nitrocellulose (cordite, guncotton)

8819 Other nitric esters

882 Primers and Fuses

8820 Mercury fulminate

8829 Others

88290 Azides

88291 Percussion caps

88292 Running fuses (safety fuses)

88293 Detonating fuses

88294 Detonating cord

88299 Other primers and fuses

889 Other explosives

8890 Cartridges

8899 Others

88990 Fire-crackers and all fireworks

89 OTHER CHEMICAL PRODUCTS**890 Baking powder****891 Inks and ink powders**

8910 Writing and copying inks

8911 Printers and lithographic inks

8919 All other inks and products

89190 Ink powders, pellets, and all solid soluble forms

89191 Indelible inks

892 Cellulose and cellulose products (except explosives and medicinal preparations)

8920 Cellulose

8921 Collodion and all other liquid solutions of pyroxilin, or of other cellulose esters, or of cellulose

8922 Pyroxilin plastics (compounds of pyroxilin or of other cellulose esters whether known as celluloid, pyralin, viscoloid, fibriloid, xylonite, or by any other name)

89220 In blocks, sheets, rods, not polished or made up into finished products

89221 Polished or if finished or partly finished articles

893 Casein and casein products

8930 Casein or lactene

8939 Other casein products

89390 Casein paints

89391 Casein adhesives

BIBLIOGRAPHY ON CARBONYL CHLORIDE (PHOSGENE) AND ITS DERIVATIVES

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This bibliography is based upon that published by the late Dr. Morris Loeb, in his Ph.D. thesis of 1887 (see reference 129), being a revision and amplification of same.

The author will be glad to have any errors or omissions in the bibliography called to his attention.

The numbers following each entry refer to the literature citations in the appended list of references, page 264.

Standard References

Beilstein, I, p. 546

Beilstein Suppl., I, p. 219

Richter, I, p. 36

Stelzner, p. 26

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WASHINGTON LETTER

By PAUL WOOTON, Union Trust Building, Washington, D. C.

A determined effort is being made to secure the enactment of legislation which will permit of the continued development of domestic potash. A hearing has been conducted by Senator Henderson, the chairman of the Committee on Mines and Mining, in which the producers of potash established clearly that they will not be able to continue operations unless some assurance is given that foreign potash may not be imported without restrictions. The bill before the committee provides a licensing system for imports, which, it is believed, will allow domestic production to be absorbed at the least possible cost to the consumer. This is urged as an advantage over a protective tariff. If an import duty sufficiently high to protect the high-cost producers were enacted, it is admitted that the cost to the consumers would be prohibitive.

Senator Jones, of New Mexico, advocates the formation of a government corporation which will purchase all domestic potash and resell it at the average price. Such a provision was included in the bill, as originally drafted by the Bureau of Mines, but that portion of it failed to secure the approval of the Secretary of the Interior. It is understood that Secretary Lane thought the bill would be workable without a corporation, which necessarily would have to have a revolving fund of several million dollars.

Every producer of domestic potash was represented at the hearing. That they made a good case is admitted, even by the opponents of the bill. They sought to establish that their industries would be able to meet any foreign competition, if additional time were granted to further perfect their practice and to reduce their costs. Realizing how necessary it is to prove to Congress that it will be possible to compete, the producers threw open their cost accounts for public inspection. Some producers expect to be in a position to compete with the foreign product within a few months, but all insisted that the licensing plan should be assured for five years if the industry is to compete to the best advantage. The original draft of the bill named five years as the time for its duration, but the committee changed it to two years.

While an effort will be made to get the bill up at this session of Congress, the chance is admittedly small. The measure is certain to be vigorously opposed. There already is evidence that the farmers will clamor against it. Since the consumers of potash are so numerous, their voice will have no difficulty in being heard on Capitol Hill. It is very evident that the farmers and the other consumers will not agree to pay, even for five years, the price which will be necessary to keep the domestic industry going; and many are of the opinion that it never will

be possible to produce potash in this country in competition with the German and Alsatian products. The opponents of the measure also include members of Congress who are making special efforts to reduce living costs. Another angle is that Germany must have a market for its potash, if she is to pay indemnities.

Producers of war minerals won a decided victory when they succeeded in attaching to the Dent Bill a provision providing for their relief. A rider to the Dent Bill, which provides for legalizing the War Department's informal contracts, was attached by Senator Henderson. The House conferees, however, decline to accept the Henderson provision without bringing it up before the Representatives. As a result, the matter was debated in the House. Sentiment appeared to be almost equally divided. After much discussion, the House refused to instruct the conferees. This left them free to safeguard the provision in any way that they saw fit. As finally agreed upon, the matter is left in great measure to the judgment of the Secretary of the Interior. It is regarded as certain that \$8,000,000 will be returned to the producers of war minerals under the provision, but some estimate that a very much larger amount will be disbursed. The section, in its entirety, is as follows:

Sac. 5. That the Secretary of the Interior be, and he is hereby, authorized to adjust, pay, or discharge any agreement, express or implied, upon a fair and equitable basis the amount or amounts of money heretofore invested or contracted to be invested and obligations incurred in good faith by any and all persons, firms, or corporations for producing or in good faith acquiring property for producing, within the United States, for the purpose of supplying the urgent needs of the nation during the war, any ores or mineral substances mentioned and enumerated in the act entitled "An act to provide further for the national security and defense by encouraging the production, conserving the supply, and controlling the distribution of those ores, metals, and minerals which have formerly been largely imported, or of which there is or may be an inadequate supply;" approved October 5, 1918, the production of which was requested or demanded by the War Industries Board, the War Trade Board, the Shipping Board, the Emergency Fleet Corporation, or the Department of the Interior and which has been performed in whole or in part by any such person, firm, or corporation prior to November 12, 1918; and that said Secretary ascertain, determine, adjust, liquidate, and, out of the moneys provided and appropriated by said act, pay to the parties justly entitled thereto the amounts of such losses and damages as he, the said Secretary, shall find and determine to have been sustained by reason of having made said investments for said purposes, and that in each case he shall make such determination, provision, settlement, advancement, or final payment, or by agreement with claimants take such other action as he shall find and determine to be just and equitable; that the decision and action of said Secretary in each case shall be conclusive and final; that all payments shall be made, and all expenses incurred by the said Secretary shall be paid from the funds appropriated by the said act of October 5, 1918, and that said funds and appropriations shall continue to be available for said purposes until such time as the said Secretary shall have fully exercised the authority hereby granted, and performed and completed the duties hereby provided and imposed: *Provided*, however, that said Secretary shall consider, approve, and dispose of only such claims as shall be made hereunder and filed with the Department of the Interior within three months from and after the approval of this act.

That a report of all operations under this section, including receipts and disbursements, shall be made to Congress on or before the first Monday in December of each year.

That nothing in this section shall be construed to confer jurisdiction upon any court to entertain a suit against the United States.

An appropriation of \$100,000 has been granted by Congress to the Bureau of Mines for the investigation of lignite and peat. The Bureau is completing its plans for engaging in an intensive effort to prove that the better lignites of the country can be treated commercially. While attention is to be given its by-

products, the main effort will be to obtain a solid fuel and a gaseous fuel.

Many chemists are writing the Bureau, urging work on this or that secondary product but it is being pointed out to them that the by-products will be developed rapidly, once that a commercial fuel can be obtained. The work is under the general supervision of O. P. Hood, the chief mechanical engineer of the Bureau, and under the immediate direction of S. M. Darling.

The Bureau of Mines authorizes the following statement with regard to Spanish pyrites:

The embargo on the production of pyrite was removed on January 13, but no charters are reported since that time. Efforts are now being made to obtain charters, and it is expected that ore will commence coming in within the next two months, although it is not thought that shipments will be made rapidly until late in the spring. One cargo chartered late in December is now under way. There is a brisk demand for the material by the large consumers in the Northern markets, and some demand in the South.

The high rates of 35 to 40 shillings per ton on Spanish pyrite, which prevailed during 1918, have been substantially reduced since the close of the war, and recently rates as low as 20 shillings per ton have been quoted. The pre-war rates ranged from 8 to 10 shillings, but it is not likely that these low rates will again prevail for some time to come.

During 1918 the price of imported pyrite delivered at Atlantic ports varied widely, depending largely on ocean rates. The prices varied from 25 to 35 cents per unit of sulfur, with an average of perhaps 30 cents. A recent quotation at New York is 16½ cents per unit, on the basis of a 10-shilling ocean freight.

With regard to chemical manganese, the Bureau of Mines says:

Approximately 25,000 tons of manganese dioxide ore are consumed yearly in the United States in the manufacture of dry batteries and chemical work, which ore was not subject to the schedule established to fix the price of metallurgical ore. A large part of the battery ore was imported, considerable coming from Japan, but the demand was largely met by using lower grade ores, which were obtained from domestic sources and South America. The grade of the ore used during 1918 had about the following composition: 70 to 75 per cent manganese dioxide; 2 to 4 per cent iron; and less than 0.05 per cent copper, nickel, and cobalt.

As to manganese in general, this prediction is vouched:

There is a strong probability that some of the larger and better-equipped manganese plants may attempt to operate in competition with foreign ores, which in turn will be materially affected by the new conditions resulting from the signing of the armistice.

Correspondence between employers of chemists and Charles L. Parsons, the secretary of the AMERICAN CHEMICAL SOCIETY, shows conclusively that the large corporations are going into research work on a greatly increased scale. This is opening new places for many chemists, but the demand is largely for those having the Ph.D. degree or its equivalent.

Application has been made to the Federal Trade Commission for the use of enemy patents as follows:

E. I. du Pont de Nemours & Company, Wilmington, Del., has filed additional applications for 48 dye, acid and compound patents; National Aniline & Chemical Co., Inc., New York City, has asked for the use of 142 similar patents; and Semet-Solvay Co., Solvay, N. Y., has applied for licenses to cover 25 patents covering ammonia manufacture.

The National Aniline & Chemical Co., Inc., New York City, has applied to use 35 dye, acid and compound patents which they represent are enemy-owned or controlled. The application is in addition to previous applications covering patents related to dye manufacture.

The Consolidated Color & Chemical Company, New York City, has applied for licenses to use 7 dye patents which they claim are enemy-owned or controlled.

INDUSTRIAL NOTES

The United Sulfur Company has been incorporated at Wilmington, Del., by M. L. Rogers, L. A. Irwin, and W. G. Singer with \$1,000,000 capital, to separate sulfur from metallic sulfides, ores, etc.

The Jordan Coal-Tar Products Co., Inc., of New York City, began operation January 1. The vice president and general manager will be James A. Dowd, formerly manager of the coal-tar division of Ralph L. Fuller & Co., prior to which he was with the Bayway Chemical Company and the du Pont Company.

The American Tanning Materials Corporation has been incorporated under the laws of Delaware, with a capital of \$250,000. Charles B. Bishop, S. H. Baynard, and A. M. Fox, of Wilmington, are the incorporators.

The quicksilver imported for consumption in the United States for the 6 months ending June 30, 1918, amounted to 261,879 lbs., or about 3,491 flasks, valued at \$365,930. In the 11 months ending November 30, 1918, the exports amounted to 216,770 lbs., or about 2,890 flasks, valued at \$313,272.

LIST OF APPLICATIONS MADE TO THE FEDERAL TRADE COMMISSION FOR LICENSES UNDER ENEMY-CONTROLLED PATENTS PURSUANT TO THE "TRADING WITH THE ENEMY" ACT

YEAR	PATENT NO.	PATENTEE	ASSIGNEE	PATENT	APPLICANT
1913	1,081,897	Paul Ehrlich and Alfred Bertheim, Frankfurt - on - the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Medicinal preparation	Phenarsenyl Distributing Company, 154 Nassau Street, New York City
1913	1,081,592	Paul Ehrlich and Alfred Bertheim, Frankfurt - on - the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Medicinal preparation	Phenarsenyl Distributing Company, 154 Nassau Street, New York City
1907	860,958	Wiland Astfalck, Tegel, near Berlin, Germany, a corporation		Hydraulic press	Heulings Lippincott and Alfred J. Major, receivers of Camden Iron Works, Camden, N. J.
1905	782,739	Emil Fischer, Berlin, Germany	Firm of E. Merck, Darmstadt, Germany, a copartnership	C,C-Dialkylbarbituric acid and process of making same	Takamine Laboratory, Inc., 120 Broadway, New York City
1904	757,109	Gillis Gullbransson, Höchst-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Blue-red lake and process of making same	Ultron Chemical Corporation, 41 Union Square, New York City

Researches by the chemists of the Forest Products Laboratory at Madison, Wis., upon the production of ethyl or grain alcohol from wood waste, which before the war made possible a materially increased output, were continued as a means of conserving foodstuffs and of relieving tonnage for overseas transport. Similar researches to produce the same product from waste sulfite liquor in pulp-making have shown and demonstrated commercially that the yield of ethyl alcohol from this source can be increased by over 50 per cent. Field studies were made and aid given during the war to several large hardwood distillation plants upon the matter of temperature control as a means of increasing output. By use of proper methods the increased output amounts to 3 gals. of 82 per cent spirit per cord and the acetate of lime product was increased as much as 5 lbs. per cord of wood distilled. In addition to this, large quantities of fuel were conserved, due to the more efficient temperature regulations. This work supplemented much more extensive efforts conducted before the war. Extensive researches were carried out upon the preparation of acetic acid by the fusion of sawdust with sodium hydroxide. It was shown that 15 to 20 per cent of the dry weight of the wood can thus be converted into acetic acid. This work is at present awaiting commercial or large-scale application.

In Tokio and Osaka a new society was recently organized by scientists and manufacturers, under the presidency of Dr. Toyokichi Takamatsu, an eminent authority on chemical industries. The aim of the new organization is to undertake investigations into the possible effects of peace on chemical industries and devise means for their help. The society has also as one of its aims a movement for the establishment of protectionist tariff on dyes and some other chemicals as a relief of chemical lines.

Great strides have been made in chemical industry in Canada during the past two years, and development on an unprecedented scale within the next few months is looked for. Supplies of raw material and equipment are being secured much more easily than was the case before the signing of the armistice. One of the outstanding features of accomplishment by Canadian chemists has been the manufacture of aspirin. A firm formed in 1916 under the name of Chemical Products of Canada, Ltd., has produced aspirin successfully. Manufacture has been as high as 14,000 to 15,000 lbs. per month, of which 3,000 to 4,000 lbs. have been required for consumption in Canada. The balance is exported to England principally, but quantities are being shipped to South Africa and Japan. It is recognized that the principal competition which the Canadian industry has to meet is with the United States firms. Manufacture of sal ammoniac has been entered upon during the past few months, owing to the embargoes placed on this product by the United States and Great Britain. Realizing the importance of securing a supply of this material, the Chemical Products Company installed equipment and has entered upon its manufacture. Between 4,500 and 5,000 lbs. a day are now turned out, which is more than sufficient to supply the requirements of the market. Other products which are made by this company include phenacetin, potassium permanganate, glycerophosphate, oil of mustard, arsenic acid, and sodium acetate. Paramido phenol has been produced for about a year.

The largest potash reduction plant in the world is located at Antioch, Nebraska. It began to operate on September 17, 1918. Nebraska is now producing about 700 tons of potash a day. Next to the packing industry the potash industry is Nebraska's largest manufacturing institution.

The International Vegetable Oil Company, with general offices in Atlanta and mill properties in Georgia, North Carolina, and Texas, has given up its Massachusetts charter and incorporated under the laws of Georgia with a capital stock of \$2,500,000.

Kali Company of America, potash, etc., has been incorporated under the laws of Delaware with a capital of \$1,000,000. Incorporators: Stuart H. McIntosh, Joseph W. Henry, Thomas Robinson, all of New York.

The Sulfate of Ammonia Association of London proposes to form a trading company to be owned and controlled exclusively by manufacturers. The Association will indirectly develop both the home and the foreign markets. Work looking toward development of the home market has already been undertaken as revealed in the Association's report recently issued in which reference is made to the steps which have been taken since 1915 to secure the interest of home distributors. At a meeting of the Association held a week ago it was stated that no results on a commercial scale are to be expected from synthetic sulfate of ammonia for some time.

An interesting discussion of the chemical, paint, and allied industries of St. Louis is contained in an advance summary of a survey of the St. Louis industrial district, conducted by Edgar Gengenbach, industrial commissioner of the St. Louis Chamber of Commerce, in conjunction with Ernest P. Goodrich, consulting engineer of New York City.

The F. S. Royster Guano Company has purchased five acres adjoining its new fertilizer factory, Stickney Avenue, Toledo, Ohio, and will erect a \$500,000 sulfuric acid plant.

The Omaha Potash & Refining Company, capitalized for \$1,000,000 and headed by Everett Buckingham, Frank May, and other well-known Omaha and South Omaha men, are erecting a new \$500,000 potash plant at Lakeside, Omaha. The company was organized during the past summer and secured leases on several thousand acres of water on the Webster ranch, twenty miles south of Lakeside. The lakes were thoroughly tested out and sufficient potash deposits found to care for a plant of a capacity of 100 tons of potash per day.

A company has been organized at Boise, Idaho, under the title of the National Potash Corporation with its principal place of business at Boise. The company owns many thousands acres of cement rock land at Huntington, Ore., McCammon and Lava, Idaho. The purpose of the company is to manufacture potash for the time being and cement later. Certain patents owned and controlled by the company will enable them, it is stated, to manufacture potash on a large scale from silicate rocks.

The Champion Chemical Company, of Asheville, N. C., manufacturing chemical supplies for cotton mills, has elected the following officers: President, W. Floyd Byram; vice president, Archibald Nichols; treasurer, S. M. Hanes; secretary, Charles Nichols.

An explosion in the plant of the American Aniline Products, Inc., Nyack, N. Y., on Friday, January 31, destroyed the building and set fire to other buildings in the neighborhood and shook the town of Nyack like an earthquake. The loss is estimated at about \$200,000, partially covered by insurance. Four workmen were killed and eighteen injured. The first explosion was in the drying house and is supposed to have been caused by overheating of chemicals. There are about 16 buildings in the plant and the company employs over 300 men. The plant is said to have been appraised at \$165,000 about one year ago. The company has offices at 80 Fifth Avenue, New York City.

Establishment of fertilizer standards by the Federal Government, with regulations covering the sale and shipment in interstate and foreign commerce, and designed to prevent deceptions in regard to fertilizers, is proposed in a bill introduced by Representative Asbury F. Lever, chairman of the House Committee on Agriculture. The bill as introduced gives the authority to the Secretary of Agriculture, and was prepared after conference between officials of the Department and Representative Lever.

The Metals and Chemicals Extraction Company has been incorporated at San Francisco, with a capital stock of \$100,000, by E. G. Lewis, Granville Moore, Albert Hanford, C. E. Gilman, and R. P. Henshaw.

For the first time paraffin wax is being manufactured in California on a commercial scale from crude oil. The plant now in operation is that of the Ventura Consolidated Oil Fields Company, of which W. P. Hammon is president. Most of the oil produced in California is of a heavy type but the product flowing in the Ventura field has a specific gravity ranging from 30° to 34° Bé.

The Southeastern Dyestuff Co., Atlanta, Ga., has filed articles of incorporation with a capital of \$25,000 to engage in the manufacture of dyestuffs and allied specialties. William A. Parsons is the principal incorporator.

Leading dry color producers have organized the Institute of Dry Color Manufacturers. P. S. Tilden, of E. I. du Pont de Nemours & Company, is president; Edward Kohnstamm, vice president; and Marcus M. Marks, treasurer.

The Suckow Chemical Co., Los Angeles, Cal., has been incorporated with a capital of \$400,000 to engage in the manufacture of chemicals and allied specialties. John K. and O. Suckow, and George S. Greene, Los Angeles, are the incorporators.

Washington University, of St. Louis, is contemplating the creation of an industrial research department which will be closely linked with the chemistry department and school of engineering and will cooperate with the manufacturers of St. Louis in solving chemical and mechanical problems.

Work has been started on the erection of a large storage warehouse for the Pompeian Oil Company, at Highlandtown, Md. The structure is to cost not less than \$50,000. The company is using large quantities of peanut oil in its operations.

Remodeling to cost approximately \$20,000 will be undertaken by the Union Seed & Fertilizer Co., of Prichard, Ala., to fit the plant for extensive peanut crushing.

Fire destroyed recently the coopeage and storehouse of the Southern Cotton Oil Company at Bayonne, causing \$100,000 loss. The building stood near the works of the Tidewater Oil Company and the Standard Oil Company, where thousands of barrels of oil are stored. The main building of the works was saved by a concrete fire wall separating it from the storehouse.

The Distillers' Securities Company will convert at once three of the great distilleries in Peoria, Ill., and one distillery at Perkin, Ill., into sugar manufacturing plants, to be devoted to a new process of manufacturing sugar from corn. The company will have six large plants remaining for the manufacture of alcohol for commercial and medicinal use, capable of producing 250,000 gallons a day.

A conference of State and local food and drug authorities from fifteen Middle Western States was held in St. Louis recently to consider the extension of food control legislation to the individual States as a substitute for the regulations of the National Food Administration. The meeting was held at the request of the United States Department of Agriculture. Dr. Carl L. Alsberg, chief of the Bureau of Chemistry of the Department of Agriculture, presided.

Consumers Graphite Company has been incorporated under the laws of Delaware with a capital of \$500,000. Incorporators: Samuel W. Osgood, Albert C. Bell, James W. Luther, all of Chicago.

New uses have been found for the breweries made idle by recent legislation. Some who were unprepared are now actively seeking new lines of manufacture. One large plant is being converted into a food dehydrator; another is very successful with malted milk; sweet, pasteurized cider has attracted a third; and maltose syrup is the product of several others. Maltose syrup has proved very useful during the sugar shortage, and it seems certain to maintain its place upon its merits.

Elk Chemical & Color Company has been incorporated under Delaware laws to deal in clay and other minerals; capital, \$500,000; incorporators, W. I. N. Lofland, Charles H. Jones, Dover; Andrew Urrman, Ridgeway, Pa.

PERSONAL NOTES

President William H. Nichols has appointed the following committee to prepare a report to the Advisory Committee, A. C. S., on an estimate of costs and an outline of policies of the proposed institute for drug research: Charles H. Herty, *Chairman*; John J. Abel, Johns Hopkins University Medical School; Reid Hunt, Harvard University Medical School; P. A. Levene, Rockefeller Institute; Raymond F. Bacon, Mellon Institute; F. R. Eldred, Indianapolis, Ind.; Treat B. Johnson, Yale University; F. O. Taylor, *Chairman*, Pharmaceutical Division, A. C. S.

Word has been received of the death of Sidney E. Lunak, chemist at the Forest Products Laboratory, Madison, Wis. Mr. Lunak received his technical education at the Armour Institute of Technology, Chicago, and was graduated from that institution as bachelor of science. He had been connected with the Forest Products Laboratory for more than eight years. He was the author of several papers on testing methods in sulfite work and sulfite cooking, having specialized to a great extent in the chemical engineering of sulfite pulp manufacture.

Mr. Arthur Lachman is now connected with the Great Western Electro-Chemical Co., San Francisco, Cal.

Mr. F. L. Shannon, formerly general superintendent for the Thomas Canning Co., Grand Rapids, Mich., is now quality man for P. J. Ritter Co., Philadelphia, Pa.

Mr. E. T. Casler, formerly chemist for the Phosphate Mining Co., Nichols, Florida, is now with the Air Nitrates Corporation as chemist.

Mr. D. D. Berolzheimer, librarian of the American Chemical Society, 1910 and 1911, librarian of The Chemists' Club, 1910 to 1915, and librarian of the Barrett Co., New York, since April 1915, has severed his connection with the latter firm and is now assistant technical editor with the Chemical Catalog Company, New York City.

Mr. I. D. Hager, formerly chief chemist of the Mound City paint and varnish division of the Certainteed Products Corporation, at St. Louis, is now paint specialist in the Sales Engineer's Department of the New Jersey Zinc Co., New York City.

Mr. J. V. Bassett, who has been a member of the Research Division of the Chemical Warfare Service, at Washington, has returned to his former position with the Hewitt Rubber Co., Buffalo, N. Y.

Dr. Harry Everett Barnard, of the State Laboratory of Hygiene, Indianapolis, has been made editor of the *American Food Journal*.

Major F. E. Breithut, Chemical Warfare Service, has been detailed by the War Department to the War Trade Board to act as chairman of the Chemical Group of the Price Section. Those who will be associated with Major Breithut are: Mr. F. W. Cassebeer, Capt. P. W. Carleton, Lt. Charles L. Fry, Lt. W. N. Jones, Dr. H. L. Lewenberg, Capt. W. Lee Lewis, Dr. W. B. Meldrum, and Capt. H. L. Trumbull.

Mr. John Helfrich has become associated with the Chemical Catalog Co., Inc., as manager of the Information Bureau.

Major A. C. Fieldner, Chemical Warfare Service, U. S. A., who was in charge of the gas mask research at the American University Experiment Station, Washington, D. C., has returned to the Pittsburgh Station of the Bureau of Mines, where he will have charge of the chemical research laboratory.

Mr. H. L. Olin, having been discharged from the Army at Edgewood Arsenal, where he had the rank of Captain, C. W. S., is now chemist in the research department of the Barrett Company at Edgeware, N. J.

Mr. B. E. Reuter, since October 1, 1917, chief of the Fats and Oils Division of the United States Food Administration, which work he is now closing, is opening his consulting engineering office in Baltimore, Md. In addition to being chief of the Fats and Oils Division, Mr. Reuter was chairman of the Inter-Departmental Fat and Grease Committee, a member of the Inter-Departmental Committee on Fats and Oils, and a member of the Inter-Departmental Glycerin Committee, also adviser on Fats and Oils, Soap, and Glycerin to all departments in Washington. At Mr. Hoover's request, Mr. Reuter will still act as consulting adviser to him during the readjustment or reconstruction period and will devote at least one day each week in Washington to this work.

Mr. George B. Bradshaw, formerly president of the American Synthetic Color Co., Stamford, Conn., is now superintendent of intermediates at the du Pont Dye Works at Deepwater Point, N. J.

William Klaber, Ph.D., formerly chemist for Castle Kid Co., Camden, N. J., is now consulting and research chemist with office and laboratory at 430 Walnut Street, Philadelphia, Pa.

Dr. R. E. Nelson, having received his discharge from the Army, December 10, 1918, where he served as 1st Lieutenant in the Research Division of the Chemical Warfare Service, at the American University Experiment Station, has accepted an assistant professorship in chemistry at Purdue University.

Mr. Frank M. Jones, formerly civilian chemist at the American University, Washington, D. C., Pyrotechnic Section of the Research Division, C. W. S., has accepted a position in the research department of the Brown Company (paper and pulp mills) at Berlin, N. H.

Lt. Charles F. Hawkins died at the home of his parents on December 27, 1918, of pneumonia following influenza. In August 1917, he accepted a position as professor of chemistry at Williams College, resigning in February 1918, to enlist with the Chemical Warfare Service. He was mustered out of the service December 21 and returned to his home December 23.

Mr. Theodore W. Fowle has resigned his position with the General Chemical Company, where he has been working on synthetic ammonia, to go into work with the American Committee for Relief in the Far East. He will probably be in sanitary work.

Mr. Carl Moe, formerly of the Bogalusa Paper Company where he had charge of the operations of the sulfate pulp mill, is now connected with the Stevens Point Pulp & Paper Company in the capacity of works and research chemist.

Mr. Frank L. Wright, formerly chemist with the Locomobile Company of America, is now located in Philadelphia as assistant metallurgist with the Standard Roller Bearing Division of the Marlin-Rockwell Corporation.

Mr. John F. McBride, who until last August was working in his private laboratory on some problems in organic synthesis, is now with the research department of the National Aniline and Chemical Company.

Mr. W. B. Meldrum, formerly head of the chemistry department at Haverford College and later in the Chemical Warfare Service on duty at the American University Experiment Station, having been transferred to it from the Infantry, received his discharge from the Army, January 6, and has accepted a temporary position as chemical expert with the Price Section of the War Industries Board.

Lt. Charles L. Burdick, of the Nitrate Division of the Ordnance Department, stationed at the experimental laboratories of Nitrate Plant No. 1, Sheffield, Ala., after receiving his discharge from service in the Army, entered the metallurgical research department of the Chile Exploration Co., New York City. On January 11 he sailed for Chile to work eight or nine months in the copper producing regions about Chuquicamata Province of Antofagasta, and in the vicinity of Braiquen.

Mr. Frederic Bonnet, Jr., formerly chief chemist of the U. S. Ammonium Nitrate Plant, operated by the Atlas Powder Company at Perryville, Md., has been transferred to the forcite works of the Atlas Powder Company at Landing, N. J., where he is taking charge of the experimental laboratory for industrial development.

Mr. R. A. Barkhuff, formerly assistant chemist with the American Thread Co., Williamantic, Conn., is now assistant superintendent of the dry lime sulfur department of the Sherwin-Williams Company.

Mr. David E. Worrall has resigned as 1st Lieutenant, Chemical Warfare Service, U. S. A., to accept a position as instructor in chemistry at Harvard University for the remainder of the college year.

Major J. H. Mathews, Ordnance Dept., U. S. A., has been released from military service and has returned to the University of Wisconsin. While in the military service Major Mathews was in charge of the Gas and Flame Branch of the Trench Warfare Section, Engineering Division, Ordnance Department. Before taking up this work he spent several months in Europe studying gas warfare. Since his return to civil life he has been promoted to a full professorship at the University of Wisconsin, and has charge of the courses in physical chemistry at that institution.

Mr. George W. Morey, of the Geophysical Laboratory, Carnegie Institute, Washington, has been granted leave of absence for one year to take charge of the optical glass plant of the Spencer Lens Co., Hamburg, N. Y.

Mr. William E. Spandow has resigned from the United States Military Academy, at West Point, N. Y., to continue his studies toward a M.Sc. degree in chemistry at the University of Denver.

Mr. Louis S. Potsdamer has been discharged from the Army and has taken up civilian labors as chemical engineer with The Chemical Pigments Corporation.

Mr. Bruce O. Ranck, formerly chemist with the du Pont Engineering Company at the government smokeless powder plant, is now employed by E. I. du Pont de Nemours and Company in their research department on azo dyes.

Elias Yanovsky, formerly connected with the Bureau of Chemistry, U. S. Department of Agriculture, doing research work in chemistry of sugars and food, is now employed by the Norwalk Tire & Rubber Company as a research chemist.

Mr. Herbert J. Krase, formerly chief of the shell loading unit of the Chemical Warfare Service, Dispersoid Section, American University, Washington, D. C., is now chemical engineer for the Special Chemicals Co., Highland Park, Ill.

Mr. B. E. Long, formerly connected with sugar companies in Mexico, is now superintendent and chief chemist for the Cayey Sugar Co., Cayey, P. R.

Mr. R. H. Gerke, who served as 2nd Lieutenant in the Chemical Warfare Service, Dispersoid Section of the Research Division, has been honorably discharged from the Army and is now continuing graduate work at the University of Illinois.

Mr. Henry Wigglesworth, of the General Chemical Company, will take a leave of absence to serve for a time as a trade commissioner for the Bureau of Foreign and Domestic Commerce to study the dyestuff and textile conditions in France.

Mr. Oscar F. Boyd, recently returned from service where he was enlisted with the Gas Defense Division of the Chemical Warfare Service, is back in his former position as professor of chemistry at Wilmington College.

Col. G. A. Burrell, of the Chemical Warfare Service, has returned to private chemical engineering work at Pittsburgh, Pa. In cooperation with R. H. Brownlee he has installed at Pittsburgh complete equipment for the laboratory and plant testing of chemical processes and especially of petroleum, gasoline, and natural gas.

Mr. H. F. Staley, formerly professor of ceramic engineering at Iowa State College, and who had been engaged in war research at the Bureau of Standards since June 1918, joined the staff of the Bureau in December as metallurgical ceramist.

Dr. Edgar T. Wherry, of the Bureau of Chemistry, U. S. Department of Agriculture, has been appointed editor-in-chief of *The American Mineralogist*. Among the associate editors is Dr. W. T. Schaller, of the U. S. Geological Survey.

Edward Charles Pickering, professor of astronomy in Harvard University and director of the Harvard College Observatory, died on February 3 at the age of seventy-two years.

Lt.-Col. J. H. Hildebrand who has recently been Commandant of Hanlon Field, near Chaumont, France, which included the Experimental Field and the A. E. F. Gas Defense School of the Chemical Warfare Service, has returned after an absence of a year in France to his position of professor of chemistry in the University of California.

Mr. Edward Wallace Pierce, who has been chief chemist of the U. S. Conditioning and Testing Company for two years, is now vice president and technical director of the Zobel Color Works, New York City.

Mr. Mark Guthrie, for over fifteen years with the Behrens Drug Co., Waco, Tex., has resigned to accept a position with the National Aniline and Chemical Company, with headquarters in Kansas City, Mo.

Lt. George O. Richardson, who, before his enlistment in the U. S. Chemical Warfare Service where he was stationed in Washington, D. C., was chemist for the Roessler and Hasslacher Chemical Co., Perth Amboy, N. J., has been appointed technical assistant of the National Aniline and Chemical Co., Inc., at Shanghai, China.

Dr. Leo Forst, former head of the Cincinnati office of the U. S. Pure Food and Drug Laboratory, returned to his old position on January 15, from war work in Washington.

The death from influenza is announced of Edwin Henry Ingersoll, chemist in the Bureau of Animal Industry, U. S. Department of Agriculture.

Professor R. Nietzki, professor of chemistry at Bâle, known for his work on the chemistry of dyestuffs, has died at the age of seventy-one years.

Mr. John T. Ward, who has been with the National Carbon Co., Inc., as chemical engineer at the Cleveland works, has been transferred to the New York office of the company as assistant to the works manager.

GOVERNMENT PUBLICATIONS

By R. S. McBRIDE, Bureau of Standards, Washington

NOTICE—Publications for which price is indicated can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. Other publications can usually be supplied from the Bureau or Department from which they originate. Commerce Reports are received by all large libraries and may be consulted there, or single numbers can be secured by application to the Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington. The regular subscription rate for these Commerce Reports mailed daily is \$2.50 per year, payable in advance, to the Superintendent of Documents.

UNITED STATES TARIFF COMMISSION

Dyes and Other Coal-Tar Chemicals. Report to Congress recommending amendments to Title V of Act of September 8, 1916. 83 pp. Issued December 1918.

This report, issued as one among the publications of the United States Tariff Commission on industries affected by the tariff, is divided into six parts.

1—A statement to Congress recommending amendments to Title V of the Act of September 8, 1916. In this statement possible evasions of the intent of the law and difficulties in certain administrative features are explained.

2—A draft of a bill to amend Title V of the Act of September 8, 1916. This proposed bill is designed to prevent evasions which are possible under the Act of September 8, 1916.

3—Text of Title V of the Act of September 8, 1916.

4—Text of Title V of the Act of September 8, 1916, edited to show proposed amendments.

5—Detailed technical discussion of reasons for the proposed amendments.

6—Decisions of the Treasury Department, United States Board of General Appraisers, and the United States Court of Customs Appeals upon classifications under Title V of the Act of September 8, 1916.

UNITED STATES EMPLOYMENT SERVICE

The Bureau of Labor Statistics has prepared various pamphlets, describing occupations, some of which are of chemical interest as follows:

Boots and shoes, harness and saddlery, tanning
Cane-sugar refining, flour milling
Medicinal manufacturing
Metal working, building and general construction, railroad transportation, shipbuilding
Mines and mining

CONGRESSIONAL COMMITTEE REPORT

Lignite. The Mines and Mining Committee of the House of Representatives has reported on Senate Bill 3230, authorizing the Secretary of the Interior to make investigations, through the Bureau of Mines, of lignite coals and peat to determine their practicability of their utilization as fuel and in the production of commercial products. House Report 840. 10 pp. Submitted December 4.

UNITED STATES NATIONAL MUSEUM

Natural Gas: Its Production, Service and Conservation. S. S. WYER. Bulletin 102, Part 7. The Mineral Industries of the United States. 66 pp.

PUBLIC HEALTH SERVICE

Treatment and Disposal of Creamery Wastes. E. B. PHELPS. Public Health Reports, 34, 2169-74. Issued December 6. An experimental investigation of the treatment and disposal of creamery wastes was carried out during the years 1916-17 by the United States Public Health Service, cooperating with the Dairy Division, Bureau of Animal Industry, United States Department of Agriculture.

Resolutions Passed by National Commission of Milk Standards. Public Health Reports, 34, 69-71. Issued January 17.

GEOLOGICAL SURVEY

Phosphate Rock in 1917 with Notes on Phosphorus. R. W. STONE. Mineral Resources of the United States, 1917, Part II. 12 pp. Issued June 25, 1918.

The phosphate rock marketed in the United States in 1917 amounted to 2,584,287 long tons, valued at \$7,771,084, an increase of 601,902 tons in quantity and of \$1,874,091 in value over the production in 1916. The increase of 30 per cent in quantity is notable in view of the conditions brought about by the entry of the United States into the war. The quantity and value were greater than in 1915 or 1916 but less than in any other year since 1909.

In 1917 a general effort was made to increase the production of phosphate rock, owing to the conviction that the people of the United States must increase greatly their production of food-stuffs. Besides supplying food for ourselves we were more and more imperatively required to make large shipments to our allies, and at the close of the year it was apparent that even greater effort must be made to add to the supply of food required for shipment abroad. A great increase in the production of foodstuffs implies a greater use of fertilizer and therefore more energetic mining of phosphate rock.

The fertilizer materials imported into the United States in 1917 comprised many compounds containing phosphorus, nitrogen, and potash. Those containing phosphorus include bone ash, guano, basic slag, and crude phosphate rock. The potash fertilizers include various potash salts, kainite, manure salts, and double-manure salts. The nitrogen compounds are chiefly cyanamide, nitrates, and ammonium salts.

The quantity of calcium cyanamide, or lime nitrogen, used in the United States has increased from 5,000 tons in 1911 to 47,268 tons in 1917. It is a bluish black, odorless powder containing 20 to 22 per cent of nitrogen. The plants of the American Cyanamid Co., which manufactures it, are at Niagara Falls, Canada. It is used by more than 300 manufacturers of fertilizer in the United States, and is now a source of organic nitrogen in about one-fourth of the total ammoniated fertilizers consumed in the country.

FERTILIZERS IMPORTED AND ENTERED FOR CONSUMPTION IN THE UNITED STATES, 1917

FERTILIZER	Quantity Long Tons	Value Dollars
Apatite.....	.....	.....
Bone dust or animal carbon, and bone ash, fit only for fertilizing.....	10,521	308,497
Calcium cyanamide or lime nitrogen.....	47,268	2,472,936
Guano.....	7,067	160,923
Kainite.....	.....	.....
Manure salts, including double-manure salts.....	225	9,047
Phosphates, crude.....	92	1,169
Slag, basic, ground or unground.....	2	54
All other substances used only for manure.....	85,859	1,961,607
TOTAL.....	151,034	4,914,233

This table does not include all the imported material that is incorporated in fertilizers manufactured and sold in this country. To the materials indicated should be added the potash salts listed as such in the import tables of the Bureau of Foreign and Domestic Commerce—potassium chloride and potassium sulfate—which are largely used in manufactured fertilizers. Moreover, considerable import sodium nitrate (Chile saltpeter) is used in fertilizers. A large part of the sodium nitrate imported, however, is converted into nitric acid and nitrates for use in making gunpowder and other explosives, matches, and pyrotechnic material, in assaying and analytical operations, and in curing meats. The large importation of sodium nitrate is very significant. Sodium nitrate and potash salts are commodities

for which the United States in past years has been entirely dependent on foreign countries. The production of potash salts, an infant industry in the United States, is described in another chapter of Mineral Resources.

Gold, Silver, Copper, and Lead in South Dakota and Wyoming in 1917. C. W. HENDERSON. Mines Report. Mineral Resources of the United States, 1917, Part I. 13 pp. Issued January 27, 1919.

Fluorspar and Cryolite in 1917. E. F. BURCHARD. Mineral Resources of the United States, 1917, Part II. 12 pp. Issued November 20, 1918.

Fluorspar mining made another high record in 1917 on account of the strong demand for this mineral for use as flux in basic open-hearth steel furnaces and in the chemical, ceramic, and other industries. Prices reached the highest levels ever recorded and naturally stimulated prospecting and new developments. The number of operators who shipped fluorspar increased from 22 in 1916 to 52 in 1917, and this number does not include several very small producers who sold their output to companies that also mine fluorspar.

The total quantity of domestic fluorspar reported to the Survey as sold (shipped from mines) in 1917 was 218,828 short tons, valued at \$2,287,722, compared with 155,735 tons valued at \$922,654, in 1916, an increase in quantity of 40.5 per cent and in value of nearly 148 per cent. The general average price per ton f.o.b. mines or shipping points for all grades of spar in 1917, according to these figures, was \$10.45, compared with \$5.92 in 1916, an increase of 76.5 per cent. These prices, however, are far below those that were paid for spar for prompt delivery, quotations at mines and furnaces ranging from \$21.50 early in 1917 to \$38 and \$40 in 1918.

Mention was made in this report of Mineral Resources for 1916 of the need for fluorite, or fluorspar, suitable for optical purposes. During the last year hardly a week has passed in which one or more specimens of fluorspar have not been received by the Geological Survey for consideration as to their value for optical use. Of these, several have proved of sufficient promise to warrant careful testing at the Bureau of Standards, and a few have been found to be of value. The Bureau of Standards has issued the following statement concerning the properties and requirements of optical fluorite:

Optical properties and uses.—Fluorite is very transparent to infra-red and ultraviolet rays. It has a low refractive power and a weak color dispersion. It is, therefore, useful in correcting the color and spherical aberration errors in lenses; especially for microscopes, small telescopes, etc.

Quality of material required.—Fluorite suitable for optical instruments must be as clear as glass, that is, it must be free from cloudiness, inclusions, cracks (incipient cleavage marks), etc. Colorless material is most desired, but samples which are faintly tinged with yellow or green may be valuable. To assist in examining for cracks, inclusions, etc., the samples may be placed in a glass vessel and covered with glycerin or kerosene which reduces the reflection from the surface of the crystal.

Size of material.—At present this bureau requires a small amount of material from which clear pieces 15 to 50 mm. ($1\frac{1}{2}$ to 2 in.) in diameter can be cut. The price varies from \$1 to \$5 per lb., while a particularly fine specimen, fulfilling the above requirements, might have a value of \$10 or more.

While fluorite is a common mineral, specimens of optical quality are uncommon. Those engaged in mining this material should, therefore, keep on the lookout for clear material, which, in smaller sizes than above specified, may be used by manufacturers of microscopes.

No cryolite is produced in the United States, the entire supply used in this country being imported from Greenland.

The quantity of cryolite reported to have been imported for consumption in the United States in 1917 was 4,383 long tons, valued at \$218,500, as compared with 3,857 long tons, valued at \$165,222, in 1916. The average price per ton declared in 1917 was apparently \$49.85 as compared with \$42.84 in 1916. Cryolite is imported free of duty.

BUREAU OF MINES

California Mining Statutes Annotated. J. W. THOMPSON. Bulletin 161. 312 pp. Paper, 20 cents. Issued August 1918. This bulletin includes all California mining laws.

Extinguishing and Preventing Oil and Gas Fires. C. P. BOWIE. Bulletin 170. 50 pp. Paper, 20 cents. Issued October 1918.

The Inflammability of Aluminum Dust. A. LEIGHTON. Paper 152. 15 pp. Paper, 5 cents. Issued January 1919.

Although these experiments do not show the exact conditions under which an ignition of the aluminum dust is obtained, they do show that it may ignite at temperatures even lower than those necessary for the ignition of 200-mesh standard Pittsburgh coal dust; also more heat is needed to ignite aluminum dust. The dust used in these tests was a commercial product labeled "aluminum bronze." A summary of the precautions to be observed in handling this material is included.

Method of Least Squares Applied to Estimating Errors in Coal Analysis. J. D. DAVIS and J. G. FAIRCHILD. Technical Paper 171. 36 pp. Paper, 5 cents. Issued September 1918.

Notes on the Black-Sand Deposits of Southern Oregon and Northern California. R. R. HORNOR. Technical Paper 196. 42 pp. Paper, 10 cents. Issued August 1918.

The results of the investigation may be summarized by the statement that in general the black-sand deposits are disappointing in both value and quantity; they rarely contain enough gold and platinum or occur in adequate quantity to be exploited at a profit.

There are, it is true, a few favored places where small areas of the black sand show some precious-metal content, and these may become the site of small operations. The deposits in many places contain appreciable amounts of magnetite, chromite, and ilmenite, but these minerals are generally too scattered and too poor to constitute an important source of iron ore, especially in competition with the known deposits of magnetite on the Pacific coast.

The chief difficulties in the profitable exploitation of these deposits are: (1) lack of uniformity in occurrence and metallic content; and (2) the high cost of mining and treating the materials.

BUREAU OF STANDARDS

Proceedings of the Second Annual Textile Conference. Held at the Bureau of Standards, Washington, May 21-22, 1917. Miscellaneous Publications, No. 19. 87 pp.

DEPARTMENT OF AGRICULTURE

Accuracy in Commercial Grading of Opened Eggs. M. K. JENKINS and N. HENDERICKSON. Department Bulletin 391. 27 pp. Paper, 15 cents. Contribution from the Bureau of Chemistry. Issued December 10, 1918.

Farm Practice in Growing Sugar Beets in Three Districts in Colorado, 1914-15. L. A. MOOREHOUSE, R. S. WASHBURN, T. H. SUMMERS and S. B. NUCKOLS. Department Bulletin 726. 60 pp. Paper, 10 cents. Issued December 14, 1918. This paper is a contribution from the Office of Farm Management and the Bureau of Plant Industry, and gives results of an investigation relative to the practice and costs of growing sugar beets in the district named.

Soils of Southern New Jersey, and Their Uses. J. A. BONSTEEL. Department Bulletin 677. 78 pp. Paper, 40 cents. Issued October 24, 1918. Contribution from the Bureau of Soils.

The Beet-Sugar Industry in the United States. C. O. TOWNSEND. Department Bulletin 721. 56 pp. Paper, 15 cents. Issued November 22, 1918. Contribution from the Bureau of Plant Industry. This paper is a general statement as to the condition of this industry at the present time.

Farm Practice in Growing Sugar Beets in the Billings Region of Montana. S. B. NUCKOLS and E. L. CURRIER. Department Bulletin 735. 40 pp. Paper, 10 cents. Issued November 15, 1918. This paper is a contribution from the Bureau of Plant Industry and gives data gathered from 305 farms in the Billings region of Montana, showing total hours of labor and other costs of production of beets in 1915.

BUREAU OF FOREIGN AND DOMESTIC COMMERCE

Standard Specifications for Open Hearth Steel Girders and High Tee Rails. Adopted 1912. Industrial Standards, Series 3. 19 pp. Paper, 5 cents. Text as adopted by American Society for Testing Materials. Spanish-English editions prepared under supervision of Bureau of Standards. The series covers industrial standards for materials, which include standards prepared by the Government and by technical societies and other organizations.

Standard Specifications for Low-Carbon Steel Splice Bars. Industrial Standards, Series 4. 15 pp. Paper, 5 cents. Revised 1914.

COMMERCE REPORTS—DECEMBER 1918

Very considerable amounts of **candellila wax** are now available in Mexico. It is suggested for use in candles, varnish, shoe polish, electrical insulation, in pharmaceutical ointments, in leather greases and lubricants, and for sealing wax and wax paper. (P. 862)

The use of "paper textiles," *i. e.*, textiles made from paper yarns, has increased greatly in all European countries. In England it has been used principally as a substitute for hemp, jute, etc., in bags and sacks used for numerous materials. In Germany and Austria it has been used in clothing, containing, *e. g.*, 40 per cent of paper yarn, 40 per cent of cotton, and 20 per cent of shoddy. The best and strongest yarns are made from "Kraft" paper. (P. 872-77)

A detailed account is given of the processes and patents for the manufacture of **paper yarn** in Europe. (P. 922-26)

The plan proposed by the British Board of Trade for government aid to the **dye industry** contemplates only such assistance as is necessary to the textile and other trades, in the production of new or unavailable dyes. Assistance is to be in the form of loans and grants for buildings and for research. None of these loans or grants will exceed 40 per cent of the total costs, or 50 per cent of the material assets of the firm. Other details of the plan are described. (P. 933-7)

The **lac cultivation** in India is described in detail. The lac is formed by the secretion of an insect from the tree branches. The output has been greatly increased during the last year. (Pp. 940-42)

In connection with the shortage of **metals** in Germany and Austria, it is predicted that much greater use will be made than formerly of aluminum, antimony, and zinc. New methods of producing hollow ware from aluminum are being developed. (Pp. 973-5)

The loss to Germany of Alsace and Lorraine depends chiefly upon the loss of **petroleum, potash, and iron ore**. Prior to the war, Alsace produced 42 per cent of the oil output of Germany. Loss of the Alsace potash deposits will effectually prevent a German monopoly. The German Lorraine iron mines produced before the war 19,000,000 tons of iron ore, far in excess of the entire British production. Lorraine and Luxemburg furnished 77 per cent of the total metallic iron output of Germany. (Pp. 993-5)

A survey of Latin-American markets shows a very great demand for **caustic soda** to be used chiefly in soap making. Considerable amounts of **sodium carbonate** and **silicate** are also required. (Pp. 1026-32)

In a summary of the census of imports of chemicals into the United States in 1914, it is stated that more than 20,000 chemical invoices had been segregated from 500,000 general invoices. The value of such a census to the American industries is emphasized. (P. 1055)

In Sweden it is proposed to make **alcohol** from white moss at a cost less than that from grain or potatoes. (P. 1107)

A description is given of numerous Chinese products, including **soy bean, camphor, cassia, castor oil, cottonseed oil, gall nuts, ramie fiber, linseed, licorice, and peanuts**. (Pp. 1110-18)

Efforts to locate suitable **glass sands** in Great Britain have shown that there is no difficulty in securing suitable sand for most glasses, including good crystal glass. A few small deposits of sand suitable for optical glass have been located, but they are not as uniform or reliable as French and German sands. (Pp. 113-5)

A summary of the work of the Bureau of Standards on **optical glass** describes the scope of the work which included the manufacture of the **clay pots** as well as much of the glass required for military optical instruments. (P. 1176)

In the development of the **kauri gum** industry of New Zealand methods have been devised for recovering the gum and oil from the low-grade dirt, by a system of flotation, using salt water. (P. 1177)

SPECIAL SUPPLEMENTS ISSUED IN DECEMBER

FRANCE—5c	COSTA RICA—24c
GREECE—7c	DUTCH WEST INDIES—27a
ITALY—8c	FRENCH WEST INDIES—28c
NORWAY—10a	HAITI—30a
PORTUGAL—11a	ECUADOR—43a
BERMUDA—22a	CHINA—32b
CANADA—23d	JAPAN—55c
	BRITISH SOUTH AFRICA—66b

STATISTICS OF EXPORTS TO THE UNITED STATES

JAVA—P. 839	PORTUGAL—Sup. 11a	HAITI—Sup. 30a
Rubber	Antimony	Beeswax
Tin	Argols	Castor beans
Cocunut oil	Camphor	Castor oil
Hides	Ergot	Copra
Sisal	Glycerin	Cottonseed oil
Kapok	Gum copal	Fustic
Cinchona bark	Cork	Hides
Quinine	Hides	Logwood
Copra	Rubber	Sisal
FRANCE—Sup. 5c	Manganese ore	
Argols	Olive oil	ECUADOR—Sup. 43a
Verdigris	Palm oil	Annatto
Calcium tartrate	Wood oil	Cinchona bark
Paper stock	Sulfur ore	Hides
Glassware	Tungsten	Indigo
Essential oils		Ivory nuts
Almond oil		Kapok
Olive oil	CANADA—Sup. 23d	Gold
Perfumes	Aluminum	Rubber
Casin	Antimony	Zinc
GREECE—Sup. 7c	Asbestos	Mangrove bark
Gum mastic	Beeswax	
Licorice	Bones	TIEN-TSIN, CHINA—
Olive oil	Gums	Sup. 52b
Fusel oil	Magnesite	Egg albumen
Opium	Chrome ore	Hides
Chrome ore	Copper ore	Licorice
Emery	Glue stocks	Peanuts
Magnesite	Grease	Peanut oil
Resin	Hides	Castor oil
ITALY—Sup. 8c	Lead	
Citrate of lime	Paper stock	JAPAN—Sup. 55c
Licorice	Pigments	Antimony
Essential oils	Graphite	Agar agar
Olive oil	Roofing felt	Camphor
Pumice stone	Rubber	Menthol
Citric acid	Sulfur ore	Potassium carbonate
Licorice	Tar	Potassium chlorate
Mannite	Wood pulp	Vegetable wax
Sumac	Zinc ore	Crucibles
Tartar	Gold	Copra
DUTCH WEST INDIES		Peanuts
—Sup. 27a		Fish oil
Aloes		Castor oil
Balsam copaiba		Coconut oil
Chicle		Cottonseed oil
Divi-divi		Peanut oil
Hides		Rapeseed oil
Mangrove bark		Soy bean oil
Sugar		Scheelite
Castor seed		Starch
Fustic		
	COSTA RICA—Sup. 24a	
	Gold	
	Hides	
	Manganese ore	
	Rubber	

NEW PUBLICATIONS

By CLARA M. GUPPY, Librarian Mellon Institute of Industrial Research, Pittsburgh

Alloys: Abridgment of United States, British, and German Patents on Alloys, Covering the Production of Platinum Substitutes Including Alloys Having Certain of the Properties of Platinum. MOCK and BLUM. 319 pp. Price, \$25.00. Mock & Blum, 220 Broadway, New York.

Applied Chemistry: Reports of the Progress of Applied Chemistry. Volume 2, 1917. SOCIETY OF CHEMICAL INDUSTRY. 8vo. 538 pp. Price, 4s. 6d. to members, 6s. 6d. to non-members. Published for the Society of Chemical Industry by Messrs. Harrison & Sons, 45 St. Martin's Lane, London, W. C. 2.

Beverages: Home-Made Beverages and Vinegars, Temperance and Light Drinks; Theoretical Hints and Practical Methods with Over One Hundred and Seventy Formulas. J. P. ARNOLD. 12mo. 72 pp. Price, \$0.75. Published by the author. Chicago.

Brassfounding: A Practical Treatise. J. H. HORNER. 8vo. 190 pp. Price, 5s. Emmott & Co., London.

Butter Substitutes: List of United States, British, and German Patents Covering the Manufacture of Butter Substitutes, Hydrogenated Oils and Various Oils, and Milk Products. 8vo. 120 pp. Price, \$25.00. Mock & Blum, 220 Broadway, New York.

Cast Iron: In the Light of Recent Research. W. H. HATFIELD. 2nd Ed. Enlarged and Revised. 8vo. 309 pp. Price, 12s. 6d. Charles Griffin & Co., London.

Century of Science in America. E. S. DANA. 8vo. 420 pp. Yale University Press, New Haven.

Chemical German: An Introduction to Chemical German. E. V. GREENFIELD. 12mo. 384 pp. Price, \$1.40. D. C. Heath & Co., New York.

Chemistry: Textbook of Chemistry for Pharmaceutical and Medical Students. S. P. SADLER and VIRGIL COBLENTZ. 5th Ed. 8vo. 765 pp. P. Blakiston's Son & Co., Philadelphia.

La Chimie Raisonnée. La Chimie n'est pas une Science de Mémoire. Comment on Doit s'y Prendre. M. LEMARCHAND. 2nd Ed. 174 pp. Price, 6 fr. Gauthier-Villars et Cie, Paris.

Colloid Chemistry: Handbook of Colloid Chemistry. W. OSTWALD. 2nd English Ed. Translated from 3rd German Ed. by Martin H. Fischer. 8vo. 284 pp. Price, \$3.50. P. Blakiston's Son & Co., Philadelphia.

Electricity and Magnetism for Engineers. Part I. Electric and Magnetic Circuits. HAROLD PENDER. 8vo. 380 pp. Price, \$3.00. McGraw-Hill Book Co., New York.

Era Formulary. D. O. HAYNES. Price, \$5.00. D. O. Haynes & Co., New York.

Leather: List of United States, British, and German Patents Covering the Manufacture of Leather Substitutes. 8vo. 51 pp. Price, \$25.00. Mock & Blum, New York.

Liquid Steel; Its Manufacture and Cost. DAVID CARNEGIE and S. C. GLADWYN. 2nd Ed. 8vo. 526 pp. Price, \$10.00. Longmans, Green & Co., New York.

Oil Analysis: Short Hand-Book of Oil Analysis. AUGUSTUS H. GRILL. 8th Ed. Revised. 209 pp. Price, \$2.50. J. B. Lippincott Co., Philadelphia.

Oxy-Acetylene Welding. With a Chapter on Oxy-Acetylene Cutting. T. NEWTON and A. EYLES. 8vo. 156 pp. Price, 1s. 6d. Cassell, London.

Petrol and Petroleum Spirits: A Description of Their Sources, Preparation, Examination, and Uses. WILFRED E. CUTTING. 8vo. 135 pp. Price, \$3.40. Longmans, Green & Co., New York.

Physical Chemistry: A System of Physical Chemistry. WILLIAM C. MCC. LEWIS. 3 volumes. 2nd Ed. 8vo. 506 pp. Price, 15s. Longmans, Green & Co., London.

Volumetric Analysis: A Complete Course of Volumetric Analysis. WILLIAM T. BONE. 164 pp. Price, 3s. 6d. Blackie and Son, Ltd., London.

NEW JOURNAL

Science Progress: A Quarterly Review of Scientific Thought, Work, and Affairs. Edited by SIR RONALD ROSS. Published by John Murray, 50s, Albemarle St., London, W., England. Price, \$4.80.

RECENT JOURNAL ARTICLES

Action of Neutral Chlorides upon Chromic Chloride Solutions. M. E. BALDWIN. *Journal of the American Leather Chemists Association*, Vol. 14 (1919), No. 1, pp. 10-19.

Alcohol: Canadian Waste Sulfite Liquor as a Source of Alcohol. V. K. KRIBBLE. *Pulp and Paper Magazine*, Vol. 17 (1919), No. 5, pp. 116-120.

Aluminum: The Metallurgy of Aluminum. R. J. ANDERSON. *Journal of the Franklin Institute*, Vol. 187 (1919), No. 1, pp. 1-47.

Bronze: Effect of Heat Treatment on Bronze, Characteristics Disclosed by Brinell Hardness Tests and Photomicrographs, Quenching and Drawing Give Greater Hardness than Quenching Alone. F. F. HAUSEN and O. A. KNIGHT. *The Iron Age*, Vol. 103 (1919), No. 6, pp. 347-349.

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Ferromanganese in Blast Furnaces: Methods of Production as Shown by Investigation of Eighteen Furnaces by Bureau of Mines Experts. P. H. ROYSTER. *The Iron Trade Review*, Vol. 64 (1919), No. 6, pp. 405-407.

Flotation Process. A. W. ALLEN. *Engineering and Mining Journal*, Vol. 107 (1919), No. 2, pp. 97-100.

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Grain Limits in Heat-Treated Alloy Steels; New Etching Process which Defines the Crystal Boundaries, and Assists in Detecting Faulty Heat Treatment. R. S. ARCHER. *The Iron Age*, Vol. 103 (1919), No. 6, pp. 366-367.

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Refractory Materials: Mesure des Résistances à l'Ecrasement des Matériaux Réfractaires. Méthode du Capitaine V. Bodin. A. BIGOT. *Chimie et Industrie*, Vol. 1 (1918), No. 7, pp. 724-726.

Rubber: Some Processes of Rubber Manufacturing; Preparation and Mixing of Various Compounds; The Reclamation of Rubber; Manufacture of Rubber Substitutes; Process of Manufacturing Automobile Tires. F. J. MAYWALD. *The Chemical Engineer*, Vol. 26 (1918), No. 13, pp. 497-498.

MARKET REPORT—FEBRUARY, 1919

WHOLESALE PRICES PREVAILING IN THE NEW YORK MARKET ON FEBRUARY 15, 1919

INORGANIC CHEMICALS

Acetate of Lime, Basis 80%.....	100 Lbs.	2.00	@	2.05
Alum, ammonium, lump.....	100 Lbs.		7 00	
Aluminum Sulfate, (iron free).....	Lb.	4.50	@	4.75
Ammonium Carbonate, domestic.....	Lb.		nominal	
Ammonium Chloride, white.....	Lb.	19	@	20
Aqua Ammonia, 26°, drums.....	Lb.	7	@	9
Arsenic, white.....	Lb.	10	@	15
Barium Chloride.....	Ton	80.00	@	85.00
Barium Nitrate.....	Lb.	12	@	14
Barytes, prime white, foreign.....	Ton	30.00	@	35.00
Bleaching Powder, 35 per cent.....	Lb.	2	@	3 1/4
Blue Vitriol.....	Lb.	7 1/4	@	8
Borax, crystals, in bags.....	Lb.	7 1/4	@	10 1/4
Boric Acid, powdered crystals.....	Lb.	7 1/4	@	8 1/4
Brimstone, crude, domestic.....	Long Ton	28.00	@	35.00
Bromine, technical, bulk.....	Lb.	75	@	
Calcium Chloride, lump, 70 to 75% fused.....	Ton	18.00	@	22.00
Caustic Soda, 76 per cent.....	100 Lbs.	2.95	@	3.05
Chalk, light precipitated.....	Lb.	4 1/4	@	5
China Clay, imported.....	Ton	20.00	@	30.00
Feldspar.....	Ton	8.00	@	15.00
Fuller's Earth, foreign, powdered.....	Ton		nominal	
Fuller's Earth, domestic.....	Ton	20.00	@	30.00
Glauber's Salt, in bbls.....	100 Lbs.	2.10	@	3.00
Green Vitriol, bulk.....	100 Lbs.	2.00	@	2.25
Hydrochloric Acid, commercial, C. P.....	Lb.	8	@	8 1/4
Iodine, resublimed.....	Lb.	4.25	@	4.30
Lead Acetate, white crystals.....	Lb.	14	@	15
Lead Nitrate, C. P.....	Lb.		85	
Litharge, American.....	Lb.	14	@	15
Lithium Carbonate.....	Lb.		1.50	
Magnesium Carbonate, U. S. P.....	Lb.	25	@	30
Magnetite, "Calcined".....	Ton	60.00	@	65.00
Nitric Acid, 40°.....	Lb.		7 1/4	
Nitric Acid, 42°.....	Lb.		8	
Phosphoric Acid, 48/50%.....	Lb.	35	@	40
Phosphorus, yellow.....	Lb.	55	@	75
Plaster of Paris.....	Bbl.	2.00	@	2.50
Potassium Bichromate.....	Lb.	37 1/2	@	38
Potassium Bromide, granular.....	Lb.	1.25	@	1.30
Potassium Carbonate, calcined, 80 to 85%.....	Lb.	16	@	17
Potassium Chlorate, crystals, spot.....	Lb.	40	@	41
Potassium Cyanide, bulk, 98-99 per cent.....	Lb.		nominal	
Potassium Hydroxide, 88 to 92%.....	Lb.	60	@	70
Potassium Iodide, bulk.....	Lb.	3.75	@	4.00
Potassium Nitrate.....	Lb.	27	@	30
Potassium Permanganate, bulk, U. S. P.....	Lb.	1.00	@	1.05
Quicksilver, flask.....	75 Lbs.	90.00	@	
Red Lead, American, dry.....	100 Lbs.	11.25	@	11.50
Salt Cake, glass makers'.....	Ton	17.50	@	22.00
Silver Nitrate.....	Oz.	63 1/4	@	65
Soapstone, in bags.....	Ton	10.00	@	12.50
Soda Ash, 58%, in bags.....	100 Lbs.	1.50	@	1.55
Sodium Acetate, broken lump.....	Lb.	12	@	13
Sodium Bicarbonate, domestic.....	100 Lbs.	2.75	@	2.85
Sodium Bicarbonate.....	Lb.	12 1/2	@	13
Sodium Chlorate.....	Lb.	18	@	19
Sodium Cyanide.....	Lb.	30	@	32
Sodium Fluoride, commercial.....	Lb.	14	@	15
Sodium Hyposulfite.....	100 Lbs.	2.60	@	3.60
Sodium Nitrate, 95 per cent, spot.....	100 Lbs.	4.42 1/2	@	5.00
Sodium Silicate, liquid, 40° Bé.....	Lb.	2	@	2 1/4
Sodium Sulfide, 60%, fused in bbls.....	Lb.	4 1/4	@	5
Sodium Bisulfite, powdered.....	Lb.	6	@	8
Strontium Nitrate.....	Lb.	25	@	30
Sulfur.....	100 Lbs.	2.25	@	4.60
Sulfuric Acid, chamber 66° Bé.....	Ton		25.00	
Sulfuric Acid, oleum (fuming).....	Ton		25.00	
Talc, American, white.....	Ton		15.00	
Terra Alba, American, No. 1.....	100 Lbs.		1.17 1/2	
Tin Bichloride, 50°.....	Lb.	26	@	28
Tin Oxide.....	Lb.	70	@	80
White Lead, American, dry.....	Lb.	10	@	10 1/4
Zinc Carbonate.....	Lb.	18	@	20
Zinc Chloride, commercial.....	Lb.	14	@	14 1/4

ORGANIC CHEMICALS

Acetanilid, C. P., in bbls.....	Lb.	52	@	53
Acetic Acid, 56 per cent, in bbls.....	100 Lbs.	7.00	@	7.50
Acetic Acid, glacial, 99 1/4%.....	100 Lbs.	14.50	@	15.00
Acetone, drums.....	Lb.		15 1/2	
Alcohol, denatured, 180 proof.....	Gal.	45	@	47

Alcohol, sugar cane, 188 proof.....	Gal.	4.90	@	4.95
Alcohol, wood, 95 per cent, refined.....	Gal.	1.22	@	1.24
Amyl Acetate.....	Gal.	4.20	@	4.50
Aniline Oil, drums extra.....	Lb.	25	@	26
Benzoic Acid, ex-toluol.....	Lb.	2.00	@	2.25
Benzene, pure.....	Gal.	22	@	22 1/2
Camphor, refined in bulk, bbls.....	Lb.	1.24 1/2	@	1.25
Carbolic Acid, U. S. P., crystals, drums.....	Lb.	15	@	20
Carbon Bisulfide.....	Lb.	9	@	10
Carbon Tetrachloride, drums, 100 gals.....	Lb.	15 1/2	@	16
Chloroform.....	Lb.	63	@	70
Citric Acid, domestic, crystals.....	Lb.		1.25	
Cresosote, beechwood.....	Ton	2.00	@	2.10
Cresol, U. S. P.....	Lb.	18	@	20
Dextrine, corn (carloads, bags).....	Lb.	8	@	9
Dextrine, imported potato.....	Lb.		nominal	
Ether, U. S. P. 1900.....	Lb.	27	@	30
Formaldehyde, 40 per cent.....	Lb.	22 1/2	@	23
Glycerin, dynamite, drums extra.....	Lb.	15 1/2	@	16
Oxalic Acid, in casks.....	Lb.	36	@	38
Pyrogallol Acid, resublimed, bulk.....	Lb.	2.85	@	2.90
Salicylic Acid, U. S. P.....	Lb.	55	@	60
Starch, corn (carloads, bags) pearl.....	100 Lbs.	6.00	@	7.00
Starch, potato, Japanese.....	Lb.	13	@	14
Starch, rice.....	Lb.	12 1/4	@	13
Starch, sago flour.....	Lb.	9 1/4	@	10 1/4
Starch, wheat.....	Lb.		nominal	
Tannic Acid, commercial.....	Lb.	65	@	80
Tartaric Acid, crystals.....	Lb.	84 1/2	@	85

OILS, WAXES, ETC.

Beeswax, pure, white.....	Lb.	63	@	65
Black Mineral Oil, 29 gravity.....	Gal.	24	@	25
Castor Oil, No. 3.....	Lb.	22	@	23
Ceresin, yellow.....	Lb.	16	@	17
Corn Oil, crude.....	100 Lbs.	16.75	@	17.7
Cottonseed Oil, crude, f. o. b. mill.....	Lb.	17 1/2	@	—
Cottonseed Oil, p. s. y.....	100 Lbs.	21 1/4	@	22
Menhaden Oil, crude (southern).....	Gal.	90	@	1.00
Neat's-foot Oil, 20°.....	Gal.	2.00	@	
Paraffin, crude, 118 to 120 m. p.....	Lb.	9 1/4	@	10
Paraffin Oil, high viscosity.....	Gal.	40	@	41
Rosin, "F" Grade, 280 lbs.....	Bbl.	13.20	@	13.50
Rosin Oil, first run.....	Gal.	75	@	76
Shellac, T. N.....	Lb.	52	@	53
Spermaceti, cake.....	Lb.	31	@	33
Sperm Oil, bleached winter, 38°.....	Gal.	2.08	@	2.10
Spindle Oil, No. 200.....	Gal.	38	@	40
Stearic Acid, double-pressed.....	Lb.	22 1/2	@	24 1/2
Tallow, acidless.....	Gal.	1.15	@	1.20
Tar Oil, distilled.....	Gal.	36	@	38
Turpentine, spirits of.....	Gal.	79	@	80

METALS

Aluminum, No. 1, ingots.....	Lb.	33	@	34
Antimony, ordinary.....	Lb.	7 1/4	@	8
Bismuth, N. Y.....	Lb.	3.50	@	3.65
Copper, electrolytic.....	Lb.	23	@	nominal
Copper, lake.....	Lb.	20	@	23
Lead, N. Y.....	Lb.	5.75	@	6.00
Nickel, electrolytic.....	Lb.	55	@	56
Platinum, refined, soft.....	Oz.		nominal	
Silver.....	Oz.		1.01 1/4	
Tin, Straits.....	Lb.		nominal	
Tungsten (Wol).....	Per Unit	15.00	@	20.00
Zinc, N. Y.....	100 Lbs.	9.40	@	9.60

FERTILIZER MATERIALS

Ammonium Sulfate.....	100 Lbs.	4.75	@	—
Blood, dried, f. o. b. New York.....	Unit	6.00	@	6.25
Bone, 3 and 50, ground, raw.....	Ton	37.00	@	37.50
Calcium Cyanamide.....	Unit of Ammonia		nominal	
Calcium Nitrate, Norwegian.....	100 Lbs.		—	
Castor Meal.....	Unit		—	
Fish Scrap, domestic, dried, f. o. b. works.....	Unit		nominal	
Phosphate, acid, 16 per cent.....	Ton	17.00	@	18.00
Phosphate Rock, f. o. b. mine.....	Ton		nominal	
Florida land pebble, 68 per cent.....	Ton	5.00	@	6.00
Tennessee, 78-80 per cent.....	Ton		nominal	
Potassium "muriate," basis 80 per cent.....	Ton	270.00	@	280.00
Pyrites, furnace size, imported.....	Unit		nominal	
Tankage, high-grade, f. o. b. Chicago.....	Unit	5.00	@	5.50

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EDITORIALS

THE VICTORY MEETING

"Put me off at Buffalo," that familiar slogan of by-gone exposition days, will be revived next week by chemists assembling for the Victory Meeting of the AMERICAN CHEMICAL SOCIETY, which will be held in that hospitable city April 7-11. The very combination of dates is suggestive of a merry occasion.

News from the various committees in charge of the meeting locally gives assurance of delightful entertainment. The list of speakers at the general meetings (see page 369, this issue) promises a real contribution to constructive thought regarding many important problems of the reconstruction period.

To get the pleasure of the entertainments and the full inspiration of the addresses actual bodily presence is required, "so pack up your—" never mind the rest of the quotation—just ride, ride, ride.

Unquestionably this Buffalo meeting promises to be one of the most important ever held by the Society. The Council meeting last December, a record breaker in point of attendance, resolved itself largely into a sorting establishment for the classification of the many admirable suggestions made for furthering the work of the Society and increasing the usefulness of the chemist. The material was referred to various committees for digest and report at the Spring Meeting. The committees have been active. Your opinion of the results of their labors is needed. Buffalo is the place to express it.

POST-DOCTORATE FELLOWSHIPS

Just before going to press the following announcement was received from the Chairman of the National Research Council. Its importance as indicative of a new era in chemistry, that of the post-doctorate fellowship, has justified a complete last-minute change of the make-up of the editorial section.

NATIONAL RESEARCH FELLOWSHIPS IN PHYSICS AND CHEMISTRY,
SUPPORTED BY THE ROCKEFELLER FOUNDATION

The National Research Council has been entrusted by the Rockefeller Foundation with the expenditure of an appropriation of \$500,000 within a period of five years for promoting fundamental research in physics and chemistry in educational institutions in the United States.

The primary feature of the project is the initiation and maintenance of a system of National Research Fellowships, which are to be awarded by the National Research Council to persons who have demonstrated a high order of ability in research, for the purpose of enabling them to conduct investigations at educational institutions which make adequate provision for effective prosecution of research in physics or chemistry. The plan will include such supplementary features as may promote the broad purpose of the project and increase its efficiency.

Among the important results which are expected to follow from the execution of the plan may be mentioned:

- 1—Opening of a scientific career to a larger number of able investigators and their more thorough training in research, thus meeting an urgent need of our universities and industries.
- 2—Increase of knowledge in regard to the fundamental principles of physics and chemistry, upon which the progress of all the sciences and the development of industry depend.
- 3—Creation of more favorable conditions for research in the educational institutions of this country.

The project will be administered by the Research Fellowship Board of the National Research Council. This Board consists

of six members appointed for terms of five years and of the chairmen *ex officio* of the Division of Physical Science and the Division of Chemistry and Chemical Technology of the National Research Council. The members of the Board are:

HENRY A. BUMSTEAD, Professor of Physics, Yale University
SIMON FLECKNER, Director of the Rockefeller Medical Institute
GEORGE E. HALE, Director of Mount Wilson Observatory
ELMER P. KOHLER, Professor of Chemistry, Harvard University
ROBERT A. MILLIKAN, Professor of Physics, University of Chicago
ARTHUR A. NOYES, Director of the Research Laboratory of Physical Chemistry, Massachusetts Institute of Technology
WILDER D. BANCROFT, Professor of Physical Chemistry, Cornell University.
Chairman of the Division of Chemistry and Chemical Technology

_____, Chairman of the Division of Physical Science

The appointments of National Research Fellows will be made only after careful consideration of the scientific attainments of all candidates, not only of those who apply on their own initiative, but also of those who are brought to the attention of the Fellowship Board by professors in educational institutions and by other investigators throughout the country.

The Research Fellowships will for the most part be awarded to persons who have had training at an American university or scientific school equivalent to that represented by the doctor's degree. The salary will ordinarily be \$1500 for the first year. The Research Fellowship Board will not, however, be bound by rigid rules of procedure. Thus it may offer larger salaries to those of exceptional attainment or wider experience, and may give appointments to competent investigators who have had training other than that represented by the doctor's degree.

The Research Fellows will be appointed for one year, but they will be eligible for successive reappointments, ordinarily with increase of salary.

It is expected that fifteen to twenty Research Fellowships will be available during the coming year, and that the number will be increased in subsequent years.

Applications for the Fellowships should be made on the form provided for the purpose, and should be sent to the Secretary of the Research Fellowship Board, National Research Council, 1023 Sixteenth St., Washington, D. C. Applications will be received up to September 1, 1919, for Fellowships available during the next academic year; but a limited number of appointments will be made on the basis of the applications received before April 20, 1919.

AS OTHERS SEE US

Testimony increases in value in proportion to its disinterestedness. For this reason the tribute paid to the chemical industries by Judge A. Mitchell Palmer, formerly Alien Property Custodian and now Attorney General of the United States, will be particularly appreciated by all who have labored in the upbuilding of this industry. Not even the soft impeachment of flattery can be laid at Judge Palmer's door, for the quotation below is from an address delivered not to a gathering of chemists but to the New York City Bar Association on December 10, 1918.

Chemistry more than any other science is the very foundation of a far-flung line of industry. You have but to look about you, for example, at the tremendous part which colors play in all the necessities, comforts, and luxuries of life, to realize the grip which the control of the dyestuff industry has upon the people. Its by-products touch alike the health, the well-being, the very life of the people. In peace, and even more in war, chemistry paints the whole picture of progress. America's social and economic, possibly even her political, independence is not safe unless the industries dependent upon the development of the science of chemistry are open to American genius and energy.

I cannot too forcefully repeat that the German industrial penetration of America has not been a mere friendly desire to trade and do business with the world. It has been a knife at the throat of America. In the days before the war and during the war most of the great German-owned industrial establishments were spy centers filled with the agents of Germany long

plotting against the safety of the United States. They were depositaries of secret information gleaned by the ubiquitous spies in the German employ, and without them these spies would have been almost harmless.

I do not advocate any trade boycott out of a spirit of revenge or in retaliation for injuries done to the United States. I do not want to continue the war after the war. I am for peace. I believe that the great overshadowing result which has come from this war is the assurance of peace almost everlasting among the peoples of the earth. I would help to make that an absolute certainty by refusing to permit Germany to prosecute a war after the war. The military arm of her war machine has been palsied by the tremendous hammering of the allied powers. But her territory was not invaded, and if she can get out of the war with her home territory intact, rebuild a stable government, and still have her foreign markets subject to her exploitation, by means no less foul and unfair than those which she has employed on the field of battle, we shall not be safe from future onslaughts different in methods but with the same purpose that moved her on that fateful July day when she set out to conquer the world.

These striking statements are not based upon mere general impressions, but represent a deliberate conviction resulting from an official exploration of the American chemical industries, especially as to the infiltration of enemy interests. The chief scout in this expedition was Mr. Joseph H. Choate, Jr.

It is our purpose to include in this volume of *THIS JOURNAL* as complete a record as possible of all wartime activities in chemistry. We are therefore printing in full in this issue that section of the Custodian's report prepared by Mr. Choate, which deals especially with the chemical industries. It is a document of intense interest.

THE CHEMICAL FOUNDATION, INC.

Since the brief announcement in our March issue of the formation of the Chemical Foundation, Inc., many details concerning this remarkable organization have been made public. It is difficult to grasp the full significance of this latest development in the chemical world, but it is already very evident that it is unique, that it is filled with potentialities for good to the industry, and that it constitutes a lasting testimonial to the constructive genius of those who took part in its formulation.

The sale to the corporation of the 4,500 German patents was effected by the Alien Property Custodian acting under the authority of an Executive Order signed by the President of the United States.

The capital stock, \$500,000, is to be issued as \$400,000 of 6 per cent cumulative preferred, to be retired from surplus income, and \$100,000 of common stock, limited to 6 per cent dividends. It has been sought to distribute the stock in small holdings as widely as possible throughout the chemical industry. The voting stock is placed in a voting trust.

The officers of the company are: *President:* Francis P. Garvan; *Vice President:* Douglas I. McKay; *Secretary and Treasurer:* George J. Corbett; *Counsel:* Joseph H. Choate, Jr., and Ramsay Hoguet.

The names of these officers guarantee that the objects of the Foundation will be actively promoted and its rights vigorously defended. A new tower of strength thus springs into existence for the protection of the American dyestuff industry and the closely related industries of synthetic medicinals and photographic chemicals, for in the language of the former

Custodian: "\$250,000 has been provided for working capital so that the company may be able to commence immediately and prosecute with the utmost vigor infringement proceedings whenever the first German attempt shall hereafter be made to import into this country."

An interesting by-product of the Foundation is the new angle given to the discussion of the subject of "product patents." The chief argument of those who have sought the elimination of such from our patent system has been the German practice of patenting a product in this country, not for purpose of manufacture, but rather to prevent manufacture and to secure importation from Germany alone. Now the shoe is on the other foot. These very product patents will prevent importation and will give time and opportunity for development of American manufacture.

The irony of the situation, however, lies in that section of the articles of incorporation which provides that after retirement of the preferred stock, the surplus earnings of the Foundation are to be devoted to "the advancement of chemical and allied science and industry." That which was intended as an effective means of strangling the chemical industry in this country becomes now the strong support of its thorough development.

TO GIVE OR TO LEND

From all directions comes the good news of the rapid increase in man-power of the graduate courses in chemistry in the universities. In the light of the statements reaching this office we do not hesitate to predict that next Fall will witness an unparalleled number of applicants for the Ph.D. degree in chemistry. And allow us to make one more prediction, namely, the future historian of chemistry in America will mark this period as the passage from the day of the routine chemist to that of the trained research worker.

In a former editorial we advocated extreme personal sacrifice, if necessary, to secure this more extensive training. At the time we purposely refrained from commenting on the possibilities of financial aid in many cases in undertaking further study. It was of primary importance that the spirit should prevail to accomplish it. Fortunately a constantly increasing number of fellowships serves to diminish the sacrifices. The du Pont Fellowships, established a year ago, give aid in every section of the country. The announcement of Throop College of Technology on page 378 of this issue will prove a strong attraction to the Pacific Coast. The alumni of Lafayette College, with a fine spirit of enthusiasm, have recently raised \$10,000 for the endowment of a fellowship in that institution. Nor is the woman chemist to be neglected, for we have just learned of two fellowships in chemistry at Mt. Holyoke College, created by the National Aniline and Chemical Co., Inc.

A complete survey of these fellowships has not been attempted, but we must confess to a particular interest in the action of the New Haven Section at its meeting in Bridgeport, Conn., on March 7. There were sought methods of stimulating greater interest in the

Section. In trying to help itself it hit upon the happy thought that this could be accomplished best by helping someone else, so in a few minutes funds were raised for the creation of a scholarship in the Graduate School of Yale University, the recipient to be a candidate for a higher degree in the department of chemistry. The officers of the Section are to have a voice in the award of the scholarship, and the recipient will be expected to make a report to the Section upon the completion of his research.

The particular point of interest, however, in this action is that the funds to be advanced by the Section are to be in the form of a bona fide loan, to be repaid as soon as possible after earning days have been reached. This is an important departure and one which will do much toward lightening that sacrifice which many men are willing to make to equip themselves thoroughly for a life of highest service.

In support of this statement it may be well to record here the operation along similar lines of a fund, the remarkable results of which we have had firsthand opportunity to witness. The Deems Fund was established at the University of North Carolina in 1881 for the purpose of aiding students to get a university education. Not over \$100 per session may be obtained from this Fund by any student, and the money is advanced only in exchange for a note, legally collectable and endorsed by two responsible parties. These notes bear six per cent interest and are due as soon as the recipient is financially able to make payment. What has been the outcome of this rather unusual Fund? More than 1200 students have been aided. Among these can be counted a United States Senator, members of Congress, state officials, judges, lawyers, preachers, physicians, teachers and business men. Approximately \$125,000 has been loaned, and the fund, originally \$10,500, has increased to more than \$40,000, the losses during the first thirty years of operation being only one per cent. It reads like a romance—and it is true.

May the New Haven Section be able to show a similar accounting!

INDIVIDUAL RESPONSIBILITY

The continuous growth of the membership of the AMERICAN CHEMICAL SOCIETY is extremely gratifying to all who appreciate the possibilities for good in so great a combined effort of those to whom chemistry is the daily creed. This very bigness, however, is a possible source of danger through diminution of individual interest and lack of acceptance of individual responsibility for the welfare of the organization as a whole. In other words the enlarged body may become flabby. That would prove a national disaster at this particular period when the many problems of reconstruction must be squarely met and promptly solved. Fortunately there are no present signs of this weakness, but individuals and local sections are asking "What can we do to strengthen the Society?"

In a thoughtful address before the Lehigh Valley Section on March 14, 1919 (page 341 of this issue), Dr. B. C. Hesse discussed this question thor-

oughly, frankly, and withal in an optimistic spirit which evidently carried conviction to his hearers, for immediately after the address the Section unanimously adopted the following resolution:

RESOLVED, That the Lehigh Valley Section of the AMERICAN CHEMICAL SOCIETY adopt as a policy the continuous presentation of the interests of the Lehigh valley to the parent Society. To this end there shall be a Committee which shall consist of a chairman who shall appoint one or more members to cooperate with each of the active committees of the parent Society in which the Lehigh Valley Section has an interest or to which it may be of assistance. This Committee shall report to the Chairman of the Section during February and July of each year. These reports shall be made accessible to the councillors of this Section.

To every chemist who believes in the AMERICAN CHEMICAL SOCIETY as one of our great national agencies and who would see it function to the maximum in this capacity we commend a careful reading of Dr. Hesse's address. Its stimulative influence should result in definite action in every local section.

NOTES

Press dispatches of March 12 announce that "the peace council forbids the construction of tanks in Germany, and *prohibits the manufacture of poison gas.*" It is good to see this in print at last, though we cannot yet understand why this prohibition was not included in the original armistice terms.

There is no ambiguity in the reply of the University of Bordeaux to the request from the Universities of Leipzig and Heidelberg that pre-war relations be renewed.

Please make a short visit to the devastated regions of Northern France and then inform us upon your return how long it would be before you would renew relations with a people committing similar deeds in your country. The generation perpetrating such abominations has severed all connection with humanity. Perhaps we shall renew relations with the next generation.

Prospects are booming for the Fifth National Exposition of Chemical Industries, to be held in Chicago, September 22-28, 1919. The demand for space is so great that in addition to the Coliseum the management has already been compelled to engage the adjacent First Regiment Armory. As the two buildings are connected by a passageway no inconvenience will be experienced. Conferences will be held throughout the week in both buildings.

The composition of the Chicago Advisory Committee is in itself a guarantee of the success of the Exposition. The Committee consists of L. V. Redman, W. D. Richardson, A. V. H. Mory, Carl S. Miner, F. W. Willard and William Hoskins.

An important meeting of the chemists of the allied nations will be held in Paris this month (April). In response to the invitation to the AMERICAN CHEMICAL SOCIETY from the Société de Chimie Industrielle, President Nichols has requested a number of American chemists now in Paris to attend the conference and report to the Council of the Society.

CONTRIBUTIONS FROM THE CHEMICAL WARFARE SERVICE, U. S. A.

THE DEVELOPMENT DIVISION, CHEMICAL WARFARE SERVICE, U. S. A.

By F. M. DORSEY, Colonel, C. W. S., Chief, Development Division

Received March 5, 1919

HISTORICAL

The story of how the Development Division came to Cleveland begins on April 28, 1917. On that day, Dr. W. K. Lewis, representing the Bureau of Mines, appeared in Cleveland to enlist the aid of the National Carbon Company and the National Lamp Works of the General Electric Company in developing a gas mask capable of protecting the American soldier. The United States had just declared war on Germany. Her sons were soon to appear upon the battlefields of France. Those battlefields were being swept by German gas in ever-increasing quantities, and as yet no satisfactory canister material for gas masks had been developed by any of the Allies. The problems of gas warfare had been detailed by the Army and Navy of this country to the Bureau of Mines. The situation demanded immediate action. For once a government department omitted the step of "appointing a committee to investigate." Dr. Lewis came to Cleveland the day after he was appointed Assistant in Charge, Defense Problems, War Gas Investigations, Bureau of Mines.

of the General Electric Company, were best prepared to undertake the development of a satisfactory absorbent. The proposition was eagerly accepted and Dr. Lewis gave them two weeks to "show something."

The two Cleveland companies first began independent investigations. Later, they pooled their energies, maintaining throughout a spirit of exceedingly close cooperation. By midnight, April 28, an entire research laboratory at the plant of the National Carbon, under the direction of Mr. Batchelor and Dr. Chaney, was busy carbonizing woods. These experiments were based upon the twenty years' experience of the laboratory in just this field of investigation. In the course of the first week following April 28, the National Carbon Company spent upon this investigation \$3500 in express charges alone, having shipments of wood—chiefly cedar—sent to Cleveland from all parts of the United States, soldiers acting as convoys.

The National Lamp Works organization began with equal energy. The services of a complete laboratory were made available for this investigation, the company stating that the expense of that work would be borne by the company as their contribution to the war. It should be noted that this arrangement with respect to the Gas Defense investigation at Nela Park continued up to February 1919, when the work was stopped.

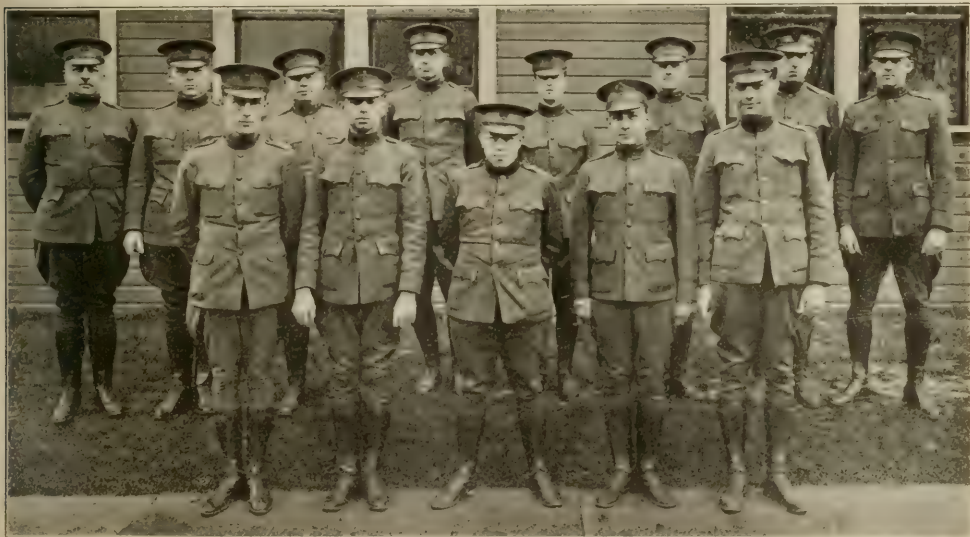


FIG. 1.—OFFICERS AT HEADQUARTERS DEVELOPMENT DIVISION, NELA PARK, CLEVELAND, OHIO

In Cleveland, Dr. Lewis consulted Mr. Allen, of the National Carbon Company, and the writer, and laid his proposition squarely before them.

Charcoal had long been known as a good absorbent for gases. Furthermore, of all the canister material tried by the Allies, different forms of charcoal as used by the Russians had shown the greatest degree of success. The National Carbon Company should know as much about charcoal as any other concern in the United States and, together with the National Lamp Works

The story of the success of these two organizations in this development work is told elsewhere in this article.

The original civilian organization at the National Carbon Company and at Nela Park was soon augmented with officers and men loaned by the Gas Defense. From April 28, 1917, to November 11, 1918, Cleveland was the center for the development of activated charcoal, material which helped to make the American gas mask the best mask found on any foreign battlefield.

In March 1918, when it became evident that the form of charcoal then developed and in process of manufacture would take care of any of the war gases being used, Dr. Lewis again came to Cleveland to "start something." The most effective weapon in gas warfare as yet discovered was mustard gas, and, so far, the development of a process for the manufacture of this material had not passed beyond the laboratory scale in this country.

No definite manufacturing procedure had been submitted to the Ordnance Department and Colonel Walker, Commanding Officer, Gunpowder Reservation (now Edgewood Arsenal), where it was proposed to manufacture mustard, suggested through Dr. Lewis that development work be started immediately in Cleveland.

The National Lamp Works organization readily agreed to take over the new problem. The General Electric Company generously agreed to meet all expenses involved in the new development, reimbursement to be made at the convenience of the War Department. By this arrangement it was possible to avoid the initial delay for securing proper appropriations. The plant of the Great Lakes Refining Company, located at East 131st Street and Taft Avenue, Cleveland, Ohio, was taken over for this investigation. This plant soon became the development center for mustard. The original personnel of 35 men was increased to 175 officers and enlisted men, men for the most part obtained through the Edgewood Arsenal directly from the colleges and universities of the country, and whose enthusiasm was dimmed only by the lack of opportunity to pour down Hindenburg's throat the mustard they were making. By July the equipment and procedure developed at this plant was in full-scale operation at the Edgewood Arsenal, Edgewood, Maryland. The story of this development is outlined elsewhere in this article.

In May, the writer was placed in charge of all the large-scale manufacturing development of war gases conducted by the Bureau of Mines. In this connection the development of mustard gas at three other stations—namely, Zinsser Company, Hastings-on-Hudson; American University, Washington, D. C.; and Dow Chemical Company, Midland, Michigan—came under his supervision. To avoid duplication, all experimental work on mustard, save that conducted at the Midland and Cleveland stations, was discontinued. It was originally intended to expand the development work at Midland to actual production, but in September the work at Midland was ordered discontinued.

On June 25, by order of the Secretary of War, the Chemical Warfare Service was authorized, thus combining the Chemical Service Section, National Army, the Gas Defense Division of the Sanitary Corps, the Edgewood Arsenal of the Ordnance Department and the 30th Engineers, or Gas and Flame Corps, at the same time drawing into the military service a large number of the civilian employees of the American University organization. On August 1, the Nela Park, East 131st Street and Taft Avenue, and Midland organizations became the Development Division, with headquarters at Nela Park on the grounds of the National Lamp Works. The function of this division, as authorized, was to take processes for the manufacture of gas warfare material as worked out on a laboratory scale by the Research Division located at the American University and develop these processes to a full-scale production basis. On the basis of these developments, the Production Divisions located at Edgewood, Astoria, and other places, were then to undertake the actual production.

In August, in addition to the three original sections of the Development Division, a fourth and fifth section were added. On August 1, 1918, a large manufacturing plant near Cleveland was taken over by the Development Division for the purpose of developing and manufacturing gas. This plant became known as the Experimental Section of the Development Division.

The question of the production of a satisfactory booster casing for gas shell in general, and the manufacture of a glass-lined shell to be held for special cases, had from the first been a source of anxiety to army authorities. In August, at the request of General Sibert, the Development Division undertook to investigate the manufacture of glass-lined shell and the manufacture of a satisfactory booster casing for gas shell. A special investigation section was established for this purpose.

The full organization chart for the Development Division is given on p. 285.

The Development Division wishes to do homage to one man whom the division cannot claim for its own, but to no other single man does it feel such a debt of gratitude. The master mind behind each step in the development and production of materials for the American gas mask was that of Dr. W. K. Lewis, of the Massachusetts Institute of Technology, assistant in charge of Defense Problems, War Gas Investigations, Bureau of Mines.

To a large degree, the success of installing and operating the apparatus at Astoria is due to the willing help rendered by Mr. W. C. Morris, chief engineer of the Consolidated Gas and Electric Company, New York.

DEVELOPMENT OF ACTIVATED CHARCOAL

Defense Section, Development Division

The finished gas mask is composed of many parts, such as facepiece, eyepiece, canister tube, canister, etc. The serviceability reached with the American gas mask was due to the successful design and development of each of these parts. The following account deals with the development of one of these parts, the canister filler or absorbent for the poisonous gases contaminating the air to be drawn into the mask.



FIG. 2.—BUILDING AT NELA PARK, CLEVELAND, USED BY DEVELOPMENT DIVISION FOR CHARCOAL DEVELOPMENT WORK

The development of activated charcoal as a canister filler was largely the work of two Cleveland organizations.

1—The Research Section of the National Carbon Company, working under the direction of Mr. H. D. Batchelor and Dr. N. K. Chaney, later made a part of the Research Division, C. W. S.

2—War Section Laboratory of the National Lamp Works of the General Electric Company, under the writer, later the Defense Section, Development Division, C. W. S.

It is impossible to make clear the part contributed by these two organizations, unless the whole story be told. At the same time, in the space available, it is not permitted to do more than outline this story.

PRELIMINARY WORK

STRAIGHT DISTILLATION PROCEDURE —On April 28, 1917, when the decision was made to develop as canister filler for the American gas masks, the most highly absorbent form of charcoal possible, both laboratories began work with the simple hypothesis that

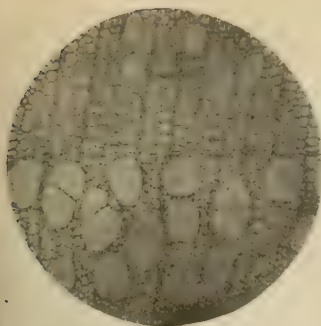


FIG. 3—CROSS SECTION OF WILLOW WOOD. MAGNIFICATION 80

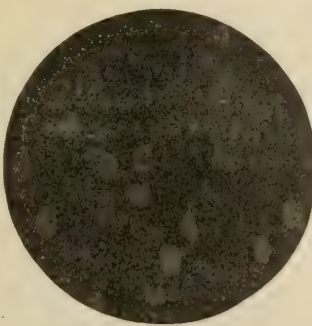


FIG. 4—CROSS SECTION OF IRONWOOD. MAGNIFICATION 80

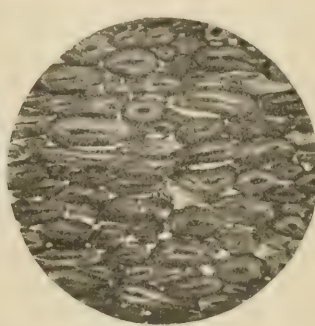


FIG. 5—CROSS SECTION OF COCONUT HULL. MAGNIFICATION 160

the absorptive power of charcoal for gases would depend upon the porosity of that charcoal; the more carbon surface exposed, the more absorbent the material. The porosity, in turn, would depend upon the specific character of the material carbonized.

The initial work was, therefore, purely empirical. To determine which material, when carbonized, would give the maximum porosity, the research laboratory of the National Carbon Company by midnight April 28, was making carbonization experiments on materials ranging from burlap to puffed rice. Apparently charcoal derived from cedar wood gave the highest absorptive value against chlorine, chlorine at that time being the only gas against which protection was desired. A carbonization schedule was quickly evolved by which a charcoal derived from cedar could be produced which was an effective absorbent for chlorine gas. This schedule consisted essentially of distilling cedar on a temperature schedule of 10° per hr. to 850° C., a straight distillation, or "one process" procedure.

Within three weeks after experimentation was begun, the furnaces of the National Carbon Company at Cleveland were turning out cedar charcoal using the above schedule. Fifteen tons of this material were produced and filled into masks, but these masks were used only for training purposes. There was now reason to believe that chlorpicrin and phosgene would soon come into use as gas warfare weapons. The form of charcoal developed, while effective against chlorine, was found not to be effective against either chlorpicrin or phosgene. It was obvious that a more active absorbent must be developed, and developed quickly.

AIR ACTIVATION PROCEDURE—A definite hypothesis guided the new development work. This hypothesis was that the absorptive value of a given charcoal would not only depend upon the surface area exposed but upon the freedom of this surface from impurities. The most common and persistent impurities in ordinary charcoals are the complex and stable hydrocarbons that during the carbonization have condensed in the pores or formed molecular films over the surface of the pure carbon. The details of the development of this "hydrocarbon theory" will doubtless be published in the near future by those members of the National Carbon organization responsible for it.

As to that raw material which would give the most porous charcoal, distillation experiments by the National Lamp Works organization had shown that the activity of charcoal derived from different materials increased with the apparent density of the raw material. Of the fifty or more materials investigated, coconut hulls—the dense shell material immediately surrounding the meat of the coconut—had the highest density, and yielded the most active charcoal.

Figs. 3, 4 and 5 are microphotographs showing the relative structures of willow (one of the lightest woods), ironwood (one of the heaviest woods), and coconut, the activity of corresponding charcoals being in the ratio 1 : 3 : 9, respectively. The higher

activity of the material made from coconut may to some extent be attributed to the stone cell structure characterizing the raw coconut. This same type cell is also found in the various fruit pits later used as substitutes for coconut hulls. At this time the supply of coconut hulls seemed sufficient to meet all demands, so it was decided to base all future work on coconut hulls as the raw material.

It had been observed by Dr. Lemon, of the University of Chicago, that the capacity of coconut charcoal for absorbing gases was increased by repeated absorption of air and subsequent evacuation, or "out-gassing" as Dr. Lemon termed it. By inference at least, the effect was supposed to be physical rather than chemical.

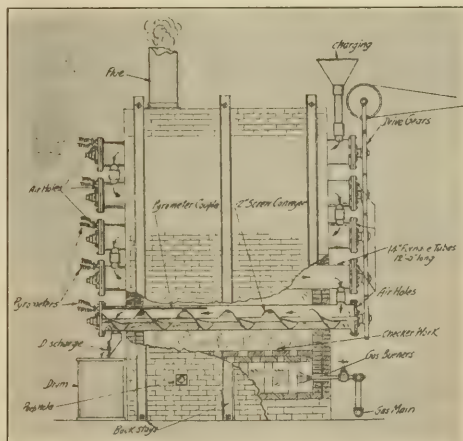


FIG. 6—UNIT FOR AIR-ACTIVATING CHARCOAL. SIX OF THESE UNITS WERE INSTALLED AT ASTORIA, L. I.

In the light of the hydrocarbon theory developed at the National Carbon Company, the above observation was properly interpreted to be the result of actual oxidation by air of hydrocarbon impurities, and complete investigation fully established this hypothesis. The air process of activating charcoal was thus developed which resulted in a charcoal of high absorptive power for such gases as chlorpicrin and phosgene. The procedure as evolved consisted essentially of

1—Initial distillation of cracked coconut hulls to a temperature of 850° C. to 900° C., and

2—"Air treating" this carbonized material, screened to 6 to

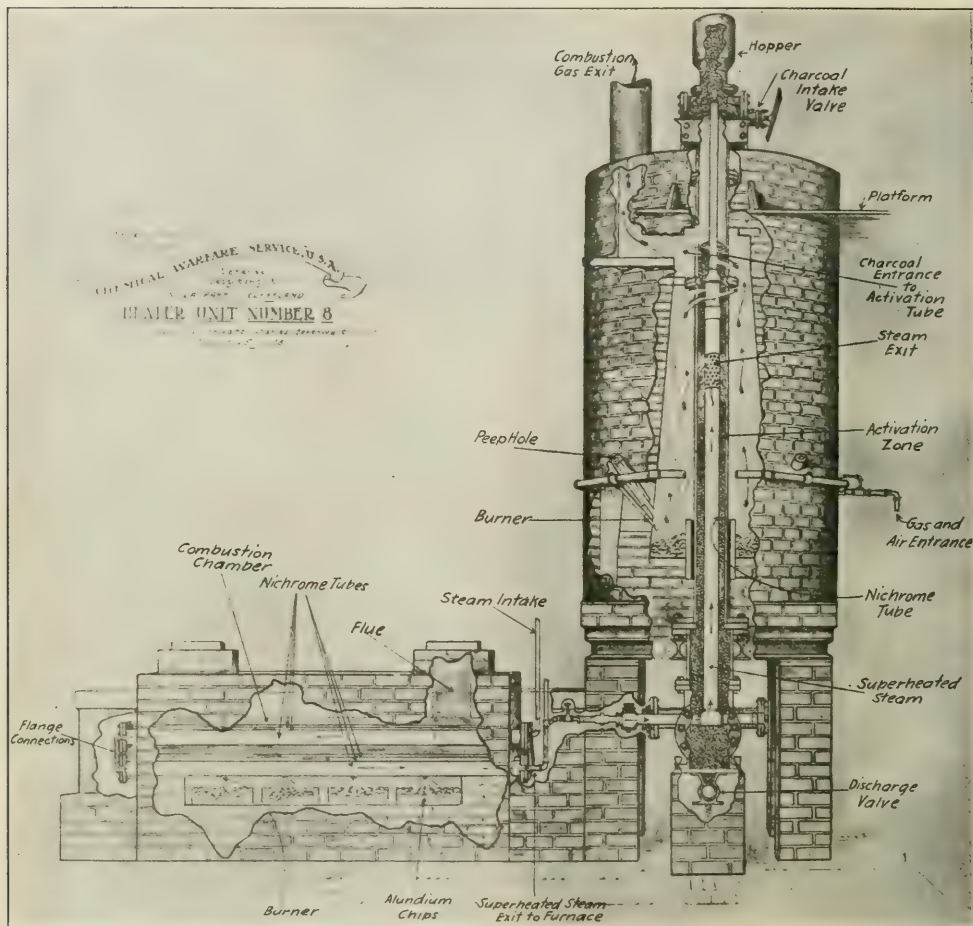


FIG. 7—DORSEY TREATER FOR ACTIVATING COCONUT CHARCOAL WITH STEAM

14 mesh, at 350° C. to 400° C., the time required depending upon the form of apparatus, depth of charcoal layer, stirring, etc.

This procedure was turned over to the National Lamp Works organization for large-scale development.

The commercial problem presented two distinct phases: (1) Initial distillation, and (2) Activation.

The first phase required but little investigation, due to past experience in the matter of wood carbonization. A few trials at the plant of the Erie Street Gas Works, Toledo, Ohio, demonstrated the type of apparatus satisfactory for the work, and the material so produced was found to respond readily to the subsequent air activation procedure.

The second phase, air activation, was first developed on a laboratory and semi-plant scale at the plant of the National Carbon Company. Large-scale apparatus was ordered for a continuation of this work at Nela Park, but the demands for charcoal for immediate use became acute, and this apparatus was sent to the plant of the Astoria Light, Heat and Power Company, Astoria, Long Island, where equipment for the com-

plete process was installed. This plant was first operated about September 1, 1917, and the first drum of active charcoal was shipped September 24. Operation of the Astoria air treaters was continuous until after the signing of the armistice. During the latter part of this period of operation, however, the air treater was mostly used to re-run material coming from the "steam activators" (later installed at the same plant) in an unsatisfactory condition. A full account of the operation of these treaters will appear in later issues of THIS JOURNAL.

In connection with the design of apparatus suitable for activating charcoal, it should be noted that the Bureau of Chemistry, under Dr. Hudson, conducted a similar but independent investigation. This investigation, though it never attained a full-scale production, gave results affording valuable assistance to the Nela Park organization.

STEAM ACTIVATION PROCEDURE—During the period July to November 1917, while the Nela organization was engaged in the installation of the air activation procedure at Astoria, the Na-

DEVELOPMENT DIVISION, CHEMICAL WARFARE SERVICE, UNITED STATES ARMY

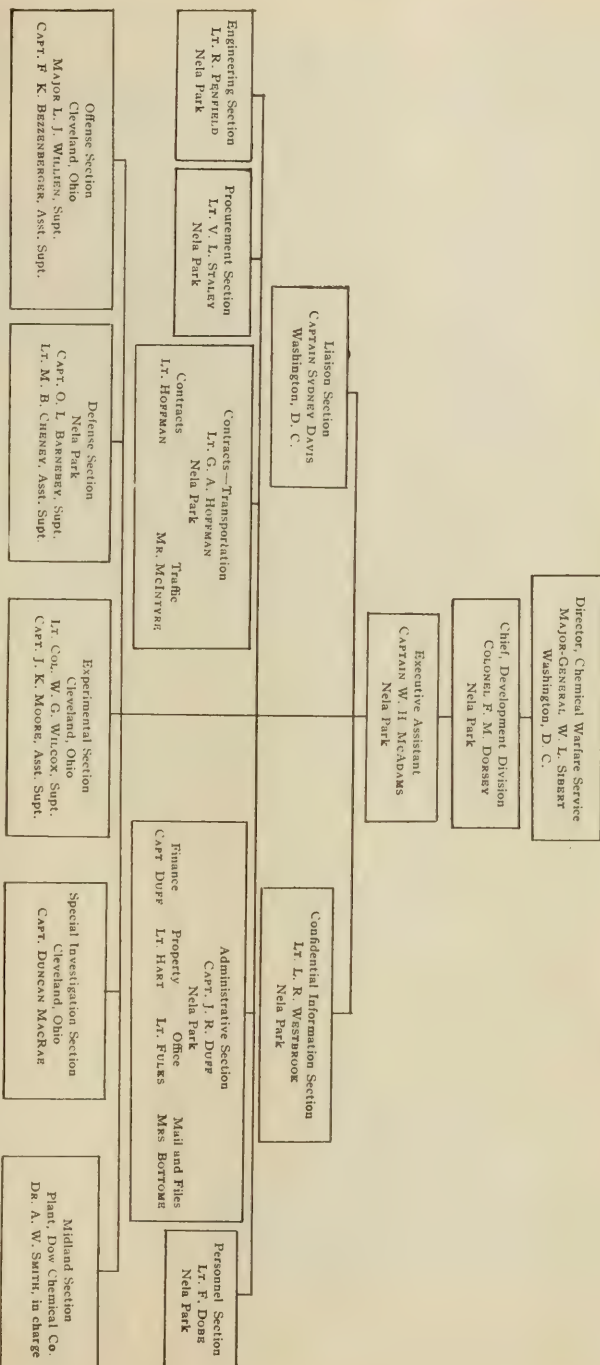
tional Carbon organization had directed the major portion of its efforts along a new line of development. The air activation procedure as developed was limited both as to production capacity and as to the degree of activity of product attainable without excessive combustion losses. Little improvement could be hoped for over the use of the dense coconut hulls as raw material, nor in variations in the carbonization schedule. It was felt, however, that the subsequent activation by air treating did not represent the most efficient possible activation procedure, and the National Carbon organization, therefore, undertook to develop a better one.

As previously noted, a series of experiments had proved conclusively that air activation was due to an oxidation, at the elevated temperature used, of the hydrocarbon impurities by the air. Of the numerous oxidizing media investigated, steam at a temperature above that for the water gas reaction (900° C.) apparently gave the maximum "selective" oxidation and the most active charcoal. Thus, by using superheated steam, not only was the free carbon surface purified of all hydrocarbon contamination but apparently a maximum of such surface was affected through a tunneling and fissuring of the charcoal particles, without the thin walls and fine structure being burned up as fast as formed. The steam activation procedure as recommended by the National Carbon Company organization consisted of exposing charcoal obtained by carbonizing coconut hulls to steam at a temperature ranging from 850° C. to 1000° C., until the requisite density reduction was obtained. The average time of treating was about one hour, using a steam-charcoal ratio of about one to one by weight. This procedure was turned over to the National Lamp Works organization for semi-large-scale development.

The problem now to be solved was a difficult one. For the sake of heat conduction it was essential to use a metallic installation. At the same time no furnace tube had as yet been developed with a demonstrated ability to withstand the conditions proposed. One large manufacturing concern, when approached on the subject, declared that the thing was impossible. The successful answer to this problem at Nela Park represents a real engineering feat.

By March 1 a vertical nichrome tube furnace had been developed, capable of producing by steam activation procedure a charcoal approximately twice as active as that obtained from the air treaters, with approximately equal loss in weight due to combustion. Coconut shell charcoal activated with steam was given the name "Dorsite."

At this time, the charcoal situation again became acute, due to the inability of



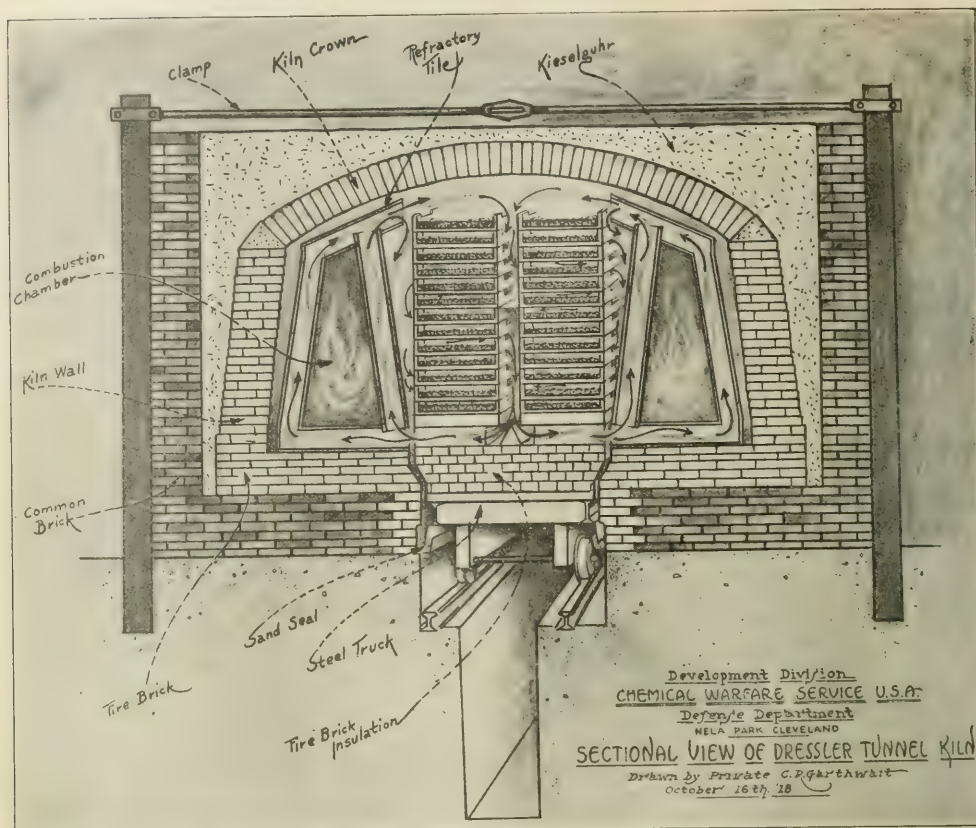


FIG. 8—SECTIONAL VIEW OF DRESSLER TUNNEL KILN ADAPTED TO ACTIVATION OF CHARCOAL

the air activators at Astoria to meet the immediate demands. Although neither the steam activating apparatus nor the operating procedure had yet reached the final development stage, it was thought inadvisable to await the development of a more perfect process.

Accordingly in the first week of March 1918, the Nela Park organization assisted in installing a battery of these steam activators at Astoria. The initial operation of these furnaces was likewise conducted with the assistance of members of this organization. Their later operation on a production basis was conducted by the Gas Defense Division. The investigation of this procedure was continued both in Cleveland and at Astoria and many improvements were made in the original installation and operating program.

CANISTER CHARCOAL SITUATION IN JUNE 1918

By June 1, 1918, the steam activators installed at Astoria, in spite of the natural initial operating difficulties, were beginning to swing on to a production basis. The production capacity of the combined air and steam treaters could not be expected to exceed 10 tons per day. The demand for active charcoal had now increased to 30 tons per day. A still more serious difficulty arose from the threatened shortage of coconut hulls. The maximum available supply of coconut was 100 tons per day. To produce 30 tons per day of Dorsite would require approximately 400 tons of hulls per day.

The situation thus demanded:

1—Increasing production capacity, either by increasing number of activating units or by developing a unit of larger individual capacity.

2—Developing a substitute for coconut hulls.

INCREASED PRODUCTION AND DEVELOPMENT OF DRESSLER TUNNEL KILN

To give immediate relief in the matter of production capacity, the original installation of steam activators at Astoria, consisting of 20 units, was increased to forty. An additional installation of 70 units was just being completed at the time of the signing of the armistice.

For various reasons, however, from the time the first steam activator was operated, it had been felt advisable to develop a new type of furnace. The capacity of the steam treater was small; the installation was costly; repairs were heavy; temperature control was difficult, necessitating that an average of 15 per cent of the product be re-run in the air activators to bring it up to the required activity; and a still considerable loss of material was incurred in the activation. Finally, these furnaces, originally designed to activate coconut hull charcoal, could not be used to activate the substitutes now being developed, such as Batchite and Carbonite. The problem of developing a new type of activator to overcome these difficulties was under-

taken by the several stations, and several important developments were quickly realized.

The experimental Wedge furnace (Mr. Utley Wedge, of Philadelphia), as operated at Nela Park, indicated that activation could be done in the presence of combustion gases. This point had always been considered bad practice in previous work on account of the English experience. In the early part of the war their work indicated that any attempt at activating charcoal in the presence of the combustion gases was dangerous on account of the fact that the charcoal absorbed large quantities of almost any kind of sulfurous gas, especially hydrogen sulfide. The fact that we were able to accomplish this point is probably due to the freedom of our natural gas from sulfur compounds and to the use of steam.

At Astoria, using an experimental externally fired horizontal furnace and introducing steam, it was shown conclusively that a fairly even heat distribution could be obtained. Whereas the vertical steam treaters were giving a mixture of high, medium and low-grade material due to irregular temperature conditions, in the rotary furnace it was found possible to have both steam and charcoal at the proper temperatures, the result being a fairly uniform product.

Experimental, internally fired, rotary furnaces, operated at Warren, Pa., and at Astoria, checked the results obtained at Cleveland with the experimental Wedge furnace, namely, that activation could be done in the presence of combustion gases.

These preliminary results were all incorporated in the adaptation of the Dressler tunnel kiln to the activation of carbon.

Before this adaptation could be made, an entirely new line of experimental study was found necessary, a study covering the diffusion of gases through layers of various kinds of carbon of different depths, rate of flow of gases over carbon of different specific gravities, differential oxidation of various kinds of carbon in different meshes and at various temperatures. The experimentation commenced in laboratory apparatus at Nela. The final large-scale installation was tested at the plant of the American Encaustic Tiling Company, Zanesville, Ohio, where a kiln suitable for the purposes was available. Although this type of furnace was not thoroughly developed until after November 11, the history of activated charcoal would be incomplete without a brief note of this particular phase.

DRESSLER TUNNEL KILN

The Dressler tunnel kiln is a type used in general ceramic work. The furnace consists essentially of a brick kiln about 190 ft. long, 12 ft. broad, and 9 ft. high, lined with fire brick. Charcoal is loaded in shallow, refractory trays in small tram cars, about 120 trays to the car. The cars enter the kiln through a double door and the charcoal remains in the hot zone at a temperature of about 850° C. for about 4 hrs., depending upon the nature of the material charged. Water is atomized into this kiln, and a positive pressure maintained in order to exclude entrance of air. The kiln is gas-fired and the charcoal is activated by the steam in the presence of the combustion gases.

Under such treatment the charcoal is given a high degree of activation without the usual accompanying high losses. Seemingly the oxidizing medium used, together with the operating conditions, produce a deep penetration of the charcoal particles without increasing the extensive surface combustion experienced in the steam activators. The capacity of such a type furnace is limited only by the size of the installation.

The advantages of this type furnace may be tabulated as follows:

- 1—High quality of product.
- 2—Small weight and volume losses
- 3—Large capacity per unit.
- 4—Minimum initial cost and maintenance of installation.
- 5—Simplicity and cheapness of operation.
- 6—Adaptability to activation of all carbon materials.
- 7—Availability of furnaces of this general type already constructed.

This type of equipment undoubtedly represents the best development of the charcoal furnace work, and, had the war continued, in all probability would have been placed in general use.

SUBSTITUTES FOR COCONUT HULLS AS RAW MATERIAL

(a) MIXED NUTS—When it became necessary to find a substitute for coconut hulls as a raw material in the production of activated charcoal, the Cleveland organization had at their disposal the results of the previous thorough investigation of raw materials which had led them to select coconut hulls as being the most suitable. These earlier experiments, made on the basis of air-activated material, were duplicated on the basis of steam-activated material. Again it had been found that with steam activation the activity of the charcoal produced from different materials in general increases with apparent density.

Various nut materials, such as cohune nuts, apricot pits, cherry pits, and vegetable ivory were found to give the most active charcoals, though these charcoals were inferior to that obtained from coconut hulls. In order to conserve coconut and at the same time retain the existing standard of activity, mixtures of charcoal from the various nut materials together with coconut charcoal were activated in the steam treaters at Astoria. The use of mixed nuts as a charge became the standard practice at Astoria, the resulting charcoal having an activity slightly inferior to that of the straight Dorsite depending upon the constituents of the mix.

(b) BATCHITE—As early as December 1917, the National Carbon Company organization had discovered that when high-grade anthracite coal, non-laminated and having conchoidal fracture, was subjected to direct steam oxidation, the coke so obtained had a very good activity. With the threatened shortage of coconut hulls, this new absorbent, or "Batchite," on the recommendation of Dr. Lewis, was developed by the National Carbon Company to a production basis. Difficulty was experienced in the plant operation, due to the occurrence of "gas treating." Anthracite coal has a high hydrocarbon content— $3\frac{1}{2}$ per cent. During the process of activation, unless unusual precautions are adopted, these hydrocarbons distil out, and in passing over coal in a hotter part of the furnace are "cracked" and deposit a layer of inactive graphitic carbon over the coal. Since the steam treaters had proved to be an unsatisfactory equipment for the production of Batchite, a coal-gas inclined retort was developed and operated under the supervision of Mr. Batchelor at the plant of the Tenney Corporation, Springfield, Mass. Following the success of the Springfield plant, steam bottom horizontal activators were installed and operated at Astoria.

DEVELOPMENT OF MUSTARD GAS

Offense Section

When the United States entered the war, the production of huge quantities of mustard gas became one of the principal objectives of those in charge of gas warfare problems.



FIG. 9—OFFENSE STATION, CLEVELAND, OHIO. PLANT USED IN THE DEVELOPMENT OF MUSTARD GAS

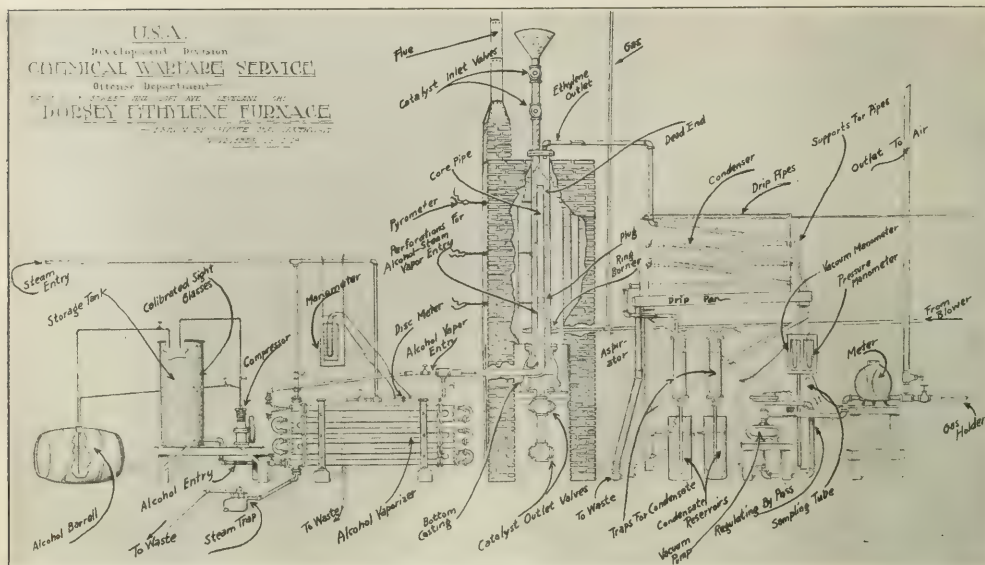


FIG. 10—EXPERIMENTAL INSTALLATION FOR THE PRODUCTION OF ETHYLENE BY KAOLIN PROCEDURE. CAPACITY 400-600 CU. FT. ETHYLENE PER HR.

Mustard gas, or dichlorethyl sulfide, when pure, is a water-white liquid boiling at 219°C . It was first prepared by the German chemist Victor Meyer in 1886, who recorded its peculiar toxic properties. However, dichlorethyl sulfide had been regarded solely as a chemical curiosity up to the time when it was used as a gas warfare weapon by the Germans at Ypres, July 20, 1917.

No one in the allied countries had ever attempted to produce the stuff in any quantity and on examination, the procedure used by Meyer, namely, the chlorhydrin procedure, proved to be very unsatisfactory for large-scale production. In addition, the development of a satisfactory generator for producing ethylene gas had proved to be a stumbling block. It was as late as February 1918 before Professor Pope in England reported the synthesis of this compound by the absorption of ethylene gas in sulfur monochloride. Strangely enough, the British cablegram anticipated by just two days the discovery of the same reaction at the American University in Washington.

The American University immediately put an entire laboratory on the problem and by the middle of March a procedure had been indicated on a laboratory scale for the manufacture of this material using sulfur monochloride and ethylene gas as the raw materials.

To develop this procedure, a small experimental plant was established in Cleveland, at East 131st Street and Taft Avenue. This plant soon became the center of mustard gas investigation on a laboratory and semi-large-scale basis in this country. No attempt was made in this plant to produce mustard in quantities beyond that required for experimental purposes, but the results obtained were immediately transmitted to the Edgewood Arsenal, the Hastings-on-Hudson plant, the National Aniline and Chemical Company plant at Buffalo, and the Dow Chemical Company at Midland, Mich., where mustard was to be made. During operation of the Cleveland plant, investigations were also begun on the development of superpalite and magnesium arsenide, but both of these investigations were stopped by the War De-

partment before final development stages were attained. When the armistice was signed, the entire plant was being turned over to the development of the production of another gas. The main result attained by the Offense Section, therefore, was the development of mustard gas.

The fundamental reaction involved in the production of mustard gas is that taking place between ethylene gas and sulfur monochloride. Sulfur monochloride was found available on the market in large quantities. The development problem, therefore, was concerned with

I—Commercial production of ethylene.

II—Suitable apparatus and plant procedure for absorption of this ethylene gas in sulfur monochloride.

III—Purification, if found necessary, of product.

I—PRODUCTION OF ETHYLENE

(a) KAOLIN PROCEDURE—It had been known for some time that in the presence of such a catalyst as kaolin, alcohol at elevated temperatures is dehydrated to give ethylene. A commercial-sized unit to produce ethylene was developed and operated within 24 days after the first occupation of the building. The process as finally evolved consisted essentially of introducing mixtures of alcohol vapor and steam, in the ratio of one to one by weight, into an 8 in. iron tube with a 3 in. core, in contact with clay at 500°C . to 600°C . The gaseous products were removed through a water-cooled surface condenser. The generator tube was provided with a double system of cock valves, by which the catalyst in the tube could be replaced in a semi-continuous fashion.

The introduction of steam along with the alcohol represents a distinct development accomplished by this laboratory, this steam rendering temperature control more uniform and accordingly giving a single unit greater capacity of a higher grade product. The tests on this unit were completed in the early part of May, the furnace having a demonstrated capacity of 400 cu. ft. per hr. of ethylene of between 92 and 95 per cent purity, with a conversion efficiency (alcohol to ethylene) of

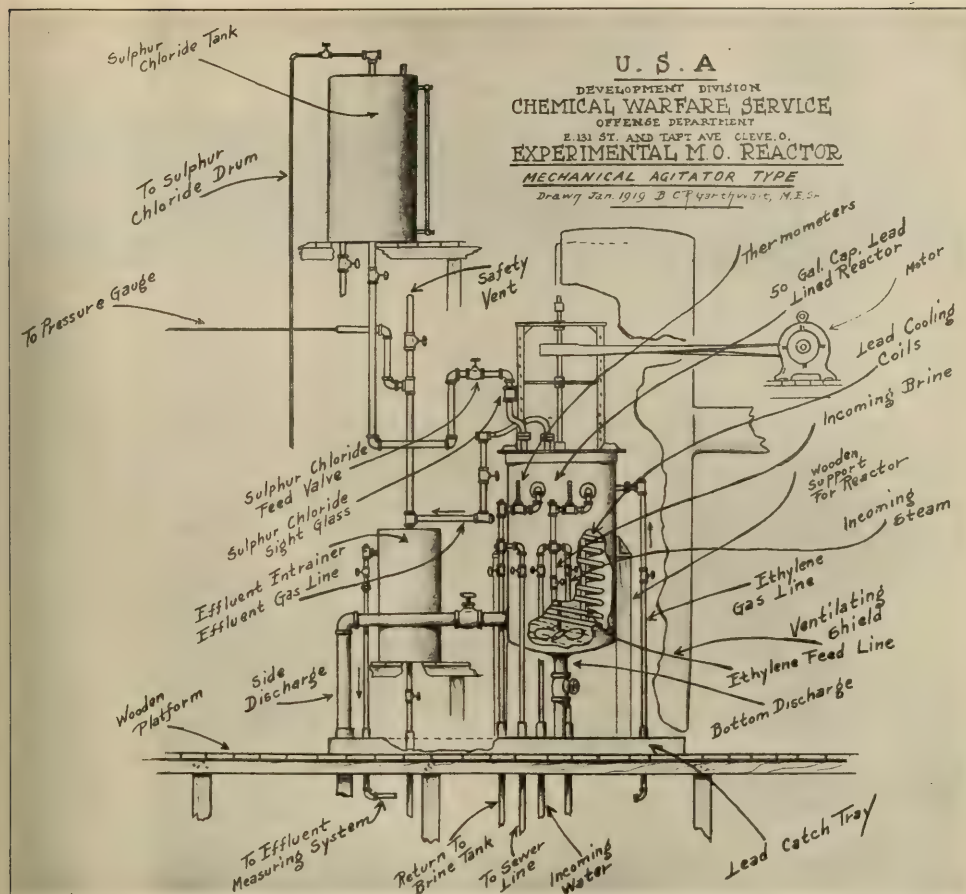


FIG. 11—EXPERIMENTAL APPARATUS FOR PRODUCING MUSTARD GAS BY 30° C. PROCEDURE. CAPACITY OF REACTOR, 250 LBS. PRODUCT

about 85 per cent. Forty units of this type, an installation capable of producing in 24 hrs. sufficient ethylene to make 40 tons of mustard, were assembled and sent to Edgewood, where they were operated successfully until after the signing of the armistice. As the prototype of the ethylene generators at Edgewood, the Cleveland unit, therefore, fully justified itself and no vertical kaolin generator has as yet been used on a commercial scale which has bettered the results obtained by this type of generator.

(b) PHOSPHORIC COKE PROCEDURE—In August, upon receipt of information from abroad concerning the British procedure for production of ethylene in which coke impregnated with phosphoric acid is used as the catalyst, investigation was started in Cleveland, the foreign directions being followed as closely as possible.

After numerous experiments a furnace was designed and built which was capable of giving 2000 cu. ft. per hr. of ethylene 98 to 99 per cent pure. Inasmuch as the kaolin type installation at Edgewood had proved satisfactory, no large-scale application of the phosphoric coke procedure for manufacturing ethylene was made at any of the American plants.

II—ABSORPTION OF ETHYLENE IN SULFUR MONOCHLORIDE

(a) 60° PROCEDURE—From the information obtained from the British and from the American University, together with the results of a further laboratory investigation in Cleveland, a satisfactory procedure was evolved on a laboratory scale. This procedure consisted essentially in introducing dry ethylene gas into sulfur monochloride until further absorption ceases. Rapid agitation of the liquid is essential, the reaction is exothermic, and the reaction temperature must be kept between 55° C. and 60° C. The rate of absorption was found to increase with the concentration of mustard produced. The reaction should produce one mole dichloroethyl sulfide plus one mole free sulfur per mole sulfur monochloride used. Under the above conditions about one-half of this sulfur reacted with the dichloroethyl sulfide to give polysulfides soluble in the mustard liquor. The remaining half of this sulfur, amounting to about 8 per cent by weight of the crude product, separated out on standing, or separated out immediately if the product were treated with moist ammonia gas. The clear supernatant liquor was to be sent to the shell-filling plants.



FIG. 12—EXPERIMENTAL PLANT, WILLOUGHBY, OHIO

This procedure was next put upon a semi-large-scale basis, and a mechanically agitated reactor of the standard nitrator type—capacity 75 lbs. of product—was successfully operated. A filtros plug reactor, designed at the American University and having a capacity of 350 lbs. of product, was also operated at this laboratory. As a result of these investigations, 4 one-ton reactors of the mechanically agitated type were designed, assembled, and sent to Edgewood where they were later operated by the Edgewood staff.

(b) 30° PROCEDURE (BRITISH)—In August, when the information was received from England concerning the production of mustard by the 30° C. procedure, the Edgewood plant immediately began installing the large-scale equipment as recommended by the British. In the meantime a thorough investigation was conducted in Cleveland on a laboratory and on a semi-plant scale. A satisfactory operating procedure was worked out in every detail, and the information, as fast as evolved, was transmitted to Edgewood.

The 30° process consists essentially in bringing together sulfur monochloride and very pure ethylene gas in the presence of crude mustard liquor as a solvent at a temperature ranging between 30° C. and 35° C. A supply of unchanged monochloride is constantly maintained in the reacting liquid until a sufficiently large batch is built up. Then the monochloride feed is discontinued and the ethylene feed continued until further absorption ceases.

The great advantage of this procedure lies in the complete sulfur "hold-up" obtained when the reaction takes place at 30° C. Apparently the sulfur remains in colloidal solution. By controlling the ratio of mustard to uncombined monochloride according to a predetermined schedule, the reaction velocity is so increased that the lower temperature may be used. The obvious disadvantage is the refrigeration required. The 30° procedure was being universally adopted when the armistice was signed.

III—PURIFICATION OF THE PRODUCT

Until the information came through on the 30° procedure, the 60° procedure had been accepted in this country as most suitable. The problem of sulfur precipitation was the greatest bar to its success from an operating point of view, also from the point of view of the shell-filling plants. In addition, it was desired to fill the shell with material as nearly 100 per cent dichlorethyl sulfide as possible. For these reasons, experiments were undertaken very shortly after the establishment of a successful absorber on the purification of the crude material. Here again the line of investigation was a duplication of laboratory procedure, in this case a vacuum distillation.

Preliminary experiments showed that in ordinary intermittent "pot" vacuum distillation, iron stills could not be used. It was found possible to use enamel-lined stills. The purity of the distillate from the enameled stills was 98 per cent, but a loss of 15 per cent of the mustard originally present in the crude was incurred,

due to the long period required for distillation. However, due to the sudden expansion of the mustard production program of this country, it became obvious that any purification installation to be satisfactory must necessarily possess a large capacity. In this respect flash stills have obvious advantage over ordinary type intermittent pot stills. Preliminary laboratory experiments had shown that mustard at 120° C. to 140° C. in contact with iron underwent little or no decomposition if this contact was not maintained for over 2 min. Acting on this information, an iron flash vacuum still for purifying mustard was designed and first operated at Midland. The final design was perfected at Cleveland.

The still consists essentially of a set of parallel steam-jacketed iron pipes 2 in. in diameter and 10 ft. long, inclined at an angle of 30° with the horizontal. Crude mustard flowing down this tube was vaporized, the vapors entered an upright steam-jacketed foaming chamber, and thence were drawn over into a condenser. The residue dropped from the bottom of the foaming chamber into a suitable container. The whole system was kept under an absolute pressure of about 1 in. of mercury.

The capacity of this still was demonstrated to be about one ton condensate per tube per 24 hrs., the condensate being 92 to 94 per cent mustard, and approximately a 5 per cent loss of the mustard in the original crude was suffered in the process.

Due to the development of the 30° or "Levinstein" procedure, where a product is obtained in which the sulfur is held in solution and accordingly presents little operating and shell-filling difficulties, the method of purification by the flash-still procedure was never put into practice at any of the large-scale plants.

MIDLAND SECTION

The work at the Dow Chemical Company, Midland, Mich., was mainly concerned with the design and construction of large-scale apparatus for the production of mustard gas, using the 60° C. procedure. By October 1 the equipment for an entire plant for the production of mustard by this procedure had been developed and operated successfully on a 5-ton unit plant scale.

The ethylene generator developed, known as the Morrison generator, used iron boxes 6½ ft. long and 5 ft. high, and 2½ in. wide as clay containers, these boxes arranged in a suitable furnace fired with oil burners. The capacity of such a generator was demonstrated to be 8000 cu. ft. ethylene per hr., of an average purity of 94 per cent, with alcohol to ethylene conversion of 92 per cent.

The absorber, known as the "Tumbling Barrel," consisted of a lead-lined steel shell 18 ft. long, 4½ ft. in diameter, rotating on hollow trunnions in a water bath. In order to produce a tumbling action of the liquid within the reactor, closely spaced longitudinal shelves were bolted against the inner lining. Ethylene gas entered through one trunnion, the effluent gas passing out through the other. This reactor had a demonstrated capacity of 10 tons of product per operating day. During the

course of the experimental work, 40 tons of mustard were produced at this plant, and shipped to Edgewood.

EXPERIMENTAL STATION

On August 1, 1918, the Development Division took over an idle manufacturing plant near Cleveland, Ohio, for the purpose of developing and manufacturing a poison gas. A personnel of 600 officers and men was rapidly assembled; barracks for 1000 men were put up. The work progressed with such rapidity that at the time of the signing of the armistice the plant was on a production basis.

DEVELOPMENT OF BOOSTER CASING AND GLASS-LINED SHELL

Special Investigations Section

BOOSTER CASING—On August 8, 1918, the problem of developing a booster casing and adapter for 75-mm. gas shell was undertaken by the Development Division at the request of the Director of the Chemical Warfare Service. This work was to be carried out independently of that in progress under the direction of the Ordnance Department.

Methods of manufacturing booster casings by die casting from an aluminum copper alloy and by machining in one piece from iron castings or bar stock steel were investigated. At the time of the signing of the armistice, a very promising die cast booster casing and adapter with a die cast lead jacket had been designed and tests on it partially completed. The chief advantage of this arrangement is the rapidity with which it can be produced.

However, the best solution to the booster question was believed to be to machine them in one piece from bar stock steel. An experimental production unit for the manufacture of these booster casings, as established at the plant of the U. S. Automatic Company, Amherst, Ohio, had a demonstrated capacity of 2000 per 24-hr. day.

GLASS-LINED SHELL—On August 17, 1918, the problem of duplicating the French process of lining gas shell with glass was assigned to the Special Investigations Section. Some experimental work on this problem had been carried out at the Corning Glass Works under the direction of the Research Division of the Chemical Warfare Service. It had been concluded from these experiments that a glass-lined shell, on account of its fragility, was inferior to an enameled or a lead-coated shell.

The experiments at the Corning Glass Works were continued under the direction of this section with the purpose of improving details of manufacture so as to produce a glass lining that would be more resistant to shock. A parallel series of experiments was begun at the National Lamp Works of the General Electric Company. More than 700 shell were lined at Corning and a lining developed that would withstand a drop of 15 in. on concrete floor. Out of 125 of these shell shipped to Cleveland, Ohio, from Corning, New York, a distance of 311 miles, only two linings cracked. The seal between the booster casing and the glass lining was so arranged that cracking of the glass would not result in leakage of the gas, but only in contact of the gas with the lining.

At the time of the signing of the armistice, production at the rate of 500 per day could have been attained on a week's notice.

DEVELOPMENT DIVISION
CHEMICAL WARFARE SERVICE
NELA PARK, CLEVELAND, OHIO

THE ORGANIZATION AND WORK OF HANLON FIELD

By JOEL H. HILDEBRAND
Received February 10, 1919

In view of the description from time to time in the pages of *THIS JOURNAL* of various phases of the work of the Chemical Warfare Service it will doubtless be of interest to include a brief description of the organization and work of Hanlon Field, where

the writer had the privilege of serving from the beginning of its experimental activity in June until the end of its work late in November 1918.

The two principal activities carried on at the Field were training and experimental work. The A. E. F. Gas Defense School was established there in June, being largely the result of the foresight of Lt. Col. G. N. Lewis, Chief of the Defense Division of the C. W. S., who appreciated the tremendous task involved in providing trained gas officers for our rapidly growing army. The success of the school was due to a great extent to the experience, skill, and devotion of Capt. W. A. Bush (of the Bush Chemical Co.) who, though an American, enlisted as a private in the Canadian army and had long and valuable experience in various capacities in the British army, including Division Gas Officer and Corps Chemical Adviser. Capt. Bush was virtually Director of the A. E. F. Gas Defense School, though he could not be officially appointed as such on account of not being an American officer at the time.

The school trained over 2000 officers in gas warfare during the period of hostilities, making thereby a contribution of incalculable value towards winning the war.

Later an offense course was added, intended primarily for officers entering the C. W. S. and destined for positions on the staffs of Division, Corps, and Army Gas Officers. This course was in charge of Capt. F. H. Scheetz, a chemist who was also an artilleryman.

The experimental work involved a wide variety of problems. Many of these were submitted by the First Gas Regiment, whose Commanding Officer, Col. E. J. Atkinson, was also for a period Commandant of Hanlon Field, so that very close relations existed between the work of the Field and the needs of the Regiment. The Engineer Officer of the Regiment, Capt. J. E. Mills (professor of chemistry at the University of North Carolina), furnished much valuable counsel in connection with this work, which included the making and correcting of range tables, the filling of large numbers of Livens drums with H. E. for use at the front, design and testing of various means of transporting gas-troop material, study of rapid means of projector emplacement, manufacture of light emergency base plates for Stokes mortars, and the formulation of problems for experiment and of specifications for equipment to be manufactured in the States.

Equipment of all sorts coming from the States was tested with a view to its performance and suitability under field conditions. The behavior of gases in the open was extensively studied in connection with tactical problems, and for the information of gas officers. A great deal of enemy material was examined and described, and the opening of enemy gas shell and the analysis of their contents was a routine operation.

Hanlon Field was situated within a few hours' run from all points of the American front, so that the constant visits of gas officers and officers of the First Gas Regiment to Hanlon Field, and the visits of the members of the Hanlon Field Staff to the front made possible an appreciation of actual conditions at the front invaluable in the work of the Field.

Sixty special reports emanating from the Hanlon Field Staff described work and presented conclusions and recommendations, many of which led to valuable results in the conduct of the war.

Since Hanlon Field represented a geographic extension of all of the activities of the Chemical Warfare Service, the Commandant of the Field was appointed by and was directly responsible to the Chief of the Chemical Warfare Service.

The table here reproduced shows the organization of Hanlon Field at the signing of the armistice, except for a few minor subsequent changes. Several well known chemists will be recognized among the members of the staff, together with names of younger chemists less well known, perhaps, but whose services were in most instances of a high order. It was often necessary

to use technically trained men temporarily for positions of an executive character, instead of for experimental work, which duties were always performed with a splendid spirit of devotion to the welfare of the Field as a whole. The sections on physiology and pathology include names of international reputation.

ORGANIZATION

COMMANDANT:	ADJUTANT:
Lt. Col. J. H. Hildebrand	Capt. G. P. Blakney
A. E. F. GAS DEFENSE SCHOOL: Capt. W. A. Bush, R. E. Capt. H. Anderson, R. E. Capt. I. J. Bowman 1st Lt. H. J. Nichols	
OFFENSE COURSE: Capt. F. H. Scheetz 1st Lt. J. O. Thoen 1st Lt. F. L. Firebaugh	
FIELD COMPANY: Capt. E. Patterson 2d Lt. D. L. Hough Mess and Billets: 2d Lt. G. J. Levy Range and Town Major: 1st Lt. E. B. Peck	
POST SURGEON: Capt. R. I. Dorge, M. C.	
SUPPLIES: 1st Lt. L. G. Eisele 1st Lt. B. G. Davidson	
EXPERIMENTAL WORK: Maj. E. M. Dunn Reports: Capt. T. D. Stewart Artillery: Capt. F. H. Scheetz 1st Lt. J. O. Thoen Chemistry: Capt. J. L. Crenshaw Capt. H. I. Cole Engineering: Capt. J. L. Alden 1st Lt. R. G. Bowman Field Gas Experiments: Capt. B. B. Freud Ordnance Laboratories: (Shell opening, shell filling, gaine filling) 1st Lt. Edwin Smith, Jr. Pathology: Maj. H. C. Clark, M. C. Maj. A. M. Pappenheimer, M. C. Maj. C. B. Farr, M. C. Capt. B. M. Vance, M. C. Physiology: Maj. A. N. Richards Cap. S. Goldschmidt Capt. D. W. Wilson	

The enlisted personnel required for all purposes numbered 250, and included a number of technically trained men assigned to the various sections. There were fifty-five major buildings, all constructed since April 1918, including barracks, mess halls, lecture auditorium, garage, machine shop, laboratories of chemistry, pathology, and physiology, animal shelter, stables, Y. M. C. A., warehouse, magazine huts, shell opening and filling plants, and gaine filling plant.

The field equipment included a plentiful supply of mortars, projectors, cylinders, 75 mm. and 155 mm. guns and ammunition.

There were two projector ranges and an artillery range provided with protected observation post, telephone line, and trenches.

In conclusion, it is desired to add a word of appreciation of the attitude towards experimental work of the Chief of the

Chemical Warfare Service, A. E. F., Brig. Gen. Amos A. Fries. General Fries is an experienced army engineer and acquired a remarkable grasp of the scientific problems connected with gas warfare. He showed himself very appreciative of the value of experimental work and exceedingly open to new ideas growing therefrom. He deserves a high place in the esteem of American chemists.

DEPARTMENT OF CHEMISTRY
UNIVERSITY OF CALIFORNIA
BERKELEY

CONTINUOUS VACUUM STILL FOR "MUSTARD GAS"¹

By ELFORD D. STREETER
Received January 24, 1919

The apparatus herein described was constructed for the continuous distillation of "mustard gas," or dichloroethylsulfide, $(CH_2ClCH_2)_2S$. As shown in the drawing, the apparatus is fitted up for a study of the process and the products obtained, rather than for plant operation. The work on this problem was left unfinished, because a change in the methods of manufacturing the crude mustard gas rendered this sort of a distillation unnecessary. This report is now being made as a matter of history, and with the hope that some features of this work may be of value in solving some peace-time problem.

The crude mustard gas with which we had to deal, contained, beside a large amount of sulfur and organic polysulfides that formed a tarry residue after distillation, considerable free hydrochloric acid, ether, and other low volatile substances that have not been identified. Mustard gas itself boils at $217^\circ C$. at atmospheric pressure, but with considerable decomposition. It may be distilled, under a high vacuum, but it is important to limit the time of exposure of a given portion of the liquid to the necessary high temperature, to the shortest possible time.

The construction and operation of the apparatus will be understood by reference to the drawing. The stock bottle for the crude mustard gas stood on a platform scale, to facilitate determining the rate of consumption. The rate of flow was regulated by a cock, and observed through a sight glass. The liquid then entered a pre-heating coil consisting of 50 ft. of $\frac{1}{2}$ -in. lead pipe, in a bath of hot oil. This oil was kept at a predetermined temperature by means of valves in the oil circulating system (not shown).

The hydrochloric acid and other low volatile substances vaporize in the coil, and in the earlier experiments made it impossible to secure a uniform flow. Therefore a gas separator was installed. This consisted of a cylinder 4 in. in diameter and 12 in. deep, surrounded by a jacket filled with hot oil. The liquid entered at the side, 3 in. above the bottom, and was withdrawn at the bottom. A gauge glass was provided to show the level of the liquid in the chamber. This level should be kept constant. The gas separated in the upper part of the chamber and was led off into the scrubbing and condensing system to be described later. A regular flow of liquid through the pre-heater was maintained by controlling the valve on

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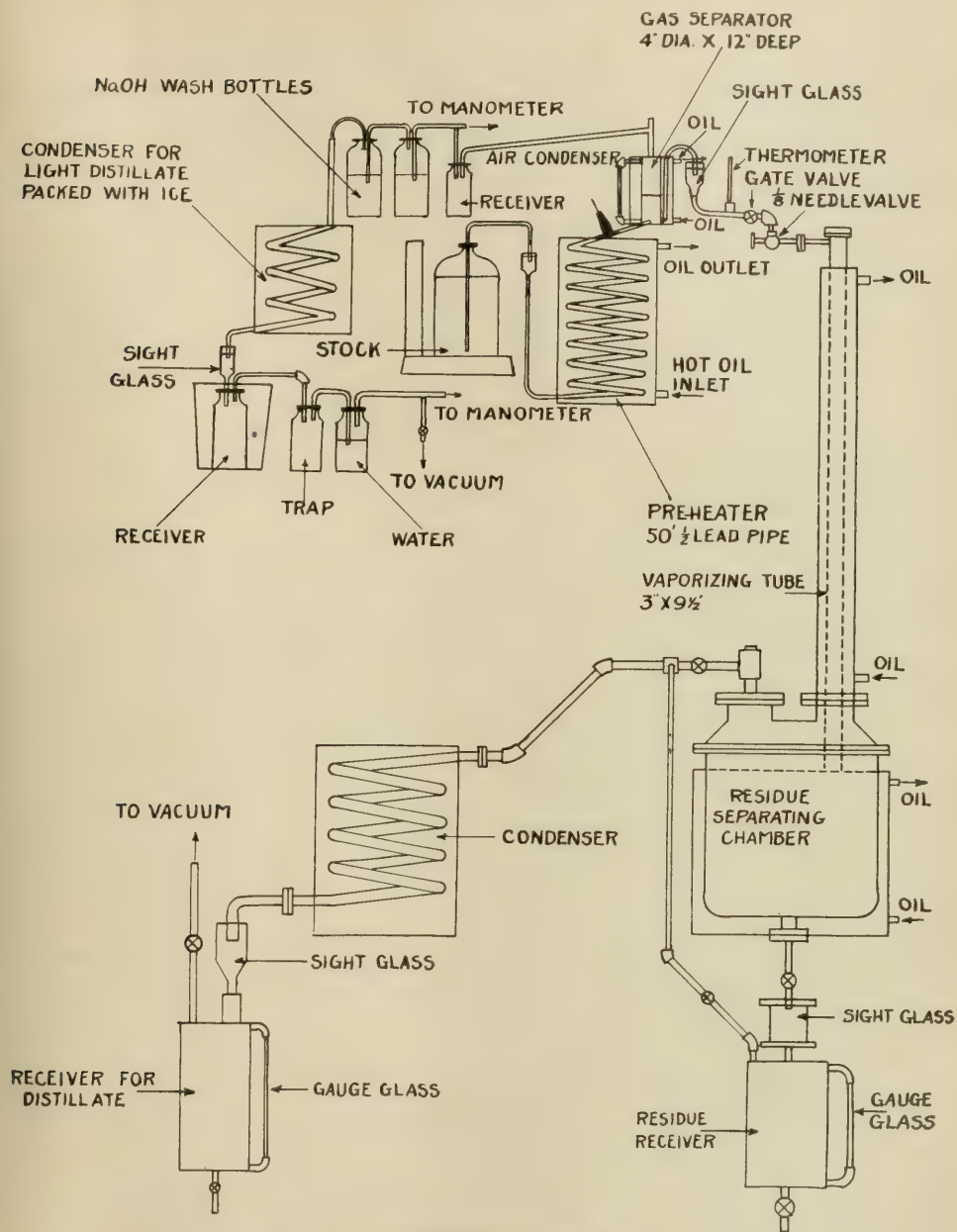


FIG. 1—CONTINUOUS STILL FOR MUSTARD GAS

the vacuum line beyond the scrubbing system so that the manometer on the gas separator registered 10 cm. of mercury vacuum. This might be made automatic.

The liquid was aspirated from the separator by the

vacuum in the still, flowing through a sight glass and two valves: the first a gate valve to control starting and stopping, and the second a needle valve to regulate the flow. It entered the vaporizing tube through a 3/8-in. lead

pipe bent to give a horizontal tangential discharge against the wall of the tube. This tube was a 3-in. iron pipe, 9½ ft. long, surrounded by a jacket through which hot oil was circulated. The liquid flowed as a thin film down the walls of this tube, and the vapors formed, together with the unevaporated residue, entered the large separating chamber below. This residue was continuously drawn off into the residue receiver while the vapor passed on to the condenser and was collected as a liquid in the distillate receiver. Both receivers were provided with sight glasses to observe the flow and gauge glasses to show the volume.

The operation of this apparatus proceeded very satisfactorily and though all runs were short, it could easily be made continuous by installing duplicate receivers and reservoirs for stock.

Several runs were made to determine the most satisfactory conditions of temperature and rate of feed. The best run gave results as follows:

Average temperatures:	
Bath of pre-heater and gas separator.....	150° C.
Bath around vaporizing tube.....	183° C.
Bath around residue separator.....	150° C.
Mustard gas entering vaporizing tube.....	147° C.
Mustard gas vapor entering condenser.....	136° C.
Average vacuum (absolute pressure), mm. mercury.....	60
Average rate of feed, lbs. per min.....	0.95
Average rate of condensation, lbs. per min.....	0.51
Per cent of charge as distillate.....	53.5
Purity of distillate (per cent mustard gas).....	92.5
Per cent of charge as residue.....	40.6
Purity of charge (per cent mustard gas).....	81.5
Per cent of original mustard gas remaining in residue (by difference).....	32.0

Other runs were made under different conditions, with the following conclusions:

- 1-Increasing the temperature at any point increased the decomposition, lowering the vacuum and lowering the yield.
- 2-Lowering the temperature at any point reduced the yield.
- 3-Increasing the rate of feed did not increase the rate of distillation, and reduced the per cent yield.
- 4-Reducing the rate of feed increased the per cent yield, but not proportionately, and reduced the rate of distillation.

It was attempted to reduce the rate of feed sufficiently to obtain a quantitative yield, but this failed; though the residue could be further concentrated by a second passage through the apparatus. It seems, therefore, that the time required for complete evaporation of the mustard gas from the film of liquid is longer than the time required for the tar to flow down the tube of given length. Accordingly, if the work had been continued on these lines, a tube of twice the length would have been built.

As stated above, there was found to be a considerable amount of material vaporized in the pre-heater and separated in the gas separator. This passed through an air condenser, the condensate being collected in a receiver and the gas continuing through two wash bottles containing 12 per cent sodium hydroxide solution, which absorbed the hydrochloric acid. The gas then entered a condenser packed with crushed ice, and the condensate was collected in a receiver surrounded with ice. The residual gas, which was insignificant after the system was cleared of air, was bubbled through water to indicate the amount. A

typical run gave results, expressed in per cent of original crude mustard gas, as follows:

Condensate, air condenser.....	1.8	Mostly HCl Smelled strongly of ether, but was decidedly heavier (0.81 sp. gr.)
Absorbed in alkali.....	2.3	
Light condensate.....	1.4	

If the temperature of the pre-heater was raised appreciably above 150° C., there was much more light material given off, and the liquid delivered to the still was lower in temperature, due to decomposition with absorption of heat. At lower temperatures nearly as much was given off. When material that had once passed through the pre-heater at 150° was again put through at that temperature, there was practically no further evolution of gas. This indicates that the amount first obtained originally existed in the crude material. It was desired to make a further examination of these impurities and of the decomposition products, but very little of this was done, on account of lack of time.

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AN AUTOMATIC COMPENSATING FLOW METER¹

By G. C. OBERFELL and R. P. MASE

Received January 4, 1919

The flow meter described in this article was intended primarily for accurately controlling the gas concentration of gas-air mixtures. By gas concentration is meant the amount of gas (either by weight or volume) per unit volume of gas-air mixture. The flow of the gas-air mixture is measured and kept constant at all times. Hence the matter of gas concentration resolves into the problem of maintaining a slow and very constant flow of the gas.

The principle of gas feed control, which is used in most laboratories, depends upon maintaining a constant gas pressure against a small capillary opening. The matter of maintaining a constant pressure in relation to atmospheric pressure is a comparatively simple one, since the use of a definite head of liquid through which a small amount of gas is permitted to waste, suffices to keep the gas pressure constant. However, it frequently happens that experiments require an arrangement of apparatus in which the outlet end of the capillary is not against atmospheric pressure but against a pressure somewhat higher. In such cases the pressure against the outlet of the capillary invariably fluctuates more or less. Hence the problem becomes that of maintaining a varying pressure on the inlet of the gas capillary such that the pressure difference between the inlet and outlet is always constant.

The apparatus evolved for this purpose is shown in the drawing. The apparatus as shown is in reality two such devices. The advantages to be gained by the double arrangement are: first, that the concentration of the gas in the gas-air mixture can be changed from one concentration to another almost instantly;

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and second, that the apparatus can be used in maintaining concentration of binary gas-air mixtures.

Referring to the accompanying drawing, *C* and *D* are leveling bottles of 3 qts. capacity. The height of liquid in these bottles determines the constant pressure difference on the inlet and outlet of the capillaries. *B* is a supply reservoir for *C* and *D*. *F* and *J* are glass tubes of about $\frac{5}{8}$ in. diameter. *G* and *H* are small glass tubes through which the excess gas escapes. These tubes reach nearly to the bottom of *C* and *D*. *X* and *Y* are the capillaries which admit the gas into the gas-air mixture line, at the mixing chamber *M*. *K* and *L* are three-way capillary stopcocks which direct the flow of gas through the capillaries *X* and *Y* and overflow tubes *G* and *H*. The line *W* is connected to the gas-air mixture line just ahead of the gas inlet by a glass "T." It passes through a bottle of charcoal, *O* and thence into the leveling bottles *C* and *D*.

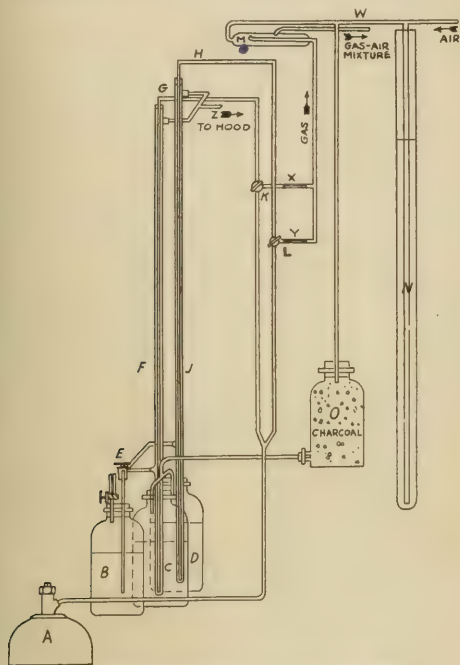


FIG. 1.—AN AUTOMATIC COMPENSATING FLOW METER

When the apparatus is in use, the pressure in the gas-air line is communicated to bottles *C* and *D*. This pressure forces the liquid in *C* and *D* up into tubes *F* and *J* until the height of liquid above the liquid levels in *C* and *D* counterbalances the pressure in the gas-air line. It is evident that any fluctuations encountered in the gas-air line, due to any apparatus which may be attached to it, are thus registered by the height of liquid in *F* and *J* above the liquid levels in *C* and *D*. This line pressure is the pressure which is against the outlets *X* and *Y* at all times. Consequently, the height of liquid in *F* and *J* above the levels of liquid

in *C* and *D* affords a measure of the pressure against the outlets of the capillaries of *X* and *Y*. The gas is permitted to flow slowly through the valve of cylinder *A* or other gas supply and is conducted by a glass line and "T" to the lower connections of stopcocks *K* and *L*. One of these stopcocks is set at a 45° angle (the one belonging to the capillary not in use) thereby shutting off the gas flow, and the other is so placed that the gas flow divides, part of it passing through capillary *X* or *Y* and the remainder through the overflow line *G* or *H*. The overflow gas bubbles out against the height of liquid in *F* or *J* above the level in *C* and *D* plus the height of liquid in *C* and *D*. As stated previously, the height of liquid *C* or *D* always counterbalances the pressure against the outlet of capillary *X* or *Y*. Hence the pressure difference on the inlet and outlet of capillary *X* or *Y* is always constant for all practical purposes and equal to the pressure afforded by the height of liquid in *C* or *D*.

The proper size for capillaries *X* and *Y* to give the required concentration must be determined experimentally. When one is found which is near the proper size the final adjustment is made by raising or lowering the level of the liquid in *C* or *D*. This is done by applying pressure or suction to reservoir *B* and turning the stopcock *E* so as to permit the liquid to flow in the proper direction.

The function of charcoal in the bottle *O* is to absorb any gas which might escape from the liquid in *C* or *D* and diffuse back into the gas-air line which leads to the board.

It is obvious that the pressure compensation afforded by this device is not absolute since a rise of level in tubes *F* and *J* is accompanied by a fall of level in bottles *C* and *D*. This fall is in proportion to the relative cross sections of the tubes *F* and *J* and bottles *C* and *D*. The cross section of the bottles should be at least 50 times and preferably 100 times the cross section of the tubes.

The apparatus as described was used in maintaining a 1 per cent concentration by volume of chlorine in an air mixture. Analysis was made by the iodine titration method. The device was found accurate over any one day within ± 0.5 per cent and required little adjustment from day to day. This serves as a good basis for judgment since the method of analysis is accurate. The device was also used in maintaining 0.1 per cent concentration by volume of another gas and was found to be absolutely satisfactory. The gas concentration was constant within the limit of error of analysis. With a gas supply of constant purity, adjustment of the level of liquid in the leveling bottle was not made oftener than once or twice a week. The limit of error of the method of analysis with this latter gas was about ± 2.50 per cent. However, it is the consensus of opinion that the variation of the 0.1 per cent concentration was much under this figure.

The apparatus described was developed for use in connection with gas mask absorbent testing boards. However, it is applicable to any work which requires an accurate regulation of gas concentration in gas mix-

tures or for control of rate of gas flow, as, for example, chlorination of natural gas and the determination of the heating value of gases.

Acknowledgment is made to the Gas Laboratory of the Pittsburgh Experiment Station of the Bureau of Mines for the pioneer work in applying flow meters to

measuring the rate of gas flow and the application of this principle to testing gas mask absorbents and gas masks.

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ORIGINAL PAPERS

THE GRAVIMETRIC AND VOLUMETRIC DETERMINATION OF MERCURY PRECIPITATED AS MERCURY ZINC THIOCYANATE¹

By GEORGE S. JAMIESON

Received July 22, 1918

The methods to be described are based upon the precipitation of the mercury from mercuric compounds in neutral or acid solutions with a reagent which contained 39 g. of ammonium thiocyanate and 29 g. of zinc sulfate per liter. The precipitate of mercury zinc thiocyanate was either weighed or titrated with a standard solution of potassium iodate in the presence of strong hydrochloric acid and an immiscible solvent such as chloroform in the same manner as recently described for the determination of zinc.² In order to get a quantitative precipitation of the mercury zinc thiocyanate there should not be more than 5 per cent of acid present in the solution before the addition of the precipitating reagent. Also it should be observed that in cases where larger quantities of acid are required for the solution of a substance the excess of acid should be neutralized with sodium hydroxide instead of ammonia because an excessive amount of ammonium salts exerts a solvent action upon the precipitate of the double thiocyanate. It was found that cobalt, copper, bismuth, and nickel were partially precipitated along with the mercury zinc thiocyanate, and consequently, if present, they would interfere with the determination of the mercury. The volumetric procedure has been applied to the determination of mercury in various kinds of antiseptic tablets and several other mercuric preparations with satisfactory results which are given below.

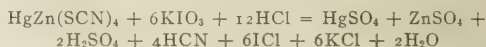
In order to test the gravimetric method several solutions of mercuric chloride were prepared and standardized by the well-known sulfide method. Measured volumes of these solutions were taken in perfectly clean, small beakers. Each solution was treated with 25 cc. of the reagent and diluted so that the final volume would be about 75 cc. The solutions were vibrated by striking the sides of the beakers with a stirring rod to facilitate the separation of the crystals. After the solutions had stood for about 5 min. they were briskly stirred with a glass rod, previously moistened with water, for about a minute. This treatment permitted the rod to be easily rinsed free from the precipitate so that it could be removed from the beaker. The solutions were allowed to stand an hour or longer before filtration. The precipitates were collected on Gooch crucibles and washed four or five times with a washing solution which contained 5 cc.

of the thiocyanate reagent and 450 cc. of water, on account of the solubility of the mercury zinc thiocyanate in pure water. The crucibles containing the precipitate were dried for an hour between 102° and 108° C. and weighed. The mercury was calculated by multiplying the weight of the precipitate by the factor 0.40258. The dried double thiocyanate has the composition $\text{HgZn}(\text{SCN})_4$. The following results were obtained:

No.	Hg Taken Gram	$\text{HgZn}(\text{SCN})_4$ Gram	Hg Calculated Gram	Error Gram
1.....	0.0402	0.1006	0.0405	+0.0003
2.....	0.1239	0.3082	0.1240	+0.0001
3.....	0.1328	0.3305	0.1327	-0.0001
4.....	0.1118	0.2783	0.1120	+0.0002
5.....	0.1451	0.3605	0.1451	0.0000
6.....	0.1209	0.3009	0.1211	+0.0002
7.....	0.1360	0.3385	0.1362	+0.0002
8.....	0.0907	0.2246	0.0904	-0.0003

In Analysis 8, the precipitate was allowed to stand for only half an hour instead of an hour or longer as recommended above. The test analyses show that satisfactory results can be obtained by this method.

In order to test the volumetric method for the determination of mercury when precipitated as the double thiocyanate, two solutions of potassium iodate were used. The first one which had been made for another purpose, contained 39.2882 g. of KIO_3 in 1000 cc., and the second one, specially prepared for this investigation, contained 19.2191 g. of KIO_3 in 1000 cc. According to the equation



the first solution will have 1 cc. equivalent to 0.006133 g. of Hg and the second solution will have the value 1 cc. = 0.00300 g. of Hg. Measured volumes of the standard mercuric chloride solutions mentioned above were precipitated and allowed to stand as previously described. The solutions were filtered on 7 cm. washed filters, using gentle suction. The precipitate adhering to the beaker was transferred to the filter by means of a small wash bottle containing 10 cc. of the thiocyanate reagent and 450 cc. of water. Then the filters were washed around the upper edge four times with small quantities of the washing solution. When the filters had drained, the suction was stopped. The filters were carefully removed from the funnels and were folded so that they could be placed in 8 oz. glass stoppered titration bottles. A thoroughly cooled mixture of 35 cc. of concentrated hydrochloric acid and 10 cc. of water along with 7 cc. of chloroform was added to one of the titration bottles containing mercury zinc thiocyanate, because it is best to titrate immediately after adding the acid to the precipitate. During the first part of the titration the potassium

¹ Published by permission of the Secretary of Agriculture.

² *J. Am. Chem. Soc.*, 40 (1918), 1036.

iodate is added rapidly while rotating the bottle in order to keep the contents mixed. When the iodine, which is liberated during the first stage of the reaction, has disappeared from the solution, the stopper is inserted and the contents of the bottle are thoroughly mixed by shaking for about half a minute. From this point the titration is continued slowly, shaking the closed bottle thoroughly after each addition of potassium iodate solution, until the iodine color has disappeared from the chloroform indicator which marks the end-point. If more than 60 cc. of the potassium iodate solution are required, 10 to 15 cc. more of concentrated hydrochloric acid are added before proceeding with the titration. The following results were obtained:

No.	Hg Taken Gram	KIO ₃ Required, Cc.	Hg Calculated Gram	Error Gram
1.....	0.1006	16.40	0.1006	+0.0000
2.....	0.0805	13.15	0.0806	+0.0001
3.....	0.0503	8.25	0.0506	+0.0003
4.....	0.0805	13.15	0.0806	+0.0001
5.....	0.0905	14.70	0.0902	-0.0003
6.....	0.0201	3.30	0.0202	+0.0001
7.....	0.0825	13.45	0.0825	0.0000
8.....	0.0945	15.40	0.0945	0.0000
9.....	0.0805	13.15	0.0806	+0.0001
10.....	0.1057	35.15	0.1053	-0.0002
11.....	0.1209	40.20	0.1206	-0.0003
12.....	0.0907	30.15	0.0905	-0.0002

Analyses 10 to 12 were made with the second potassium iodate solution mentioned above with 1 cc. = 0.00300 g. of Hg.

The test analyses show that the method gives satisfactory results providing that the directions given above are closely followed. This method was further tested by employing it for the determination of mercury in a sample of yellow mercuric oxide which had been analyzed by the sulfide method. Weighed portions of the oxide were dissolved in 2 cc. of 1 : 1 nitric acid and the resulting solutions were diluted with 35 to 40 cc. of water and precipitated in the usual manner. The following results were obtained:

No.	HgO Taken Gram	Cc. KIO ₃ Required	Hg Found Per cent	Hg by Sulfide Method Per cent
1.....	0.1828	56.40	92.56	92.56
2.....	0.2215	68.30	92.57	92.63

In applying the method to the analysis of antiseptic tablets, a sample was prepared by grinding a dozen of the tablets to a fine powder. The portions taken for analysis were dissolved in 35 to 40 cc. of water and three drops of hydrochloric acid were added before the mercury was precipitated. In the case of the mercuric cyanide tablets which contained borax it was necessary to add 1 cc. of hydrochloric acid. The following results were obtained:

PREPARATION	Sample Taken Gram	KIO ₃ Required Cc.	HgCl ₂ Found Per cent	Hg by Sulfide Method Per cent
HgCl ₂ , NH ₄ Cl.....	{ 0.2358	27.85	47.96	47.97
	{ 0.3623	42.80	47.97	48.00
Green HgCl ₂ , NH ₄ Cl.....	{ 0.3428	39.25	46.49	46.50
	{ 0.3313	37.95	46.51	46.44
Blue HgCl ₂ , citric acid.....	{ 0.2024	39.25	63.49	63.64
	{ 0.2551	39.95	63.59	63.51
Pink Hg(CN) ₂ , borax.....	{ 0.2137	20.15	35.62	35.67
	{ 0.3054	28.85	35.69	35.76

1 cc. of KIO₃ soln. = 0.003000 g. of Hg, 0.004060 g. of HgCl₂, or 0.003778 g. of Hg(CN)₂.

In the case of the green tablets, some of the dye was precipitated with the mercury zinc thiocyanate and consequently a light green color was imparted to the

chloroform indicator. However, by watching the color change in the chloroform, the end-point of the titration was easily seen.

In order to dissolve basic mercuric salicylate it was found necessary to heat the portions taken for analysis with 2 to 3 cc. of 1 : 1 nitric acid in covered beakers. When all was in solution, 40 cc. of water were added and the mercury was precipitated as soon as the solution had cooled to room temperature.

No.	Sample Taken Gram	KIO ₃ Required Cc.	Hg Found Per cent	Hg by Sulfide Method Per cent
1.....	0.2040	38.30	56.32	56.31
2.....	0.2006	37.60	56.33	56.40
3.....	0.1876	35.15	56.21	

Ammoniated mercuric chloride (HgClNH₂) was best dissolved by treating the portions taken for analysis with 5 cc. of concentrated hydrochloric acid. The mixture was allowed to stand for about half an hour with frequent shaking; then it was diluted with 5 cc. of water and heated just long enough to dissolve all of the substance. Immediately 40 cc. of cold water were added, and when the solution was cold the mercury was precipitated as described above. The following results were obtained:

No.	Sample Taken Gram	KIO ₃ Required Cc.	Hg Found Per cent	Hg by Sulfide Method Per cent
1.....	0.1709	45.50	79.87	79.86
2.....	0.1896	50.50	79.91	79.86
3.....	0.1757	46.70	79.79	...

The tables of analyses given above show that the iodate method gives very satisfactory results when applied to the analysis of antiseptic preparations. However, it should be observed that in order to get satisfactory results, it is essential that the directions given above should be closely followed in every particular. Mercurous compounds can be titrated directly by the iodate method which has been previously described.¹

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COLORIMETRIC DETERMINATION OF ORGANIC SUBSTANCES

By H. HEIDENHAIN

Received August 26, 1918

Many years ago I published a method for the volumetric determination of organic substances² which was based on the observations that a mixture of a dilute solution of potassium bichromate and sulfuric acid in certain proportions could be boiled for a long time with hardly any decomposition of the chromic acid and that a large number of organic compounds could be oxidized by such mixture either quantitatively or nearly so. According to the quantity of the organic substance present the reaction produced solutions of different shades of color ranging from a pure green, indicating complete reduction of the chromic acid, to the pure orange of the undecomposed chromic acid with all shades of yellowish green and greenish yellow between these extremes.

It occurred to me that here was an opportunity to develop a colorimetric method for the determination

¹ *Am. J. Sci.*, **33** (1912), 349.

² *J. Am. Chem. Soc.*, **18** (1893), 71.

of organic substances. The only question was, how closely the eye could discern the different shades of these colors. I found that between the pure green and the pure orange ten intervals could be distinguished with certainty, fractions of these intervals, however, only with difficulty. Even with such limitations the method has its usefulness, and I have successfully employed it in different ways. I may cite a few instances from my experiences.

In a certain glucose plant the washing of the bone-black after its decolorizing power had been exhausted was controlled by testing the wash liquors for dextrose with Fehling's solution. The content of dextrose of these liquors being too little to permit titration, the tests were made with measured quantities of the liquors, the cuprous oxide was allowed to settle, and according to its apparent quantity the washing process was declared as "good," "fair," or "bad." I substituted for this rough test the colorimetric chromate test and expressed the results in tenths and hundredths of one per cent, which, of course, was much more definite. It had, besides, the advantage that all carbohydrates present were determined, while the Fehling test indicated the dextrose alone.

In the determination of glycerol, according to Hehner's method, it is essential that the excess of bichromate solution employed be somewhere near 12.5 cc. In order to attain this the approximate glycerol content of the sample must be known. In solutions such as soap lyes in which the concentration of the glycerol varies between wide limits and the presence of sodium hydroxide and sodium chloride prevents densimetric determination, it was in most cases a matter of hit or miss. Here the colorimetric method was very satisfactorily employed as a preliminary test, and it was remarkable how closely the results checked with those obtained with the Hehner method. In fact they were so satisfactory that the question as to whether the process of recovering the glycerin had been carried far enough could be answered by the results of the colorimetric test alone. This meant a considerable saving of time as far as the progress of the work in the factory was concerned, an additional advantage of no little importance.

An example showing how the analysis of a commercial article may be facilitated by the application of this simple test is given in the following: Baking powders are composed of bicarbonate of soda, cream of tartar, tartaric acid, the alums, acid phosphates, and starch in all kinds of combinations of these substances. To prove the absence or presence of tartrates or tartaric acid I digested a weighed quantity of the powder with 100 cc. of cold dilute sulfuric acid and submitted a part of the filtrate to the chromate process. The resulting color told me whether in planning the analysis of the powder I had to take into consideration either large quantities of tartrates, or possibly small quantities, or none at all.

Not long ago I analyzed a number of vinegars. The determination of alcohol was carried through according to the official method by taking the specific gravity of the distillates. In some of these distillates the

alcohol content was found to be less than 0.5 per cent by volume. Considering the effect of small errors in weighing on densimetric determinations of highly dilute solutions, the question arose whether in these cases the densimetric method could be relied upon. I checked my results by the colorimetric chromate method, which under prevailing conditions involved in all probability smaller proportional errors than the densimetric method.

Other instances could be cited, but those given will suffice as hints to the practical analyst how to employ the method.

The advantages of this method are partly the same as those of my volumetric chromate method. They lie in the fact that being an oxidimetric method it is applicable in the presence of many inorganic substances, and that due to the great reducing power of most organic compounds, but very small quantities of substance are required as may be seen from the table of oxidimetric equivalents given below. If a solution is too concentrated, dilution is easily made. The reverse process, however, takes time and is sometimes difficult. Therefore, methods which operate with small quantities are applicable in the greater number of cases. They naturally lend themselves for the determination of minute quantities as shown in two of the practical cases above described.

Other advantages are that the performance of this colorimetric test neither taxes the patience nor calls for extraordinary care. Indeed, the solution of the substance as well as the chromate solution and the sulfuric acid may be measured in graduated cylinders with sufficient accuracy for all the purposes for which the method is intended.

PREPARATION OF THE COLORIMETRIC STANDARDS

The oxidation of organic substances by chromic acid in presence of sulfuric acid is only complete, or nearly so, when an excess of the chromic acid is employed. As this excess imparts to the solution a yellowish tint, we would exclude the purer green tints from our scale of colors, if we always worked with an excess of the chromate. As it happens, the tints in which the green predominates are more easily discerned than those in which the orange predominates. In order not to lose this advantage and also to make the range of colors as wide as possible, I sacrificed the feature of the quantitative reaction in the preparation of the colorimetric standards, and based the scale of colors on purely empirical results. The color produced by equivalent quantities of the bichromate and a substance is called 100, the color produced by the same amount of bichromate and 90 per cent of the equivalent quantity of the substance is called 90, and so on to zero, the color of the pure undecomposed bichromate.

PROCEDURE—Prepare a $N/5$ $K_2Cr_2O_7$ solution by dissolving 9.8067 g. in 1000 cc. Further prepare a $N/5$ solution of the organic substance to be determined, calculating its quantity from the number of equivalents of oxygen required for the complete oxidation of the molecule. For instance, in the case

of dextrose, $C_6H_{12}O_6$, 12 atoms oxygen are required for complete oxidation. Therefore, $\frac{180}{12 \times 2 \times 5} = 1.5$ g. is the proper quantity to make 1000 cc. of a $N/5$ solution.

Select a number of glass-stoppered bottles of cylindrical shape and uniform diameter, and a capacity of about 100 cc. (4 oz. oil sample bottles answer fairly well. Rubber stoppers may be used if care is taken that, later, the contents of the bottles do not come in contact with them.) Put 80 cc. water into the bottles and see whether the water stands equally high in them. If satisfactory in this respect make a mark with the file to indicate the 80 cc. volume.

Select a 300 cc. flask with long and narrow neck and make a reflux condenser by bending a glass tube into the shape shown in sketch to fit the neck of the flask.

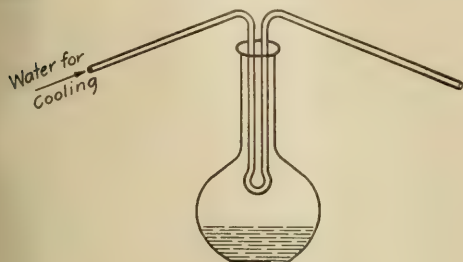


FIG. 1

Now transfer into the flask 25 cc. of the $N/5$ bichromate solution and 25 cc. of the $N/5$ solution of the substance, mix and add 30 cc. of conc. sulfuric acid in a small stream while the contents of the flask are rotated. By the addition of the acid the temperature of the liquid is raised close to the boiling point. Put the flask without delay under the reflux condenser, heat quickly to boiling, and keep at the boiling point for exactly 5 min., regulating the flame so that the liquid boils up from time to time. Cool and transfer the liquid to one of the cylindrical bottles. Fill to the 80 cc. mark with water, mix, and put a label on the neck of the bottle with the mark 100 as the first standard in the scale of colors.

Prepare the second standard by mixing 25 cc. $N/5$ bichromate solution with 22.5 cc. of the $N/5$ solution of the substance and 2.5 cc. water, adding 30 cc. sulfuric acid and proceeding further as described above. Mark this one 90.

TABLE I

$N/5$ $K_2Cr_2O_7$ Solution Cc.	$N/5$ Solution of Substance Cc.	Water Cc.	Sulfuric Acid Cc.	Color Indicates that Substance Is Present in Concentration of
25	25.0	0.0	30	100% of $N/5$
25	22.5	2.5	30	90% of $N/5$
25	20.0	5.0	30	80% of $N/5$
25	17.5	7.5	30	70% of $N/5$
25	15.0	10.0	30	60% of $N/5$
25	12.5	12.5	30	50% of $N/5$
25	10.0	15.0	30	40% of $N/5$
25	7.5	17.5	30	30% of $N/5$
25	5.0	20.0	30	20% of $N/5$
25	2.5	22.5	30	10% of $N/5$
25	0.0	25.0	30	0% of $N/5$

Prepare the other standards by always using 25 cc. $N/5$ bichromate solution and 30 cc. sulfuric acid, but

varying the volume of the $N/5$ solution of the substance and the water according to Table I.

The standards when prepared with substances which are completely or almost completely oxidized have been found to be stable for several months.

THE TEST

For the determination of the organic substance in a solution proceed as above described. Always use 25 cc. of the $N/5$ bichromate solution, 25 cc. of the solution of the substance, the concentration of which must not exceed that of a $N/5$ solution, and 30 cc. sulfuric acid. Cool the liquid after boiling to room temperature, as the color of the bichromate is affected by temperature, and bring the volume of the liquid up to 80 cc. before comparing it with the standards.

The oxidimetric equivalents of a few substances of common occurrence are given herewith.

TABLE II
1000 Cc. of a $N/5$
Soln. Contains

SUBSTANCE	Grams	Products of Oxidation
Dextrose.....	1.500	CO_2 , H_2O
Dextrin.....	1.350	CO_2 , H_2O
Maltose.....	1.425	CO_2 , H_2O
Tartaric acid.....	3.000	CO_2 , H_2O
Oralic acid.....	12.600	CO_2 , H_2O
Formic acid.....	4.600	CO_2 , H_2O
Glycerol.....	1.314	CO_2 , H_2O
Ethyl alcohol.....	2.300	$C_2H_4O_2$
Acetic acid is not oxidized		

The method may also be used for substances, the oxidation of which does not lead to definite products. However, whether or not permanent standards may be obtained with such substances is a matter of experimentation. For such cases I would recommend making comparisons with a set of permanent standards, the relative values of which are easily determined and tabulated for ready use.

Substances to be tested may be dissolved in alkalis, ammonia, sulfuric and acetic acids. Hydrochloric and nitric acids interfere with the test.

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THE ANALYSIS OF NATURAL GAS AND THE CALCULATION AND APPLICATION OF RESULTS

By R. P. ANDERSON

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The analysis of natural gas by the combustion method has been accorded considerable attention during the last few years, especially in those publications¹ of the Bureau of Mines that deal with natural gas problems. In brief, this method consists in passing a sample of natural gas slowly into oxygen in which an electrically heated platinum spiral is glowing, the calculations being made from an observation of the contraction in volume resulting from the combustion, and of the volume of carbon dioxide that is formed. For details of manipulation, the reader is referred to the publications just mentioned, it being desired here only to call attention to two slight modifications in apparatus which may be found useful.

AN INDICATOR FOR COMPLETE COMBUSTION—It is customary and usually necessary to maintain the

¹ In particular, Technical Paper 87, by Burrell and Jones, and Bulletin 42, by Burrell and Seibert.

platinum spiral at an elevated temperature for some time after the entire gas sample has been forced into the pipette in order that the combustion of the sample may be complete. The uncertainty that results from this procedure may be eliminated by a simple device which enables the operator to ascertain when no further contraction takes place. This device consists of a small glass tube fastened in a vertical position near the combustion pipette and connected by means of rubber tubing to a glass T placed in the rubber tube between the pipette and its leveling bulb. The upper end of the glass tube should extend to the highest point to which the leveling bulb is brought in making an analysis, in order that mercury may not be driven out of the opening at the top. After the entire gas sample has been passed into the oxygen, the stopcock on the leveling bulb is closed, or in the absence of a stopcock, a pinchcock may be employed on the rubber tubing between the glass T and the leveling bulb. Under these conditions contraction of the gases in the combustion pipette will cause the mercury to move downward in the small glass tube, and the stopcock or pinchcock should be opened momentarily from time to time to avoid too large a reduction in pressure within the pipette. When no further movement of the mercury in the indicating device is to be noticed, it is evident that contraction has ceased and that combustion is as near complete¹ as may be gotten for the sample that is being analyzed under the procedure that is being employed. Aside from this new feature of the manipulation the stopcock between the pipette and leveling bulb is kept open and the combustion operation is carried out as though the device in question had not been added.

PYREX GLASS FOR COMBUSTION PIPETTES—The possibility of breakage of the combustion pipettes as a result of strain caused by the heated spiral inside, is almost completely obviated by the use of Pyrex glass² in their construction. This material has been used for combustion pipettes, both of the form used in the Hempel apparatus and that in the apparatus employed by the Bureau of Mines, over a considerable period of time, and has proved unqualifiedly successful.

One important feature of the analysis of natural gas that usually receives too little attention is the accuracy of measurement of all gas volumes, and especially the volume after combustion. For convenience of presentation, discussion of this topic is postponed until the end of the section on calculation of results.

CALCULATION OF RESULTS

Natural gas usually contains more than two hydrocarbons of the paraffin series and the data obtained on combustion are not sufficient for the determination of the amount of each hydrocarbon present.³

¹ In this Journal, 9 (1917), 142, the author called attention to the difficulty in obtaining complete combustion of mixtures containing much gasoline vapor. Practically complete combustion should, however, be expected in the case of the ordinary natural gas where the gasoline content is small.

² Made by the Corning Glass Works, Corning, N. Y.

³ See Dennis, "Gas Analysis," p. 130, for proof of the statement that no more than two hydrocarbons of the same series can be determined by a single combustion.

METHOD OF EQUIVALENTS—The usual procedure has been to express the combustion results in terms of two hydrocarbons, thus obtaining a mixture equivalent, as regards combustion data, to the one actually burned. The hydrocarbons chosen are methane and ethane if the average number of carbon atoms per molecule of hydrocarbon lies between 1 and 2, ethane and propane if the average number of carbon atoms lies between 2 and 3, etc. In the case of methane, the formulas for the calculation of results are:

$$C_2H_6 = \frac{4CO_2 - 2T.C.}{3} \quad (1)$$

$$CH_4 = CO_2 - 2C_2H_6 \quad (2)$$

where C_2H_6 and CH_4 are used to represent the volumes of ethane and methane in the equivalent mixtures; T. C., the contraction resulting from the combustion of a sample of natural gas; and CO_2 , the carbon dioxide formed in the combustion. The volumes are reduced to percentages on the basis of the original sample and the percentage of nitrogen is obtained by difference. In the case of ethane and propane, using similar nomenclature, the formulas are:

$$C_2H_6 = 2T.C. - 2CO_2 \quad (3)$$

$$C_3H_8 = \frac{CO_2 - 2C_2H_6}{3} \quad (4)$$

This procedure is unsatisfactory and frequently misleads those not intimately familiar with the combustion method into thinking that the percentages apply to the natural gas itself rather than to an equivalent supposititious mixture of two paraffin hydrocarbons.

THE CORRECT METHOD—A more logical method of expressing combustion results in the case of natural gas is to state the average number of carbon atoms per molecule of paraffin hydrocarbon and the percentage of paraffin hydrocarbon in the natural gas, the percentage of nitrogen being obtained by difference as before. If n be used to represent the average number of carbon atoms per molecule of paraffin hydrocarbon, the formula from which this value may be computed is:

$$n^1 = \frac{3CO_2}{2T.C. - CO_2} \quad (5)$$

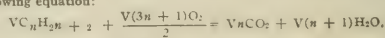
If V be used to represent the volume of paraffin hydrocarbon in the sample of natural gas, S the volume of the sample taken for combustion, and P the percentage of paraffin hydrocarbon in the natural gas, then

$$V = \frac{CO_2}{n} \quad (6)$$

and

$$P = \frac{100V}{S} = \frac{100CO_2}{Sn} \quad (7)$$

¹ Employing C_nH_{2n+2} as the formula of a mixture of paraffin hydrocarbons, the combustion of V cc. of this mixture takes place according to the following equation:



$$\text{from which } T.C. = \frac{V}{2}(3+n) \text{ and } CO_2 = Vn.$$

$$\text{Eliminating } V, n = \frac{3CO_2}{2T.C. - CO_2}.$$

TABLE I—CORRECTION FACTORS FOR DIFFERENT VALUES OF n AND DIFFERENT PERCENTAGES OF CARBON DIOXIDE IN GAS AFTER COMBUSTION

VALUE n	C_2H_6			CH_4			V			n		
	60% CO_2	80% CO_2	100% CO_2	60% CO_2	80% CO_2	100% CO_2	60% CO_2	80% CO_2	100% CO_2	60% CO_2	80% CO_2	100% CO_2
1.00	∞	∞	∞	0.991	0.988	0.985	0.997	0.996	0.995	1.0053	1.0074	1.0094
1.01	1.541	1.750	1.971	0.991	0.988	0.985	0.997	0.996	0.994	1.0053	1.0075	1.0097
1.05	1.114	1.156	1.198	0.990	0.987	0.984	0.996	0.995	0.994	1.0056	1.0077	1.0097
1.10	1.080	1.081	1.103	0.989	0.986	0.982	0.996	0.995	0.994	1.0057	1.0079	1.0100
1.15	1.041	1.056	1.071	0.988	0.984	0.980	0.996	0.995	0.994	1.0058	1.0080	1.0101
1.20	1.031	1.043	1.055	0.987	0.983	0.978	0.996	0.995	0.994	1.0059	1.0080	1.0103
1.30	1.020	1.029	1.037	0.985	0.979	0.974	0.995	0.994	0.993	1.0058	1.0080	1.0103
1.40	1.014	1.021	1.028	0.982	0.976	0.969	0.994	0.992	0.992	1.0055	1.0078	1.0102
1.50	1.010	1.015	1.021	0.979	0.970	0.962	0.994	0.993	0.991	1.0052	1.0075	1.0100
1.60	1.006	1.011	1.016	0.975	0.964	0.952	0.994	0.992	0.991	1.0048	1.0072	1.0097
1.70	1.003	1.008	1.012	0.969	0.953	0.937	0.993	0.991	0.990	1.0043	1.0068	1.0094
1.80	1.001	1.005	1.009	0.958	0.934	0.908	0.992	0.989	0.989	1.0039	1.0064	1.0091
1.85	0.999	1.003	1.007	0.948	0.915	0.879	0.992	0.990	0.988	1.0036	1.0062	1.0089
1.90	0.998	1.002	1.006	0.928	0.878	0.824	0.991	0.989	0.988	1.0034	1.0059	1.0087
1.95	0.997	1.001	1.004	0.869	0.769	0.658	0.991	0.989	0.987	1.0031	1.0057	1.0085
1.98	0.996	1.000	1.003	0.687	0.429	0.176	0.990	0.988	0.987	1.0031	1.0056	1.0083
2.00	0.996	0.999	1.003	∞	∞	∞	0.990	0.988	0.987	1.0029	1.0055	1.0083

If it be desired to compute the equivalent percentages of two hydrocarbons in addition to the values of n and P , then, for values of n between 1 and 2,

$$\text{per cent } CH_4 = P(2 - n) \quad (8)$$

$$\text{per cent } C_2H_6 = P(n - 1) \quad (9)$$

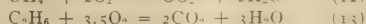
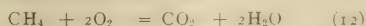
For values of n between 2 and 3,

$$\text{per cent } C_2H_6 = P(3 - n) \quad (10)$$

$$\text{per cent } C_2H_6 = P(n - 2), \text{ etc.} \quad (11)$$

CORRECTIONS—The equations which have been given so far are based upon the assumption that the gases under consideration, together with the oxygen used for combustion and the carbon dioxide formed on combustion, have equal molecular volumes. This is not the case and the importance of making corrections for these deviations has been pointed out by Wohl,¹ Dennis,² and Burrell and Seibert.³ Since the extent of the differences in the molecular volumes of the different gases depends upon their partial pressures, the correct combustion equations, and consequently any equations that may be derived from them, vary with the proportion of the various constituents in the sample and upon the percentage of carbon dioxide in the gas remaining after the combustion is completed.

Let it be assumed, for example, that a mixture of 20 per cent ethane and 80 per cent methane has been analyzed by the combustion method and that the carbon dioxide formed on combustion constitutes 80 per cent of the gas remaining after the combustion has been completed. The theoretical combustion equations of methane and ethane are:



and the equations derived from these which give the volumes of methane and ethane in the mixture in terms of carbon dioxide and contraction have already been given (Equations 1 and 2).

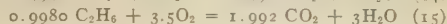
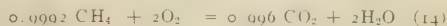
Taking 0.999, 0.990, 0.995, and 1.000 as the ratios of the actual molecular volumes to the theoretical molecular volumes of methane, ethane, carbon dioxide, and oxygen, respectively, and assuming that the ratios approach unity in proportion to the decrease in partial pressure from 760 mm. to zero,⁴ the actual combustion equations for this particular mixture become:

¹ Ber., 37 (1904), 429.

² "Gas Analysis," p. 139.

³ Bureau of Mines, Bulletin 42, pp. 80-85, Technical Paper 54.

⁴ Burrell and Seibert, Loc. cit.



From these equations it may be found that:

$$CO_2 = 0.0968 CH_4 + 1.0960 C_2H_6 \quad (16)$$

$$T. C. = 2.0048 CH_4 + 2.5110 C_2H_6 \quad (17)$$

Solving these equations for methane and ethane in the usual fashion, the following equations are obtained:

$$C_2H_6 = 1.3379 CO_2 - 0.6652 T. C. \quad (18)$$

$$CH_4 = 1.0032 CO_2 - 2.0024 C_2H_6 \quad (19)$$

To obviate the necessity of developing correct equations, either for methane and ethane, as just illustrated, or for the values of n , for each analysis of natural gas, the author has worked out correction factors for different values of n between 1 and 2 and for three different concentrations of carbon dioxide in the gas remaining after combustion. These factors are given in Table I.

The method employed was to work out three sets of equations¹ for the values of n given in the column on the left-hand side of the table, one set for 60 per cent of carbon dioxide in the gas remaining after combustion, one for 80 per cent of carbon dioxide, and one for 100 per cent. Numerical values were substituted in these equations and the correct values for ethane, methane, hydrocarbon volume, and n that were obtained were divided by the values from uncorrected equations to obtain the correction factors given in the table. The same results are presented in graphical form in Fig. 1. The numbers used to designate the different curves in the same group represent the percentages of carbon dioxide for which the curves apply.

TABLE II—CORRECTION FACTORS FOR n , "C" FACTORS
PERCENTAGE OF CARBON DIOXIDE

VALUE n	60	65	70	75	80	85	90	95
1.0.....	1.0053	1.0058	1.0063	1.0069	1.0074	1.0079	1.0084	1.0089
1.1.....	1.0057	1.0062	1.0068	1.0073	1.0079	1.0084	1.0090	1.0095
1.2.....	1.0059	1.0064	1.0069	1.0075	1.0080	1.0085	1.0091	1.0096
1.3.....	1.0058	1.0063	1.0069	1.0074	1.0080	1.0086	1.0092	1.0097
1.4.....	1.0055	1.0061	1.0066	1.0072	1.0078	1.0084	1.0090	1.0096
1.5.....	1.0052	1.0058	1.0063	1.0069	1.0075	1.0081	1.0087	1.0094
1.6.....	1.0048	1.0054	1.0060	1.0066	1.0072	1.0078	1.0084	1.0091
1.7.....	1.0043	1.0049	1.0055	1.0062	1.0068	1.0075	1.0081	1.0088
1.8.....	1.0039	1.0045	1.0051	1.0058	1.0064	1.0071	1.0077	1.0084
1.9.....	1.0034	1.0040	1.0046	1.0053	1.0059	1.0066	1.0073	1.0080
2.0.....	1.0029	1.0035	1.0042	1.0048	1.0055	1.0062	1.0069	1.0076

In employing correction factors of this sort to results obtained from theoretical formulas, at least two sets of factors are necessary. Those which have been

¹ The equations were developed as though the uncorrected values of n in question were correct. The error thus made is negligible.

chosen for practical use are the correction factors for n and for the hydrocarbon volume, these being given in slightly amplified form in Tables II and III, the additional values having been obtained by interpolation.

TABLE III—CORRECTION FACTORS FOR HYDROCARBON VOLUME.
"c" FACTORS

VALUE n	PERCENTAGE OF CARBON DIOXIDE							
	60	65	70	75	80	85	90	95
1.0.....	0.9967	0.9964	0.9962	0.9959	0.9956	0.9953	0.9951	0.9948
1.1.....	0.9963	0.9960	0.9958	0.9955	0.9952	0.9949	0.9947	0.9944
1.2.....	0.9959	0.9956	0.9954	0.9951	0.9948	0.9945	0.9942	0.9939
1.3.....	0.9954	0.9951	0.9949	0.9946	0.9943	0.9940	0.9936	0.9933
1.4.....	0.9949	0.9946	0.9943	0.9940	0.9937	0.9933	0.9930	0.9927
1.5.....	0.9943	0.9940	0.9936	0.9933	0.9930	0.9926	0.9923	0.9919
1.6.....	0.9936	0.9933	0.9929	0.9926	0.9922	0.9918	0.9914	0.9910
1.7.....	0.9928	0.9925	0.9921	0.9918	0.9914	0.9910	0.9905	0.9901
1.8.....	0.9920	0.9916	0.9912	0.9908	0.9905	0.9901	0.9896	0.9892
1.9.....	0.9911	0.9907	0.9903	0.9899	0.9895	0.9890	0.9886	0.9882
2.0.....	0.9901	0.9897	0.9893	0.9889	0.9885	0.9880	0.9876	0.9871

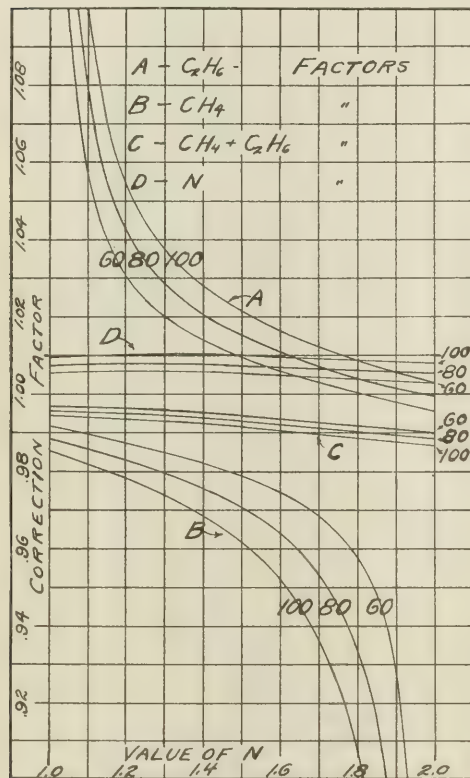


FIG. 1

The method of computing results and applying the corrections is as follows:

Compute the percentage of carbon dioxide in the gas remaining after combustion and then the value of n from the theoretical formula $\frac{3\text{CO}_2}{2\text{T.C.} - \text{CO}_2}$. Using these values, obtain from Tables II and III, by interpolation if necessary, the proper correction factors for n and the hydrocarbon volume, designated as c and c' factors. Employing the factors, and repre-

senting the volume of sample by S , the volume of hydrocarbon by V , and the percentage of hydrocarbon by P , the following equations give correct values. n_0 is used for the corrected value of n .

$$n_0 = nc \quad (20)$$

$$V = \frac{100}{n} c' \quad (21)$$

$$P = \frac{100V}{S} = \frac{100\text{CO}_2}{nS} c' \quad (22)$$

$$\text{per cent N}_2 = 100 - P \quad (23)$$

Also, if desired,

$$\text{per cent CH}_4 = P(2 - nc) \quad (24)$$

$$\text{per cent C}_2\text{H}_6 = P(nc - 1) \quad (25)$$

Except for the correction factors, these equations correspond to Equations 6 to 9 already given. The application of these equations to an actual experiment illustrates the method of calculation and the importance of the corrections.

Sample from Well 36, United Natural Gas Company, taken February 19, 1918:

EXPERIMENTAL DATA

Volume of sample employed for combustion	30.95 cc.
Volume of oxygen taken for combustion	98.00 cc.

TOTAL

Volume of gas after combustion	56.9 cc.
Total contraction	72.05 cc.
Volume of gas after absorption of carbon dioxide	6.2 cc.
Volume of carbon dioxide formed	50.7 cc.

CALCULATIONS

Percentage of carbon dioxide in gas after combustion. $\frac{50.7 \times 100}{56.9} = 89.1$

Value of n (uncorr.) = $\frac{3\text{CO}_2}{2\text{T.C.} - \text{CO}_2} = 1.628$, by Equation 5

Correction factor for n from Table II = $c = \dots\dots\dots 1.0082$

Correction factor for V from Table III = $c' = \dots\dots\dots 0.9913$

By Equation 20, $n_0 = nc = 1.628 \times 1.0082 = 1.641$

By Equation 21, $V = \frac{100}{n} c' = \frac{100}{1.628} \times 0.9913 = 30.87 \text{ cc.}$

By Equation 22, $P = \frac{100V}{S} = \frac{3087}{98.00} = 99.7$

By Equation 23, per cent $\text{N}_2 = 100 - P = 0.3$

By Equation 24, per cent $\text{CH}_4 = P(2 - nc) = 99.74 \times 0.359 = 35.8$

By Equation 25, per cent $\text{C}_2\text{H}_6 = P(nc - 1) = 99.74 \times 0.641 = 63.9$

UNCORRECTED VALUES FOR COMPARISON

$V = 31.14$ by Equation 6

$P = 100.6$ by Equation 7

Per cent $\text{N}_2 = -0.6$

Per cent $\text{CH}_4 = 37.4$ by Equation 8

Per cent $\text{C}_2\text{H}_6 = 63.2$ by Equation 9

The uncorrected values have been placed above for comparison with the corrected values. This particular analysis was chosen because the uncorrected hydrocarbon volume exceeds the volume of the sample. This will be the case with any sample of natural gas containing no nitrogen or only a small amount when the results are computed by the theoretical equations.

The objection may be raised to this method of computing results that correction factors applying strictly to mixtures of methane and ethane are here applied to such complex mixtures as natural gas. The error that results from this procedure is of unknown magnitude but it is, in all probability, considerably less than the error introduced by the use of the theoretical equations without correction.

NECESSITY FOR ACCURACY IN THE MEASUREMENT OF GAS VOLUMES—Assuming complete combustion of a sample of natural gas, and the introduction of proper

corrections in the computation of results from the theoretical formulas, the accuracy of the analysis depends upon the accuracy with which total contraction and carbon dioxide can be measured. Computations have been carried out to determine the effect of errors of 0.1 per cent in the amounts of contraction and carbon dioxide upon the final results for mixtures having different values of n . The errors in the final results thus introduced have been expressed as correction factors for n , V , and the volumes of methane and ethane in an equivalent mixture, and are shown in graphical form in Fig. 2, where the correction factors have been plotted against the value of n in the mixture. The errors resulting from the incorrect measurement of carbon dioxide (Curves A) have been plotted separately from those resulting from the incorrect measurement of total contraction (Curves B), except for n , where the errors from the two sources are practically equal.

The correction factors as shown in Fig. 2 apply for values of carbon dioxide 0.1 per cent too large and for values of contraction 0.1 per cent too small. If the values for carbon dioxide and contraction be made 0.1 per cent too small and too large, respectively, the correction factor will be modified accordingly, *i. e.*, a factor of 0.99 becomes 1.01 and *vice versa*. It will be noted that the two correction factors for V differ by 0.001 for any value of n and the same relationship holds true between the correction factors for CH_4 and C_2H_6 .

Four measurements of gas volumes are made during the course of a combustion. These are (1) the volume of oxygen taken, (2) the volume of sample, (3) the volume after combustion, and (4) the volume after absorption of carbon dioxide. From these readings, the contraction is obtained by subtracting the third from the sum of the first and second, and carbon dioxide is obtained by subtracting the fourth from the third. The relative importance of these readings as regards the effect of an error upon the accuracy of the final results may be illustrated by means of an example.

Let it be assumed that a gas sample of 30 cc. was burned with oxygen giving a contraction of 63 cc., and 36 cc. carbon dioxide. The theoretical value of n is thus 1.2 and no nitrogen is present. Let it be assumed further that all measurements are correct to 0.05 cc.

The first reading taken was of the volume of oxygen. A variation of 0.05 cc. here causes a variation of 0.05 cc. in the total contraction, constituting an error of 0.08 per cent. From Fig. 2 it may be found that an error of 0.1 per cent in contraction causes an error of 0.14 per cent in the hydrocarbon volume and in n . An error of 0.08 per cent in contraction will therefore affect both the hydrocarbon volume and n by $4/5 \times 0.14$, or 0.11 per cent.

A variation of 0.05 cc. in the volume of sample, which was next measured, affects the total contraction, and, independently, the percentage of hydrocarbon. The effect of the variation of 0.05 cc. in the total contraction is the same as before, causing an

error of 0.11 per cent in both the hydrocarbon volume and n . The variation of 0.05 cc. in the volume of the sample amounts to 0.17 per cent of this volume, and since the sample is assumed to consist entirely of hydrocarbons, their percentage in the sample is affected by 0.17 per cent. These two errors in the hydrocarbon percentage have opposite signs, so that the actual error is $0.17 - 0.11 = 0.06$ per cent.

The volume after combustion was the third reading taken. A variation of 0.05 cc. here causes a variation of 0.05 cc. in the total contraction in one direction and an equal variation in the other direction in the volume of carbon dioxide. The error in the total contraction amounts to 0.08 per cent, affecting as before both n and the hydrocarbon percentage by 0.11 per cent. The error in the carbon dioxide amounts

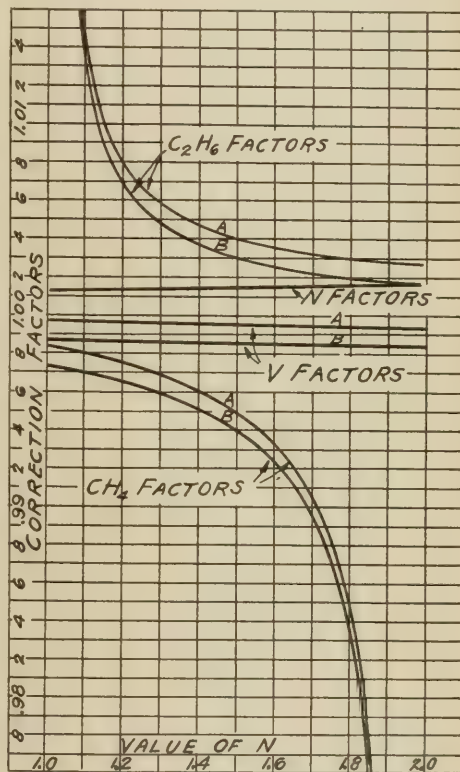


FIG. 2

to 0.14 per cent of its volume. From Fig. 2 it may be found that 0.1 per cent in the carbon dioxide causes an error of 0.04 per cent in the percentage of hydrocarbon and 0.14 per cent in n , and accordingly in the present case, the error will be 0.06 per cent in the hydrocarbon percentage and 0.20 in the value of n . The corrections have the same sign and the total effect of an error of 0.05 cc. in the volume after com-

bustion is an error of 0.17 per cent in the percentage of hydrocarbon and 0.31 per cent in the value of n .

The last reading taken was the volume after the absorption of carbon dioxide. A variation of 0.05 cc. here affects the volume of carbon dioxide, the variation amounting to 0.14 per cent of its volume, affecting the hydrocarbon percentage by 0.06 per cent and n by 0.2 per cent. These percentage errors are tabulated below, introducing the sign of the error:

		Percentage error in	
		n	V
Vol. Oxygen.....	0.05 cc. too large	-0.11	+0.11
Vol. Sample.....	0.05 cc. too large	-0.11	-0.06
Vol. after Combustion.....	0.05 cc. too large	+0.31	-0.17
Vol. after Absorption of CO ₂	0.05 cc. too large	-0.20	+0.06

These figures apply only to the example that was chosen, but they are useful in a general way in establishing the relative importance of the various measurements with regard to the errors in the final results, the volume after combustion being by far the most important of the four measurements.

If it happened that the maximum error of 0.05 cc. was made on each of the four measurements and in such a direction as to render the errors in n accumulative, the maximum possible error in n would be 0.73 per cent, the error in V amounting to 0.28 per cent and of opposite sign; if the errors in V were accumulative the maximum possible error would be 0.40 per cent, the error in n amounting to 0.51 per cent under these conditions and of opposite sign to the error in V .

APPLICATION OF RESULTS

CALCULATION OF SPECIFIC GRAVITY—The theoretical specific gravity of any gas mixture may be computed by multiplying the specific gravity of another gas by the ratio of the molecular weight of the first to that of the second gas. Thus for a mixture of paraffin hydrocarbons of formula C_nH_{2n+2} ,

Sp. gr. hydrocarbon mixture =

$$\begin{aligned} \text{Sp. gr. hydrogen} \times \frac{\text{Mol. wt. mixture}}{\text{Mol. wt. hydrogen}} \\ = \frac{0.06065(12n + 2.016n + 2.016)}{2.016} \\ = 0.4842n + 0.07^1 \end{aligned} \quad (26)$$

If the percentage of hydrocarbon in natural gas is represented by P , and the percentage of nitrogen by N_2 , the theoretical specific gravity of natural gas containing no carbon dioxide and oxygen will be given by

$$\frac{(0.4842n + 0.07)P + 0.068 N_2}{100} \quad (27)$$

If carbon dioxide and oxygen are present and their chemical formulas are employed to represent their percentages, the formula becomes

$$\frac{(0.4842n + 0.07)P + 0.068 N_2 + 1.520 CO_2 + 1.038 O_2}{100}$$

Lacking the necessary data for applying a correction to the theoretical specific gravity of natural gas to obtain the actual specific gravity, the corrections

¹ n is here used to represent the true average number of carbon atoms per molecule. This equation is equivalent to computing the specific gravity from the hypothetical mixture of methane and ethane, using their theoretical specific gravities.

for the equivalent mixture of methane and ethane may be applied as being a close approximation to the proper corrections. Table IV contains corrections computed from a knowledge of the observed and theoretical specific gravities of methane and ethane.¹

TABLE IV

VALUE n	Correction to Theoretical Specific Gravity
1.0.....	0.0005
1.1.....	0.0005
1.2.....	0.0008
1.3.....	0.0012
1.4.....	0.0020
1.5.....	0.0029
1.6.....	0.0042
1.7.....	0.0056
1.8.....	0.0073
1.9.....	0.0092
2.0.....	0.0114

The proper correction is chosen from the table and added to the theoretical specific gravity in order to obtain the actual specific gravity. It will be noted that for values of n below 1.3, the correction is so small as to be negligible for most purposes.

The combustion data give no information as to the amount of water vapor which the gas contains and the results are computed on the basis of dry gas. If the amount of water vapor in the gas has been determined, correction can easily be made for its effect upon the specific gravity. Since the specific gravity of water vapor is 0.6219, such a correction is usually negligible except for natural gas of high specific gravity. Table V contains the corrections to be employed for each per cent of water vapor in gas of different specific gravities between 0.6 and 1.0.

TABLE V

Specific Gravity of Dry Gas	Correction for 1 Per cent Water Vapor
0.60.....	+0.0002
0.65.....	-0.0003
0.70.....	-0.0008
0.75.....	-0.0013
0.80.....	-0.0018
0.85.....	-0.0023
0.90.....	-0.0028
0.95.....	-0.0033
1.00.....	-0.0038

The correction as shown in the table is multiplied by the percentage of water vapor in the gas and this product is added or subtracted, as the case may be, to the specific gravity of the dry gas. As in Table IV, it will be noted that for values of n below 1.3 (sp. gr. 0.7 when only paraffin hydrocarbons are present) the correction for water vapor is too small to be important for most purposes unless its percentage is unusually large.

The accuracy with which the specific gravity of natural gas may be computed from its analysis depends most largely upon the accuracy of the combustion results. If a gas be chosen which contains only paraffin hydrocarbons and where $n = 1.2$, the theoretical specific gravity is

$$0.4842 \times 1.2 + 0.07 = 0.651$$

If the experimental error of the analysis is such that n is 0.73 per cent too large and V 0.28 per cent too small (see discussion on necessity of accuracy in the measurement of gas volumes), the theoretical specific gravity as determined by computation is

¹ The theoretical specific gravities of methane and ethane were taken as 0.5539 and 1.0381, and the observed specific gravities as 0.5544 and 1.0495

$$(0.4842 \times 1.2 \times 1.0073 + 0.07) 0.9972 + 0.968 \times 0.0028 = 0.6562,$$

or 0.8 per cent higher than the correct theoretical value.

If the experimental error of the analysis is such that n is 0.51 per cent too large and V 0.40 per cent too small, the theoretical specific gravity as determined by computation becomes

$$(0.4842 \times 1.2 \times 1.0051 + 0.07) 0.996 + 0.968 \times 0.004 = 0.6552,$$

or 0.6 per cent higher than the correct theoretical value.

It has been found by experiment that, under proper working conditions, duplicate analyses of samples of natural gas usually give figures for specific gravity agreeing within 0.5 per cent, although occasionally wider variations are obtained.

CALCULATION OF HEATING VALUE—According to Thomsen,¹ methane has a heating value of 211,900 calories per gram-molecule, and ethane, 370,440 calories per gram-molecule. Using these values as a basis, the heating value of these two gases may be variously expressed as follows:

TABLE VI

GAS	Heating Value B. t. u. per Cu. Ft.		
	At 760 mm.	At 30 in.	At 60° F.
	dry	dry	moist
Methane, using theoretical wt. per liter (0.7166 g.)	1063.3	1008.5	991.2
Methane, using observed wt. per liter (0.7166 g.)	1064.2	1009.4	992.0
Ethane, using theoretical wt. per liter (1.342 g.)	1858.9	1763.2	1732.9
Ethane, using observed wt. per liter (1.3567 g.)	1879.3	1782.5	1751.9

The values of the middle column are obtained from those in the left-hand column by multiplying by the factor 0.9485, while those in the column on the right are obtained by using the factor 0.9322.

The theoretical heating value (*i. e.*, heating value employing theoretical weights per unit volume) of a mixture of methane and ethane, expressed in B. t. u. per cu. ft. at 60° F., 30 in. mercury, moist, may be expressed in terms of n as follows:

$$\text{B. t. u. per cu. ft.} = 9991(2 - n) + 1732.9(n - 1) \\ = 249.5 + 741.7n$$

This formula may be taken as representing very closely the heating value of a mixture of paraffin gases, and thus is applicable to natural gas containing only these gases. If non-combustible gases are present, the formula becomes:

$$\text{B. t. u. per cu. ft.} = (249.5 + 741.7n) P,$$

in which P represents the percentage of hydrocarbon in the natural gas.

Having no data for applying a correction to the theoretical heating value of natural gas to obtain the actual heating value, the corrections for the equivalent mixture of methane and ethane may be applied as being a close approximation to the proper corrections. Table VII contains corrections computed from the theoretical and observed weights per liter as given in Table VI.

TABLE VII

VALUE n	Correction to Theoretical Heating Value, B. t. u.
1.0.....	1
1.1.....	1
1.2.....	1
1.3.....	2
1.4.....	3
1.5.....	5
1.6.....	7
1.7.....	9
1.8.....	12
1.9.....	15
2.0.....	19

The proper correction is chosen from the table and added to the theoretical heating value at 60° F., 30 in., moist, to obtain the correct heating value. The correction is so small that it need not be considered for most natural gases.

CARD No.

NATURAL GAS ANALYSIS

Sample from.....
Taken..... Analyzed.....

ABSORPTION

Initial Sample.....cc.
Vol. after KOH.....cc. Per Cent CO₂.....
Vol. after Pyro.....cc. Per Cent O₂.....

COMBUSTION

Vol. O₂ for combn.....cc. Time, start.....
Vol. sample.....cc. Time, gas over.....
Total.....cc. Time, end.....

Vol. after combn.....cc. T. C.....cc.
Vol. after KOH.....cc. CO₂.....cc.
Percentage of CO₂ in gas after combn. =

$$n \text{ in } C_n H_{2n+2} = \frac{3CO_2}{2T.C. - CO_2} =$$

Corr. Factor for $n = c =$ Per Cent C₂H₆ =.....
 $P(n-1)$

Corr. Factor for $V = c' =$ Per Cent CH₄ =.....
 $n_0 = nc =$ $P(2-nc)$

Percentage of hydrocarbon = $\frac{100 CO_2}{n \text{ sample}}$ Per Cent N₂ =.....
 $100 - P$

SPECIFIC GRAVITY
of dry gas (air = 1)

1.520 X..... =..... (CO₂)
1.105 X..... =..... (O₂)
(0.484 n_0 + 0.07) X..... =..... (P)
0.968 X..... =..... (N₂)
Computed.....
Observed.....

HEATING VALUE

at 30 in. Hg, moist, and 60° F.
Heating Value = (249.5 + 741.7 n_0) P
" " "..... B. t. u.
per cu. ft.

Observed.....

Analyst

FIG. 3

The calculation of the results of natural gas analyses and their application in calculating specific gravity and heating value is greatly simplified by the use of a printed form such as is shown in Fig. 3. This form contains blank spaces for all of the data taken during the course of an analysis as well as all formulas and constants required in the calculation of results. When printed on a card of convenient size, *e. g.*, 4 in. X 6 in., the completed results can easily be filed for permanent record.

In certain cases, especially where the composition of the various natural gases being analyzed shows

¹ Landolt-Börnstein, "Physikalisch-chemische Tabellen," 3rd Ed., 1908, p. 416.

but little variation, it may be convenient to prepare curves to obviate the necessity of calculating specific gravities and heating values. For example, if the natural gas usually contains less than 2 per cent nitrogen, three curves might be drawn to show the relationship between specific gravity (or heating value as the case may be) and the value of n —one curve for zero per cent nitrogen, one for 1 per cent, and one for 2 per cent. In this way, if the proper scale be chosen, the specific gravity or heating value may be expeditiously and accurately obtained from the curves without calculations.

SUMMARY

1—Two modifications of the apparatus for the analysis of natural gas are described: one an indicator for complete combustion of the sample, and the other the substitution of Pyrex glass for the glass ordinarily employed in the combustion pipette.

2—The calculation of results of natural gas combustions according to the theoretical equations is discussed. A statement of the average number of carbon atoms per molecule of paraffin hydrocarbon and the percentage of paraffin hydrocarbon in the natural gas is recommended as being more logical than a statement of the percentages of two hydrocarbons forming a mixture equivalent, as regards combustion data, to the one actually burned.

3—Tables of correction factors have been prepared for use in correcting results obtained by the theoretical equations for differences in the molecular volumes of the gases considered. A simple method of applying these corrections has been worked out and illustrated.

4—The necessity for accuracy in the measurement of gas volumes is shown by means of various simple calculations.

5—The calculation of specific gravity and heating value is discussed from the point of view of the theoretical and actual values.

6—A printed form is suggested which may be found useful in recording and computing results.

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THE DETERMINATION OF TOTAL NITROGEN INCLUDING NITRIC NITROGEN

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INTRODUCTION

The development of methods of nitrogen determination suitable for the attack of soil biological problems has been the subject of extended study in this laboratory.¹ Soil biological investigations, approached from the physiological and biochemical viewpoint, require chemical methods of nitrogen determination of extreme accuracy and reliability, applicable to amounts of nitrogen ranging from 1 to 25 mg. contained in 250 cc. of soil extract or physiological solution. Naturally,

methods for the determination of total nitrogen, including nitric nitrogen, are required. This particular problem has been the subject of a very considerable amount of discussion and experimentation, especially among chemists concerned with the analysis of fertilizers. The somewhat extensive referee work by the Association of Official Agricultural Chemists has resulted in the more or less arbitrary adoption of certain methods which are designated as official. The fact that the methods have received such designation does not necessarily remove serious objections, but recognizes them as probably the most reliable of the existing methods for such determinations. Although the standards of accuracy have not been as high¹ as those in this laboratory, a satisfactory method has not been formulated. The existing uncertainty of the procedures in vogue is revealed, for instance, by recent callings² for a trustworthy method for the determination of total nitrogen including nitric nitrogen. It was imperative, therefore, that this problem be attacked with the aim of the development of a method capable of a high degree of accuracy.

HISTORICAL

It is neither necessary nor desirable to give a review of all the work dealing with the problem of determining total nitrogen including nitric nitrogen. The large amount of literature upon the subject, dealing as it does almost entirely with investigations whose aim was mediocre accuracy, shows that even as measured by such a standard the various methods have not as yet reached a point where they yield uniformly satisfactory results.

Two general types of procedure are employed for determining total nitrogen including nitric nitrogen. These two forms of nitrogen are determined together as ammonia by reducing the nitric nitrogen previous to the Kjeldahl digestions, or they are determined separately, in which case the nitric and ammonia nitrogen are leached from the sample and determined together after the reduction of the nitric nitrogen. The residue from the leaching is then Kjeldahlized for the remaining nitrogen. This latter type of procedure might be used where the organic nitrogen exists in the insoluble form but is frequently not applicable to biological studies.

Soon after the introduction of the Kjeldahl method it was observed that the nitrates were not completely converted to ammonia by the original procedure. Advantage was then taken of the fact that the quite readily formed nitrophenols were more easily reduced than the inorganic nitro compounds, and salicylic acid or phenol was added to the sulfuric acid sample to furnish conditions for the nitration of a phenol. The resulting nitrophenol was then reduced, with the aid of a reducing agent, to an aminophenol which was subsequently completely hydrolyzed in the boiling alkaline solution with the liberation of ammonia.

THE GUNNING-JODLBAUER MODIFICATION³ of the

¹ The general problem of refinement of nitrogen methods was outlined and begun by Dr. E. R. Allen, who has had general direction of the work and has assisted in the preparation of this manuscript. Papers which have appeared on this general project are: *This Journal*, 7 (1915), 521; *J. Am. Chem. Soc.*, 38 (1916), 1683; *This Journal*, 8 (1916), 896; *Ibid.*, 10 (1918), 600.

² With the exception of the work of Mitscherlich and associates.

³ Lipman, *Am. Fertilizer*, [11] 41 (1914), 33, Breckenridge, *This Journal*, 9 (1917), 1054.

⁴ Olsen, "Quantitative Chemical Analysis," 5th Ed., 1916, p. 288.

Kjeldahl method consists in treating the sample with 30 cc. of sulfuric acid containing 2 g. of salicylic acid, the solution being kept cool and shaken. Two grams of zinc dust are then added and after 2 hrs. the solution is heated gently at first and the digestion completed after the addition of 10 g. of potassium sulfate.

FORSTER'S MODIFICATION—Having failed to obtain complete recovery of the nitric nitrogen by the Gunning-Jodlbauer modification, Forster used sodium thiosulfate as the reducing agent. According to his recommendation¹ the sample is treated with a mixture of 30 cc. sulfuric acid, 1 g. salicylic acid, and 1 to 2 g. of sodium thiosulfate, and the solutions heated slowly at first and finally digested.

THE ULSCH MODIFICATION OF KJELDAHL'S METHOD² consists in the reduction of the nitric nitrogen by means of hydrogen evolved from the action of sulfuric acid (1.35 sp. gr.) and 2 to 3 g. of reduced iron. The sample is treated with the acid and iron, allowed to stand until the violence of the reaction ceases and then digested after adding potassium sulfate and more sulfuric acid. In the analysis of fertilizers the nitric nitrogen is usually leached from the sample and determined separately by the Ulsch reduction method. The residue is then Kjeldahlized for the organic nitrogen.

Winton³ used the Gunning-Jodlbauer modification and found that more consistent results were obtained when the mixture of acids and sample was allowed to stand 2 hrs. previous to the addition of the zinc dust. After the addition of the zinc dust, the mixture was heated slowly and digested for 2 hrs., and the digestion completed after adding 10 g. of potassium sulfate. Sherman⁴ compared Winton's procedure with the procedures where the solution stood only a short time before adding the zinc, and the use of sodium thiosulfate for reducing the nitrates. He concluded that Winton's modification gives better results than either of the other procedures. Sherman thinks the long digestion before adding the zinc is advisable, especially if much chloride is present, and that even then the method is hardly dependable.

Dugger and Davis⁵ employed Forster's modification for determining total nitrogen including nitric nitrogen in culture solution used in studying nitrogen fixation. They found that only by using 3 g. sodium thiosulfate and allowing 10 to 15 min. after apparent decomposition had taken place before digestion was completed, could complete recovery be obtained. It should be stated, however, that the official method calls⁶ for the use of 5 g. of sodium thiosulfate, which is even more than the amount employed by Dugger and Davis.

Schenke⁷ recommends the Ulsch-Kjeldahl method for determining total nitrogen. After reducing

the nitric nitrogen he uses sulfuric acid containing phosphorus pentoxide, some cupric oxide, and completes the digestion. He claims higher results are obtained by this method than by the use of phenol and zinc.

The report¹ upon the Ulsch method for reducing nitrates shows that the method tends to give low results in the hands of different chemists. Buhler and Fickendey² found that the method gives low results for nitric nitrogen when much soluble humus substance is present.

Mitscherlich and Herz,³ working in the field of soils and plant nutrition, found that none of the methods in vogue for determining nitric nitrogen would give reliable results. They were unable to obtain theoretical results by the use of phenolsulfonic acid and zinc dust, sodium hydroxide and zinc-iron dust, or by Jodlbauer's or Forster's method. Since they were unable to recover this deficiency by digesting the residues according to Kjeldahl for total nitrogen or by the use of larger amounts of reducing substances, they concluded that the loss was due to the evolution of gaseous nitrogen. They chose Devarda's procedure which effects the reduction in an alkaline solution by means of a zinc-copper-aluminum alloy, and as the result of a careful and extended study perfected a method⁴ for determining total nitrogen including nitric nitrogen. Their procedure is as follows:

A weighed amount of soil, 5 to 10 g., and 200 cc. of water, or a definite volume of nitrogen-containing solution (up to 800 cc.) are brought into a 1 liter Kjeldahl flask and 3 g. of Devarda's alloy added. The flask is closed with a 2-hole rubber stopper carrying a funnel and a still head terminating in a delivery tube which reaches to the bottom of a 500 cc. Kjeldahl flask containing 60 cc. of H_2SO_4 diluted with 20 cc. of water. The nitrate solution is made strongly alkaline by adding 50 cc. of concentrated sodium hydroxide, the funnel closed, the flask carefully heated, and the solution distilled as far as possible. The ammonia nitrogen from the sample and that from the reduction of the nitrates is absorbed by the strong acid. When the distillation is complete, the flame is removed and the acid allowed to suck back into the flask containing the alkali. The flask is again heated and the steam used to wash out the flask which contained the strong acid. The condensed water is allowed to suck back and the process repeated. The contents of the flask are then digested until the solution becomes clear and bluish green. All the nitrogen of the sample exists now as ammonium sulfate as in the regular Kjeldahl digestion. The melt is diluted with a definite volume of water and dissolved by careful warming. In determining total nitrogen of soils, only an aliquot is used for distillation in order that a small amount of the salt may be present in the distilling flask. The distillation is made by adding alkali and scrubbing the steam through water containing a pinch of magnesium oxide and one of magnesium sulfate before passing into the standard acid, no condenser being used.

Extremely accurate results were obtained. Indeed these workers concluded that as a result of their work it was possible to determine the total nitrogen in dilute solutions with an accuracy of ± 0.01 mg.

¹ Convention of Assoc. Official Agr. Chemists, *Bull.* 35 (1892), 73 and 88.

² *Landw. Vers.-Sta.*, 63 (1909), 239.

³ *Landw. Jahrb.*, 38 (1909), 279.

⁴ *Ibid.*, 38 (1909), 279, 533.

¹ Olsen, "Quantitative Chemical Analysis," 5th Ed., 1916, p. 288.

² *Z. anal. Chem.*, 30 (1891), 175-182, after Street in Division of Chemistry, U. S. Dept. of Agr., *Bull.* 35, p. 88.

³ *Conn. Agr. Expt. Sta.*, *Bull.* 112 (1892), 4.

⁴ *J. Am. Chem. Soc.*, 17 (1895), 567.

⁵ *Annals of Missouri Botanical Garden*, 3 (1916), 413.

⁶ U. S. Dept. of Agr., Bureau of Chemistry, *Bull.* 107 (1908), 8 (Revised).

⁷ *Chem. Ztg.*, 17 (1893).

Comparative results¹ on a garden soil showed this method to give results 10.4 per cent higher than the Kjeldahl-Jodlbauer, and 7.5 per cent higher than the Forster method. The authors attributed this to the fact that they could determine quantitatively the nitrate nitrogen, which was apparently not completely possible up to this time.

It has recently been shown in this laboratory² that the quantitative reduction of nitrates can be accomplished by the use of a small amount of Devarda's alloy in *N/10* alkaline solutions. One gram of alloy is sufficient to reduce 25 mg. of nitric nitrogen in 250 cc. of solution and the reduction is complete in 10 min. after the solution begins boiling. The method yielded results for nitric nitrogen essentially as accurate as those reported by Mitscherlich and Herz for total nitrogen including nitric nitrogen.

DISCUSSION

Although the Gunning-Jodlbauer and Forster modifications have long been in use for reducing the nitric nitrogen previous to the Kjeldahl digestion, there exists considerable disagreement as to the accuracy of the results obtained by these procedures. The methods do not give concordant results in the hands of different chemists, a fact which compels one to question their accuracy. The most probable sources of error are the loss of gaseous nitrogen and the lack of complete reduction of the nitric nitrogen. It is important that all the nitric nitrogen enter into the nitrophenol combination before reduction is made. The proper conditions for quantitative nitration of a phenol cannot be produced in dilute aqueous solutions and methods dependent on such a reaction are inherently liable to error when applied to these conditions.

As concerns the Ulsch method, it has been and still is widely used, yet more or less uncertainty exists as to the accuracy of the procedure. The method has been found to give unreliable results in the presence of any considerable amount of organic matter, a condition which is constantly encountered in biological studies.

The work in this laboratory on nitric nitrogen and the work of Mitscherlich and Herz on total nitrogen, including the nitric form, present an appreciably higher degree of accuracy than is characteristic of the other work mentioned above. The combination, therefore, of the features of the method of this laboratory for nitric nitrogen with those of the method of Mitscherlich and Herz for total nitrogen including nitrates appeared promising, and constitutes the main part of the work reported in this paper. A brief study of the Gunning-Jodlbauer, the Forster, and the Ulsch modifications of the Kjeldahl method was also included.

EXPERIMENTAL

DISTILLING APPARATUS³—The apparatus finally adopted more or less provisionally in this work con-

sists of a glass condenser made of Pyrex glass tubing and water cooled. The steam is scrubbed through a magnesium oxide solution previous to condensation, thus removing all danger of alkali being carried into the receiver. The receivers were 250 cc. Pyrex Erlenmeyer flasks. The condensers were cooled for 25 min. after distillation started and then drained and the distillation continued for 10 min. By using this procedure the volume of the receiving flask was kept below 150 cc.

STANDARD SOLUTIONS—The materials and methods of preparation are the same as those used in former work.¹

SOLUTIONS HIGH IN ORGANIC MATTER—These solutions were prepared from urea and asparagine and from a mixture of soil and manure extracts. The latter solution was treated with dextrose, and after becoming nitrate-free it was sterilized by a few drops of chloroform and preserved in a glass-stoppered bottle. These solutions were carefully standardized by a series of Kjeldahl determinations.

BLANK DETERMINATIONS—Many chemicals, especially sodium hydroxide and sulfuric acid, carry some nitrogen which necessitates the use of blanks in total nitrogen determinations. A large number of blanks were run upon the reagents and an average taken for the correction to be made. All data reported have had such corrections made where necessary.

KJELDAHL DIGESTIONS—Several procedures are in vogue for Kjeldahl digestions, and while it is apparent that reliable results are obtained by more than one procedure, it is equally apparent that the best procedure has not yet been established. In this work, 20 to 35 cc. of sulfuric acid, 0.5 g. cupric oxide and 5 g. of potassium sulfate were used and the digestions continued for about one hour after the solution became clear. Where Devarda's alloy was used, no additional copper was used.

GUNNING-JODLBAUER AND FORSTER MODIFICATIONS—The procedure followed in both cases was the same as that recommended as official. A pure solution of sodium nitrate was measured into a 500 cc. Kjeldahl flask and diluted to 200 cc.² In the case of the former modification, the sulfuric and salicylic acid mixture was added and the reduction made with 2 g. of zinc dust, and the digestion then carried out slowly until the solution became clear. In the case of the second modification, 5 g. of crystallized sodium thiosulfate were used together with 1 g. of salicylic acid and 30 cc. of sulfuric acid. The data are reported in Table I.

TABLE I

MODIFICATION	Gunning-Jodlbauer	Forster's
NITRIC NITROGEN TAKEN	13.70 mg. Found	13.70 mg. Found
	Mg.	Mg.
	10.02	9.60
	10.66	9.65
	10.25	9.98
	10.35	9.49
	10.43	9.89
	9.70	10.09
	10.35	10.04
	10.70	9.76
	10.62	9.50
		9.30
AVERAGE DEVIATION FROM ACTUAL VALUE	-3.12	-3.96

¹ This Journal, 10 (1918), 600.

² In the rather extended work which has been carried out in this laboratory on nitrogen methods numerous difficulties have been encountered with different distillation devices. The development of the proper type of distillation procedure and apparatus is a quite complicated matter and will be discussed in a later paper.

³ The solutions were made to a volume of 200 cc. because that volume of soil extract is generally employed.

¹ Landw. Jahrb., 33 (1909), 533.

² This Journal, 7 (1915), 521.

The figures reported here are representative of a great amount of data obtained with these two procedures. The errors are very high but a careful purification of chemicals and checking of conditions did not yield different results. Since theoretical results could not be obtained upon pure solutions with these methods, no experiments were conducted with solutions high in organic matter.

When sodium thiosulfate was used it was found that some nitrates were not reduced, but with zinc dust the nitrates had disappeared, as shown by qualitative tests. Since the nitric nitrogen could not be recovered by the Kjeldahl digestion there must have been a loss of gaseous nitrogen.

THE ULSCH MODIFICATION—The procedure recommended as official was used in studying this modification. The acid solution in which the reduction was made was about 1.35 sp. gr. in all cases. Three grams of iron, reduced by hydrogen, were used, and after standing 30 min. the solutions were heated to boiling for 5 min. Traps were used to prevent spattering. With pure solutions the method may give almost theoretical results, but with solutions containing organic matter the results are invariably lower than the theoretical. In the manure and soil extract with added nitric nitrogen the results are much lower than those where the urea and asparagine were used. The data in Table II suffice to show the behavior of the method. While the results reported for pure solution are quite satisfactory, many were obtained which were far from the theoretical value.

TABLE II—THE ULSCH MODIFICATION

SOLUTION USED.....	Pure Solution	Urea and Asparagine	Manure and Soil Extract
NITROGEN TAKEN { Organic nitrogen.....	17.82 mg.	17.81 mg.	2.18 mg.
{ Nitric nitrogen.....	17.82 mg.	10.96 mg.	10.96 mg.
{ Total nitrogen.....	17.92 mg.	28.47 mg.	13.14 mg.
	Found Mg.	Found Mg.	Found Mg.
	18.02	27.54	11.27
	17.88	28.22	9.98
	17.85	28.10	11.45
	17.87	27.52	9.79
	17.98	28.08	9.82
	17.92	28.50	...
	18.13	28.28	...
	17.97	27.31	...
	17.98	27.31	...
	17.90	28.22	...
AVERAGE DEVIATION FROM TRUE VALUE	± 0.07	± 0.57	± 2.65

THE DEVELOPMENT OF A NEW PROCEDURE

Since the above modifications gave little promise and since the combination of the method for nitric nitrogen developed in this laboratory with the Mitscherlich and Herz procedure appeared promising, this latter problem was next taken up. Reduction was therefore effected in $N/10$ alkali by means of 1 g. of Devarda's alloy instead of the 3 g. of alloy and strong alkali used by Mitscherlich and Herz. At the outset, however, the difficulty of incomplete absorption was encountered using an apparatus essentially the same as that employed by Mitscherlich and Herz. The considerable volume of hydrogen evolved before the solution boils sweeps out with it some ammonia and this ammonia is difficult to scrub from the mixture of air and hydrogen. An absorption tower readily overcame the difficulty, the hydrogen being completely scrubbed as it passed through the acid in the

tower. The apparatus used is shown in Fig. 1. The tower can be easily made in the laboratory or it can be made by dealers at very little cost. The tower should be about $1\frac{1}{4}$ to $1\frac{1}{2}$ in. in diameter and 14 in. long. A contains the nitrate solution, B is a 6 in. column of glass balls or broken glass rods about $\frac{1}{4}$ in. in length, and C is a small perforated plate which may be porcelain or made from rubber gasket material. The tower is easily washed after the reduction is complete.

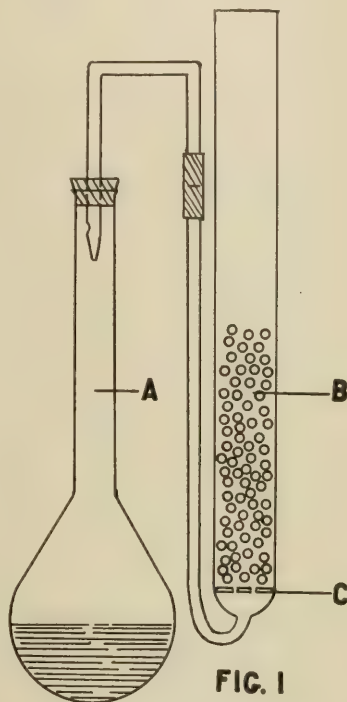


FIG. 1

Solutions high in organic matter show a tendency to foam when reduction is made in an alkaline solution. This trouble can be greatly overcome by using about 4 drops of ordinary lubricating oil, the oil being easily destroyed subsequently in the Kjeldahl digestion.

Using the apparatus as described and the procedure outlined below, several determinations were made upon organic solutions with added nitric nitrogen. Determinations were not made upon pure solutions of nitrates, since it had already been shown that nitrates can be completely reduced in $N/10$ NaOH with 1 g. of Devarda's alloy.¹ The results are found in Table III.

This method has given concordant and trustworthy results. It has been applied to an organic solution which must be considered abnormal and it is there-

¹ Loc. cit.

fore without doubt applicable to all conditions arising in biological studies.

TABLE III

SOLUTION USED.....	Urea and Asparagine Solutions		Soil and Manure Extract	
	Found Mg.	Found Mg.	Found Mg.	Found Mg.
NITROGEN TAKEN.....	Organic.....	17.51 mg.	2.18 mg.	2.18 mg.
	Nitric.....	10.96 mg.	10.96 mg.	3.12 mg.
	Total.....	28.47 mg.	13.14 mg.	5.30 mg.
	28.43	13.14	5.29	
	28.45	13.19	5.29	
	28.41	13.19	5.35	
	28.36	13.05	5.28	
	28.48	13.21	5.36	
	28.39	13.21	5.29	
	28.39	13.20	5.24	
	28.49	13.15	5.20	
	28.45	13.09	5.28	
	28.44	13.15	5.28	
Average.....	28.43	13.15	5.30	
Average deviation from true value.....	± 0.047	± 0.046	± 0.035	
Probable error.....	± 0.03	± 0.03	± 0.03	
Probable error expressed in per cent....	0.09	0.25	0.56	

Although the work of this laboratory is not concerned with the analysis of fertilizers, it was thought advisable to determine whether the method is applicable to such work. A fertilizer was prepared consisting of potassium sulfate, acid phosphate, with 2.55 per cent of nitrogen as dried blood and sodium nitrate. The sample used was 0.59 g. The analysis of this fertilizer is shown in Table IV and the results show that the method is applicable to such determinations.

TABLE IV—ANALYSIS OF FERTILIZER

Nitrogen taken in dried blood.....	12.22 mg.
Nitrogen taken in sodium nitrate.....	2.62 mg.
True value.....	14.84 mg.
Found Mg.	N in Sample Per cent
14.88	2.525
14.76	2.501
14.74	2.498
14.78	2.505
14.75	2.500
AVERAGE, 14.78	2.505

DISCUSSION

While the Gunning-Jodlbauer and Forster modifications may give acceptable results when the sample consists of solid material, the data reported in this paper show that these procedures are not reliable for studies in biology where large volumes of solutions must be employed. The nitrates in dilute solutions will not all be converted into nitrophenol upon the addition of the sulfuric acid and salicylic acid mixture, and therefore unsatisfactory results will be obtained.

The Ulsch method of reducing the nitric nitrogen must be considered as not altogether reliable. A serious objection to the method is making the reduction in a strongly acid solution by means of hydrogen evolved from a dissolving metal. There is danger of loss of gaseous nitrogen, and the formation of ferrous sulfate in the presence of nitrates is not desirable. The oxidation of some ferrous salts will certainly cause a loss of some nitrogen as nitric oxide. Furthermore, the results reported in this paper support the finding of Buhlert and Pickendey that the method does not give reliable results in the presence of organic matter.

The method proposed by Mitscherlich and Herz, while satisfactory from the standpoint of accuracy,

must be considered somewhat cumbersome in manipulation. The large amount of alkali used and the necessarily large amount of sulfuric acid, together with the 3 g. of alloy, produce such a large quantity of material in the flask that the digestion can be carried on only with the greatest difficulty. The new procedure, therefore, which accomplishes the reduction in dilute alkali and thereby reduces the amount of alloy from 3 g. to 1 g. and the amount of concentrated sulfuric acid from 60 cc. to 30 cc., avoids the large amounts of solid material so troublesome in the digestion. Moreover, the employment of the absorbing tower insures complete absorption of the ammonia evolved during reduction. The method in its present form is easy of manipulation and the time necessary for an analysis is much less than that required for the methods where salicylic acid is used.

PROCEDURE RECOMMENDED

In the absorbing tower are placed 35 cc. of sulfuric acid consisting of 4 parts of acid and 1 part of water. The solution, 200 cc. of soil extract, or if the solution is smaller in volume it should be diluted to at least 100 cc., is placed in a 500 cc. Kjeldahl flask and sufficient 50 per cent (the quantity of alkali to be used should be determined) sodium hydroxide added to make the solution N/10 in sodium hydroxide. To the solution are added 4 drops of oil and 1 g. of Devarda's alloy (60 mesh, made free from ammonia by heating to about 200° C. for 30 min.) and the flask connected with the tower. The solution is heated to boiling in minimum time and kept boiling gently for 20 min., during which time the acid in the tower just about reaches the boiling temperature. The flame is now removed and the acid allowed to suck back into the flask after which the solution is boiled for a few minutes and the flame removed. The tower is then washed with small quantities of distilled water and the water permitted to suck back into the flask. Four washings with about 25 cc. each of water are sufficient to remove all the ammonia from the tower. The solution is now evaporated to charring, 5 g. of potassium sulfate added and the digestion continued for about 1 hr. after becoming bluish. After digestion is complete the ammonia is distilled after adding strong caustic soda carrying potassium or sodium sulfide. It is necessary to add a relatively large excess of alkali to the melt before distilling.

Fertilizers carry considerable insoluble organic material which, when present during the reduction of the nitrates, causes foaming. This difficulty may be overcome by placing the sample in a beaker, adding 50 cc. of water, heating to boiling, and filtering through a small nitrogen-free filter paper into a 500 cc. Kjeldahl flask, and washing the residue and beaker several times with hot water. The nitrates are now in solution and are reduced as outlined above. After the reduction is complete and the water boiled off, the filter paper with the residue is added to the flask together with 5 to 7 g. potassium sulfate, the mass digested, and the ammonia determined in the usual manner.

SUMMARY

I—The procedures designated as official for determining total nitrogen including nitric nitrogen are not suitable for studies in soil biology where large volumes of solution must be employed.

II—The presence of much organic matter interferes in the reduction by the Ulsch method.

III—The reduction of nitric nitrogen in an alkaline solution with Devarda's alloy removes any danger of loss of gaseous nitrogen.

IV—The method which has been perfected effects the reduction in alkaline solution, thus avoiding loss of gaseous nitrogen; dilute alkali is used, and the amount of interfering substances in digestion thus largely avoided; and by means of a reliable absorbing device escape of ammonia is guarded against. It possesses the added features of ease of manipulation and extreme accuracy of results.

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SODIUM PYROGALLATE SOLUTIONS AS AN ABSORBENT FOR OXYGEN^{1,2}

By G. W. JONES AND M. H. MEIGHAN

In this report are shown experiments made for the purpose of determining the feasibility of using sodium hydroxide to replace the more expensive potassium hydroxide in pyrogallate solutions for the absorption of oxygen. In view of the high price of potassium hydroxide, due to the war, and the inability at times of obtaining it at all, relief was sought by using sodium hydroxide.

HISTORICAL

A great amount of experimental work has been done by different investigators along these lines. Of recent date, Shipley³ made exhaustive tests on sodium hydroxide as a substitute for potassium hydroxide and concludes that it is as good or superior to potassium hydroxide, that no carbon monoxide is given off, and that the rate of absorption is proportional to the concentration of the pyro. Anderson⁴ criticizes the solutions recommended by Shipley as being too viscous, and states that expense saved in cost of material is more than offset by the time lost for complete absorption and the extra amount of manipulation. Liebig⁵ was one of the first to make use of potassium pyrogallate for absorbing oxygen. He found from experiments that 1 g. of pyro in ammoniacal solutions absorbed 0.38 g. of oxygen or 260 cc., and 1 g. pyro in a potassium hydroxide solution absorbed 189. The strength of the ammoniacal or potassium hydroxide solution is not stated. He also tested gallic and tannic acid as an absorbent but found them very slow as compared to pyro. Boussingault⁶ found when

using 5 cc. of potassium hydroxide solution containing 2 g. potassium hydroxide and 0.8 g. pyro, that 0.4 to 3.4 per cent of carbon monoxide were given off. Calvert¹ found that 2 to 4 per cent carbon monoxide were produced when pyro acted upon oxygen. Weyl and Goth² reached the conclusions that the absorption was at a maximum when the soda was sufficient to form the compound $C_5H_2(ONa)_3$, but this is not the case when potash is used instead of soda. He recommended 0.25 g. pyro in 10 cc. sodium hydroxide, sp. gr. 1.030. Weyl and Zeitler³ state that the maxi-

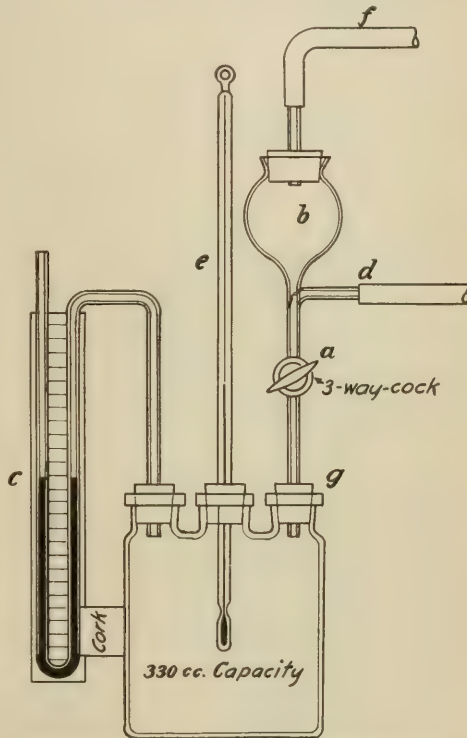


FIG. 1.—RELATIVE ABSORPTION OF LIQUIDS TESTING APPARATUS

mum absorption was obtained with potassium hydroxide of specific gravity 1.05, and that 1.50 is too strong. Lewes⁴ states that freshly made pyro solution must not be used, that it should stand 24 hrs. After the solution had been used for some time carbon monoxide was given off. Clowes⁵ found that carbon monoxide was given off unless there was excess of potassium hydroxide. He recommends a solution of 160 g. potassium hydroxide and 10 g. pyro in 200 cc. water. This solution will not give off carbon monoxide even when analyzing pure oxygen. Berthelot⁶ states

¹ Published by permission of the Director, Bureau of Mines.

² Read at the 56th Meeting of the American Chemical Society, September 10 to 13, 1918

³ *J. Am. Chem. Soc.*, **38** (1916), 1687.

⁴ *This Journal*, **7** (1915), 587; **8** (1916), 999.

⁵ *Ann.*, **77** (1851), 107.

⁶ *Compt. rend.*, **87** (1863), 885.

¹ *Ann.*, **130** (1864), 248.

² *Ber.*, **14** (1881), 2659.

³ *Ann.*, **208** (1880), 255.

⁴ *J. Soc. Chem. Ind.*, **10** (1891), 407.

⁵ *Ibid.*, **16** (1896), 742.

Compt. rend., **126** (1898), 1066.

TABLE I

TEST No.	Vol. of Soln. Cc.	Vol. of Pyro Cc.	1 Min. Mm.	2 Min. Mm.	3 Min. Mm.	4 Min. Mm.	5 Min. Mm.	6 Min. Mm.	7 Min. Mm.	8 Min. Mm.	9 Min. Mm.	10 Min. Mm.	CO Per cent	PdCl ₂ Test	Oxygen Absorbed Cc.
1.....	25 A	2	26	35	40	46	52	56	61	66	70	74	.....	.....	Not measured
	25 A	2	26	36	42	50	54	58	64	69	73	78	.....	.....	Not measured
	25 A	2	26	36	42	48	54	58	65	70	76	82	0.00	Neg.	Not measured
2.....	25 A	5	40	61	76	88	96	103	110	116	120	123	.....	.....	.....
	25 A	5	48	58	75	86	96	104	113	118	123	127	.....	.....	.....
	25 A	5	50	67	78	88	96	102	108	114	120	124	0.00	Neg.	Not measured
3.....	25 A	10	32	53	75	88	98	106	114	120	124	128	.....	.....	.....
	25 A	10	32	52	65	84	97	112	117	124	131	135	.....	.....	.....
	25 A	10	33	53	74	92	103	112	120	125	133	136	0.00	Neg.	Not measured
4.....	25 B	2	16	26	34	41	48	54	58	64	70	74	.....	.....	.....
	25 B	2	15	24	34	41	48	54	60	65	70	74	0.00	Neg.	Not measured
5.....	25 B	5	34	42	58	76	82	89	96	104	108	114	.....	.....	.....
	25 B	5	20	36	50	62	73	83	92	98	104	110	.....	.....	.....
	25 B	5	24	41	56	68	78	88	96	104	110	116	0.00	Neg.	Not measured
6.....	25 B	10	32	61	83	98	111	119	128	133	138	140	.....	.....	.....
	25 B	10	32	58	80	96	110	119	127	132	136	138	0.00	Neg.	Not measured
7.....	25 C	2	29	48	60	72	82	90	97	103	108	112	.....	.....	.....
	25 C	2	29	48	62	73	85	93	101	105	110	115	0.13	Pos.	Not measured
8.....	25 C	5	43	74	94	106	118	125	130	134	136	138	.....	.....	.....
	25 C	5	45	79	99	113	122	128	130	134	135	136	0.08	Pos.	63.5
9.....	25 C	10	66	103	119	126	130	132	132	132	132	132	.....	.....	.....
	25 C	10	60	99	118	126	130	132	132	132	132	132	0.11	Pos.	63
10.....	25 D	2	47	71	87	99	108	115	120	125	127	129	.....	.....	.....
	25 D	2	48	69	85	99	109	115	120	124	126	129	0.31	Pos.	63
11.....	25 D	5	55	98	115	125	130	132	134	134	135	135	.....	.....	.....
	25 D	5	63	97	113	122	127	130	131	132	132	132	0.15	Pos.	62
12.....	25 D	10	80	117	127	130	130	130	130	130	130	130	.....	.....	.....
	25 D	10	83	120	128	130	130	130	130	130	130	130	0.11	Pos.	61
13.....	20 D	15	54	94	113	121	125	126	127	127	128	129	.....	.....	.....
	20 D	15	57	100	113	122	125	127	128	128	130	130	0.16	Pos.	62

that pyro mixed with more than three equivalents of potassium hydroxide gave off carbon monoxide equivalent to $1/75$ the oxygen absorbed, the absorption is constant between the temperatures of $15^{\circ}\text{C}.$ to $62^{\circ}\text{C}.$, using from 1 to 3 equivalents, and with $1/2$ equivalent the absorption is reduced and the carbon monoxide increased. The solution recommended is as follows: 32 g. pyro in 100 cc. water mixed with 3 or more equivalents of potassium; strength of potassium hydroxide not stated.

EXPERIMENTAL

The ideal solution should absorb rapidly, not be too viscous, and above all, should not give off appreciable quantities of gases such as carbon monoxide. Where analyses are made to an accuracy of 0.01 to 0.02 per cent if only a trace of carbon monoxide is given off, these solutions could not be used.

Reagent g, recommended by Shipley as most suitable for gas analysis, was found to be too viscous, and after a short time readings could not be made when used on Haldane apparatus.

Tests were made with sodium hydroxide from the highest concentration to very dilute and with varying amounts of pyro. Very accurate tests were made for carbon monoxide produced with different solutions. This is more important for accurate mine air analysis than rapidity of absorption.

To test the relative absorption of the different solutions, the authors devised the apparatus shown in Fig. 1. The relative absorption could be read by the reduction of pressure on the manometer per minute. By using approximately the same amount of solution and using the same procedure of shaking, the relative absorption could be determined directly from curves plotted against pressure and time. To make a test the sodium hydroxide solution was introduced by removing the rubber stopper g. After the sodium hydroxide had been added the bottle was tightly stoppered; heavy cylinder oil on the stoppers helped to prevent leaks. To test for leaks pressure was ap-

plied by forcing air into the bottle through the three-way cock *a*, then closing *a* and noting any pressure drop. After the bottle had been found leak-proof the desired amount of pyro solution was introduced by means of the funnel and three-way cock *a*, by blowing on rubber tube *f*. Immediately after the pyro had

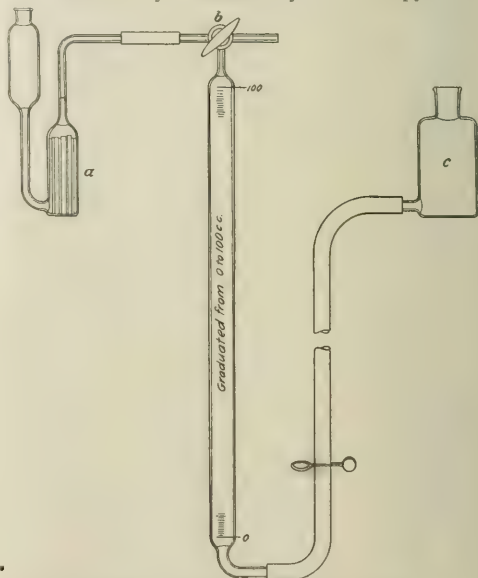


FIG. 2—BURETTE AND ABSORPTION PIPETTE FOR GAS LABORATORY

been introduced the three-way cock *a* was turned 180° to connect with *d*, leading to the air to allow the pressure in the bottle to become atmospheric. Cock *a* was then closed by turning through 90° and readings of pressure taken every minute on the manometer *c* for 10 min. while the apparatus was given uniform shaking by sliding the bottle back and forth on

SOLN. No.	Vol. of Pyro Cc.	Vol. of NaOH Cc.	Vol. O ₂ absorbed, Cc.	Time Min.	CO Produced	REMARKS
3	10 { 1 g. Pyro } { 3 cc. H ₂ O }	25 Sp. gr. 1.49	100 100 100 100 (air) Sample left 86.6 cc.	9 14 15 26	0.03 cc. from 400 cc. O ₂	Solution rather viscous but did not gum capillary tubes. Very dark and rather difficult to see through film on the glass. Meniscus could be easily read
6	10 { 1 g. Pyro } { 3 cc. H ₂ O }	25 Sp. gr. 1.30	100 100 100 100 (air) Sample left for CO 94.2 cc.	8 1/2 11 14 19	0.04 cc. CO from 400 cc. O ₂	Solution less viscous than above soln. Very dark and difficult to see through film on glass. Easy to read meniscus
Shipley's No. 9	35 { 10 g. Pyro } { 120 g. KOH } { 7.36 g. NaOH } { 11.62 cc. H ₂ O }	.....	100 100 100 100 100 100 100 100 100 100 (air)	9 9 1/2 12 15 13 14 15 14 1/2 13 16 11 1/2	1.48 cc. CO formed after absorbing 1100 cc. O ₂	Solution very rapid with a high specific absorption but too viscous to use in our pipettes. Also it is very dark, and as it sticks to the walls of the pipette it is impossible to accurately read the meniscus in any of our pipettes
	35 K Pyrogallate { 120 g. KOH } { 80 cc. H ₂ O } { 5 g. Pyro } { 15 cc. H ₂ O }	.....	100 100 (56.6 cc. left)	25 Incomplete in 1 hr.	About 0.51 cc. CO formed absorbing 243 cc.	Pyro used by Bureau of Mines. Made according to Hempel

a table at a uniform rate. By introducing the solutions separately and just at the moment of making an analysis, there was no absorption of oxygen before making a test. A thermometer, *e*, indicated any rise of temperature due to the reaction of pyro and sodium hydroxide. For very high concentrations of pyro the heat given off is considerable and other methods are necessary. In the results obtained in this table, the temperature was kept near 20° C. and in no case did the heat of reaction cause the gas to rise over 3° C.

TABLE III—SHOWING THE RELATIVE AMOUNT OF NaOH AND H₂O USED IN GRAMS AND PER CENT OF CO FORMED IN EACH TEST

SOLUTION No.	Pyro ¹ G.	NaOH G.	H ₂ O G.	CO Per cent
1.....	0.54	17.12	21.75	Negative
2.....	1.35	17.12	24.18	Negative
3.....	2.70	17.12	28.23	Negative
4.....	0.54	9.10	25.02	Negative
5.....	1.35	9.10	27.45	Negative
6.....	2.70	9.10	31.50	Negative
7.....	0.54	4.68	29.19	0.13
8.....	1.35	4.68	28.62	0.08
9.....	2.70	4.68	31.67	0.11
10.....	0.54	2.78	26.59	0.31
11.....	1.35	2.78	29.02	0.15
12.....	2.70	2.78	33.07	0.11
13.....	4.05	2.22	32.13	0.16

¹ Used sp. gr. pyro as 1.08.

In the following tests the pyro used was made in the proportion of 5 g. pyro to 15 cc. water.

Sodium hydroxide solutions were as follows:

Solution A commercial stick sodium hydroxide and water in equal amount by weight. The sodium carbonate present was filtered off by suction over glass wool; resulting solution had a specific gravity 1.49 or 46 per cent sodium hydroxide.

Solution B, sp. gr. 1.30, or 28 per cent sodium hydroxide.¹

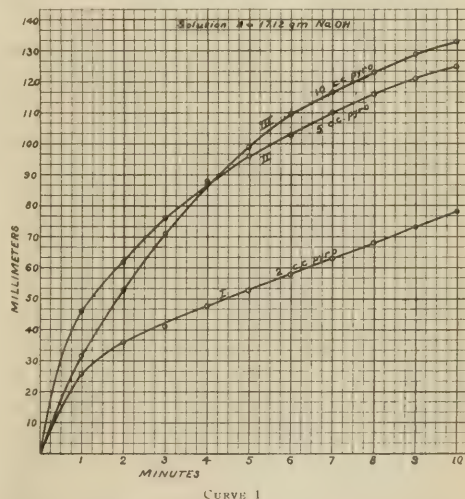
Solution C, sp. gr. 1.17, or 16 per cent sodium hydroxide.

Solution D, sp. gr. 1.11, or 10 per cent sodium hydroxide.

Solutions B, C, and D were made by diluting A.

Table I shows results of using different amounts of pyro with different concentrations of sodium hydroxide over a wide range of concentration varying from concentrated solutions to those containing only 10 per cent sodium hydroxide. All tests were made in duplicate, or triplicate, if necessary to check.

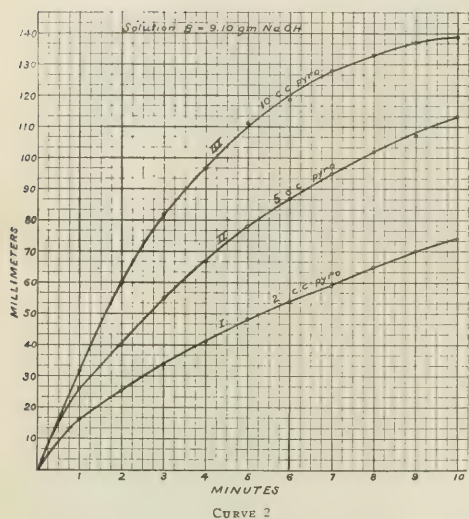
To test for the presence of carbon monoxide after the oxygen absorption was complete, mercury was added through the funnel *b* and three-way cock *a* until the pressure on the manometer was zero. In this way the amount of oxygen absorbed could be determined by measuring the mercury added. The gas was then transferred to a gas apparatus for the exact analysis of carbon monoxide. Burrell's modification of the Haldane apparatus¹ was used in these tests. A little over 15 cc. were introduced into the burette and accurately measured, then air added until the total volume equaled about 20 cc. and again measured;



CURVE I

next the carbon monoxide was burned by the slow combustion method. From the contraction and carbon dioxide produced the percentage of carbon monoxide was determined: $2\text{CO} + \text{O}_2 = 2\text{CO}_2$. The carbon

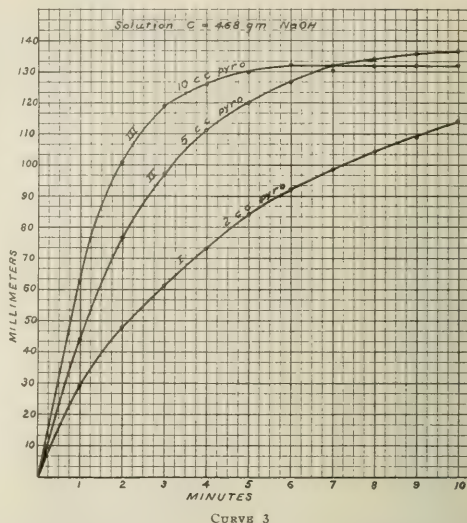
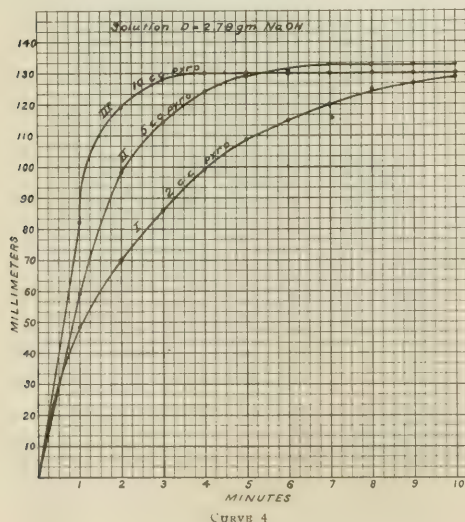
¹ For description and method of use, see Bureau of Mines' Bulletin 43, "The Sampling and Examination of Mine and Natural Gas," by G. A. Burrell and F. M. Seibert.



monoxide is equal to twice the contraction or equals the carbon dioxide produced. Analyses were made on one determination of each test and were checked to 0.01 per cent. All tests showing carbon monoxide were confirmed by the palladium chloride test whereby metallic palladium is precipitated in the presence of carbon monoxide.

The following curves were made by averaging the readings in Table I.

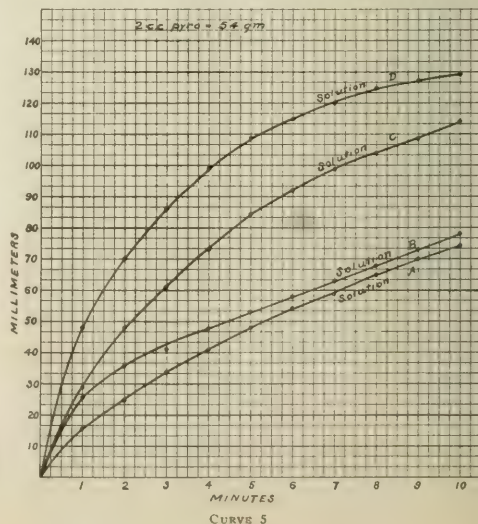
Curves 1, 2, 3, and 4 show averages of tests made with constant amounts of sodium hydroxide and varying amounts of pyro and water. All solutions used in Curves 3 and 4 gave off small amounts of carbon

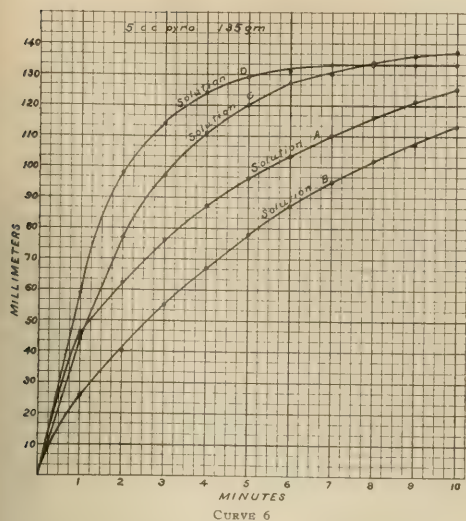


monoxide. Curves 5, 6, and 7 show a combination of the above, using the same amounts of pyro and varying amounts of sodium hydroxide and water.

From the curves it is evident that the rate of absorption increases with the dilution of the sodium hydroxide, and for any given sodium hydroxide solution increases with the concentration of pyro. The most rapid sodium hydroxide solutions gave off carbon monoxide, therefore are not suitable for oxygen absorption.

Further tests were made on the two most promising solutions, Nos. 3 and 6, using apparatus shown in Fig. 2. The pipette was made to hold 35 cc. of solu-





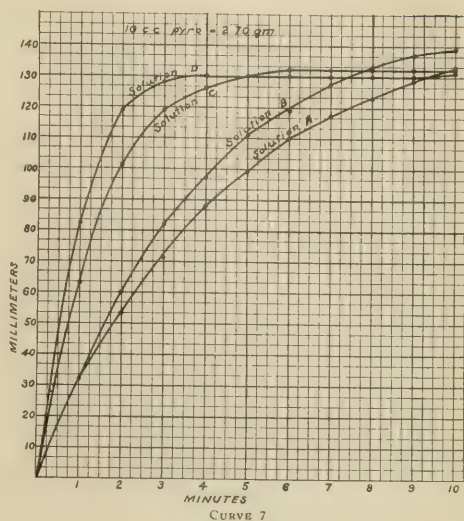
tion and was filled with small glass tubes. The solutions were introduced as follows: Nitrogen was passed through *a* by way of stopcock *b* for some time to displace all the air, then 25 cc. of the sodium hydroxide solution added and the required amount of the pyro solution and the pipette immediately closed with a rubber bag not shown in the drawing. This also had been previously filled with nitrogen.

These tests were made to determine how the solutions behaved in actual operation: First, with regard to the absorption of oxygen of high and low percentages; second, how much carbon monoxide was given off under different conditions; third, ease in making readings after being used for some time; and fourth, the tendency to foam or clog the capillary tubes.

Oxygen made from oxone cartridges was used to exhaust the solutions. Then air was added and carbon monoxide determined in the residual gas. Table II shows the composition of the solutions, time required for absorbing each 100 cc. of pure oxygen, and quantity of carbon monoxide produced.

Of the above four solutions, Shipley's No. 9 has by far the fastest rate of absorption, but too large quantities of carbon monoxide are produced for accurate work, and it is so viscous that it is almost impossible to read the meniscus accurately.

The potassium pyrogallate solution used in the above test is that used by the Bureau of Mines for absorbing oxygen in mine air analysis and corresponds to that proposed by Hempel and is made as follows: 1200 g. of potassium hydroxide are dissolved in 800 cc. of water and allowed to cool. In a separate beaker 50 g. of pyrogalllic acid are dissolved in 150 cc. of water making 184 cc. of solution. The potassium hydroxide solution, after cooling, is evenly distributed in 350 cc. magnesium citrate bottles and 46 cc. of pyro solution added to each bottle. The



bottles are then tightly stoppered by a rubber gasket and thoroughly shaken. By using these quantities enough solution is made to fill four magnesium citrate bottles and there is no absorption of oxygen during the process of making.

When using the above solutions with air no carbon monoxide was given until they were nearly exhausted, when traces of it were detected by the palladium chloride test. In no case was there found over 0.03 per cent.

SUMMARY

A new apparatus for testing the relative absorption of oxygen with different solutions has been devised.

Tests made over a wide range of concentrations of the different reagents show that the rate of oxygen absorption in sodium pyrogallate solutions increases with the dilution of the sodium hydroxide and for any given concentration of sodium hydroxide the rate of absorption is proportional to the concentration of the pyrogallic acid.

Sodium pyrogallate solutions made by using sodium hydroxide solutions of less than 1.30 specific gravity give off carbon monoxide which increases with the dilution.

All sodium pyrogallate solutions give off carbon monoxide when analyzing oxygen samples containing above 95 per cent oxygen.

A sodium pyrogallate solution which gives off a minimum amount of carbon monoxide, having a fairly high rate of absorption, and adapted for pipettes, using glass tubes, is recommended. This solution is made as follows:

Stick sodium hydroxide is dissolved in an equal weight of water, and constitutes the stock sodium hydroxide solution. In another container stock pyro solution is made up in proportions of 1 g. of pyro to 3 cc. of water. When ready for use, 5 parts of the

sodium hydroxide solution are mixed with 2 parts of pyro.

In cases where the small quantity of carbon monoxide given off is below the error of analysis, as when used in the Orsat apparatus, Solution 6 will be found suitable.

BUREAU OF MINES
WASHINGTON, D. C.

THE DETERMINATION OF URANIUM IN ALLOY STEELS AND FERRO-URANIUM

By G. L. KELLEY, F. B. MYERS AND C. B. ILLINGWORTH
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The recent use of uranium in alloy steels has made it desirable to develop a convenient and reliable method for determining this element in the presence of any of the other elements now in common use in the manufacture of alloy steels. Uranium has been used in the manufacture of commercial high-speed steels where it might be associated with chromium, molybdenum, vanadium, tungsten, and cobalt; and it has been used, experimentally at least, in steels containing chromium and nickel. In addition to the elements named above, carbon, manganese, silicon, phosphorus, and sulfur are always present, and aluminum and titanium may be present in small amounts. The method as outlined below provides for these possibilities.

A 2 g. sample is dissolved in 75 cc. of 1 : 1 hydrochloric acid. After solution is complete the solution is oxidized by the dropwise addition of nitric acid. In the case of samples where tungsten is present an easily filterable product is obtained by diluting to 300 cc. and boiling for 15 min. The tungstic oxide is then filtered out and washed, the filtrate and wash waters being returned to the original beaker for evaporation to dryness, followed by baking at a moderate temperature. On dissolving the residue with 50 cc. of 1 : 1 hydrochloric acid and diluting with hot water, a solution is obtained from which the balance of the silica and the last traces of tungsten can be separated by filtering. The two precipitates after washing are available for the determination of tungsten and silicon by the usual methods. Filtrates and wash waters from these precipitates are combined and evaporated to a syrupy consistency in preparation for the extraction of most of the iron with ether. In the absence of tungsten the original solution is evaporated to dryness and baked with the object of removing silica. After the extraction of the iron, the aqueous layer is evaporated to a small volume to free it from the excess of acid. It is then diluted to a volume of 150 cc. with hot water, and an excess of sodium carbonate in the form of a saturated solution is added. This solution is boiled and, after settling, filtered, the precipitate being washed with hot water. The precipitate consists of the hydroxides of chromium, iron, manganese, cobalt, nickel, copper, and aluminum, if all of these elements are present, together with traces of silica, titanate, phosphorus, and vanadium compounds. The filtrate contains uranium, molybdenum, vanadium, and traces of the elements which occur chiefly in the precipitates.

Bulky precipitates should be dissolved in hydro-

chloric acid and reprecipitated one or more times with sodium carbonate solution to insure a complete separation of the uranium. The difficulties from this source are not as great as might be expected.

All filtrates from the precipitate are cautiously acidified with sulfuric acid and boiled long enough to insure the complete removal of all carbon dioxide. Ammonia free from carbonate is then added in slight excess. Boiling precipitates the uranium, much of the vanadium, and traces of impurities. The molybdenum is left in the filtrate. Steels contain only small amounts of phosphorus and the contamination of the uranium from this source is usually negligible. When, however, as may occur, the amount of phosphorus is large, it may be necessary to dissolve the precipitate in nitric acid, and after suitable oxidation, precipitate the phosphoric acid with ammonium molybdate. The phosphorus can then be removed as ammonium phosphomolybdate. The uranium and vanadium may be reprecipitated from this filtrate along with the manganese, if permanganate is used to oxidize the phosphorus, by adding a few drops of sulfuric acid, a small amount of ammonium persulfate, and enough carbonate-free ammonium hydroxide to give an excess. The precipitate obtained by boiling the solution is in the condition corresponding to the first uranium precipitate mentioned above.

The impure uranium precipitate containing phosphorus in negligible amounts, or free from it, is transferred to a beaker with a little water and solid ammonium carbonate added. On heating this solution under conditions and for a time calculated to result in only a partial decomposition of the ammonium carbonate, the uranium and vanadium go into solution leaving the manganese, iron, and other impurities undissolved. The filtrate is acidified with sulfuric acid and boiled until it is free from carbon dioxide, when a slight excess of carbonate-free ammonium hydroxide is added. This precipitates only the uranium and vanadium. In common with other investigators we have not been successful in finding convenient and satisfactory procedures for separating these elements.

The combined precipitates of uranium and vanadium are ignited at dull redness in a platinum crucible, allowing free access of air to reoxidize any reduced material. The ignited residue is weighed as $U_3O_8 + V_2O_5$. In general, only a small part of the vanadium is present in this precipitate, thus making it unavailable for the vanadium determination. It is necessary, however, to determine the vanadium to correct the weight of uranium oxide. This may be done by almost any of the several known methods for determining vanadium. To this end we determine the vanadium after reduction with hydrochloric acid by permanganate titration, and by oxidation with ammonium persulfate and silver nitrate, followed by electro-metric titration. The latter method is the more certain and convenient, but the former gives entirely satisfactory results. For the purpose of either method the precipitate is dissolved in 50 cc. of concentrated hydrochloric acid and evaporated with 30 cc. of sulfuric acid (sp. gr. 1.58) until fumes appear. When

the titration is to be completed with permanganate, the sulfuric acid solution is diluted to 250 cc. with hot water and titrated at 80° C. to the first pink color. At the same time like quantities of sulfuric and hydrochloric acids are evaporated, diluted, and titrated in similar fashion to obtain a blank correction for the vanadium. When the titration is to be made electrometrically, the sulfuric acid solution is diluted to 250 cc. with hot water, oxidized with silver nitrate and ammonium persulfate as described elsewhere¹ by one of us, and titrated with ferrous sulfate. The weight of vanadium so found is multiplied by 1.784 to convert it into the corresponding weight of the oxide V_2O_5 . This weight is subtracted from the weight of the residue $U_3O_8 + V_2O_5$. The corrected weight of the oxide U_3O_8 is converted into the corresponding weight of uranium by multiplying by 0.8483 from which the percentage of uranium can be calculated.

A solution of uranium was prepared by dissolving about 4.5 g. of uranium nitrate in one liter of water. This salt was made by the J. T. Baker Chemical Company and was described as containing less than 0.001 per cent of sulfur trioxide, and as being free from alkali metals, alkaline earth metals, uranous salts, and other foreign metals. We evaporated 50 cc. of this solution in a platinum dish and ignited the residue as described above. By this analysis we found 0.1340 g. of the oxide U_3O_8 . In another experiment we acidified 50 cc. of the solution with sulfuric acid, and added 0.05 g. aluminum, 1 g. ammonium phosphate, and 0.025 g. vanadium as ammonium vanadate. On carrying out the procedure described above, we found 0.1350 and 0.1343 g. of the oxide U_3O_8 . Electro-metric analysis of the uranium salt indicated less than 0.1 mg. of vanadium in this amount of solution.

Below we have given a few determinations of uranium in 2 samples of steel. One of these was a nickel-chromium steel in which the approximate respective percentages of manganese, nickel, and chromium were 0.35, 3.00, and 1.45. The other was a high-speed steel in which the approximate respective percentages of manganese, chromium, tungsten, vanadium, and cobalt were 0.25, 4.00, 14.00, 2.00, and 5.00. To both of these samples definite amounts of the uranium solution were added. The determinations appear below:

	Per cent U Present	Per cent U Found
Nickel-Chromium Steel.....	5.69	5.71 5.64
High-Speed Steel.....	5.69	5.65 5.65

The determination of uranium in ferro-uranium is similar to the analysis of steel for this element. A 1 g. sample was dissolved in a small amount of concentrated nitric acid, and when solution was completed, hydrochloric acid was added cautiously to the amount of 30 cc. The solution was then evaporated to dryness with the object of separating silica. After the removal of silica, the procedure was identical with that in the case of steel.

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¹ *J. Am. Chem. Soc.*, **38** (1916), 350.

STUDIES ON MANGANATES AND PERMANGANATES—I

THE COURSE OF THE REACTION BETWEEN MANGANESE DIOXIDE, POTASSIUM HYDROXIDE, AND OXYGEN, AND THE MANUFACTURE OF POTASSIUM MANGANATE

By H. I. SCHLESINGER, R. D. MULLINIX AND S. POPOFF¹

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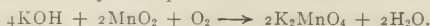
Among the important chemicals which in the past have been imported at so low a price that American manufacturers had not, up to the time of the European war, undertaken its production to any large extent is potassium permanganate. The obvious need for the product and its extreme scarcity have, however, made its manufacture in this country a necessity, and a number of plants are now engaged in producing it. Some of them encountered certain difficulties when they began continuous operation and one of us was asked by the Bureau of Mines to investigate the matter. Out of this investigation a number of results of both scientific and practical interest have developed and of these the most important are reported in this paper.

There are several methods for manufacturing the permanganate; the most widely used is apparently the one in which potassium manganate is first prepared as an intermediary product by heating a mixture of potassium hydroxide and manganese dioxide in a current of air. The resulting mix is then extracted with water or a dilute solution of caustic potash and the solution of manganate thus obtained is converted into a solution of the permanganate. The methods employed for this latter step need not be discussed here as the research now to be reported deals only with the first step. It is necessary, however, to point out that in this second step a large proportion of the caustic combined in the first is again liberated either in a form in which it can be directly utilized or in which it can be used after suitable treatment, depending upon the process used for the second step. Furthermore, owing in part to the spontaneous decomposition of manganate and permanganate solutions, in part to manganese dioxide precipitated out in the second step and in part to the fact that the first step never results in complete interaction of the components, there is always a relatively large amount of manganese dioxide left over from each treatment. It is therefore self-evident that economical working of the process not only requires as high a yield as possible of the manganate in the first step, but that it is also necessary that the neutralization of the residual and recovered manganese dioxide and potassium hydroxide must be highly successful. Difficulties have apparently been encountered in both of these phases of the process and we have therefore made a study of the factors which influence their successful carrying out.

The conversion of manganese dioxide into potassium manganate by heating it in a current of air with potassium hydroxide has been extensively investigated. The most recent and apparently the most thorough of these investigations are those of Askenasy and

¹ This paper is taken from material presented to the faculty of the University of Chicago by R. D. Mullinix and by S. Popoff in part fulfillment of the requirements for the degree of Doctor of Philosophy.

Klonowski¹ and of Sackur² and his associates. The researches of the two groups of investigators do not lead them to the same conclusion. While the first named seem to hold to the opinion that the reaction follows the course usually found in the text books, represented by the equation



Sackur concludes that potassium manganate is never formed in this way, but that the product obtained in the reaction is a "mangan-manganate" which can be represented by the formula, $2\text{K}_2\text{MnO}_3 \cdot 3\text{K}_2\text{MnO}_4 \cdot 3\text{K}_2\text{O}$. In this conclusion he is corroborated by the work of Auger³ who obtained a compound of similar composition by heating potassium permanganate with excess of potassium hydroxide. If Sackur's conclusion is correct it is clear that the highest yield that could be obtained in the reaction in terms of the amount of manganese dioxide oxidized to the manganate stage could be only 60 per cent, since the remaining 40 per cent must always remain as manganite. In support of this consequence of his theory of the course of the reaction Sackur cites his own experiments which show a maximum yield of between 55 and 66 per cent, the results of Askenasy and Klonowski who obtained similar yields, and the statements, made personally to Sackur by German manufacturers, that a yield of 60 per cent was the maximum attained in practice.⁴ When we first undertook this investigation the manufacturers with whom we were coöperating were not obtaining yields as high as those demanded by Sackur's theory and we, therefore, attempted to determine the best conditions for duplicating his results. The outcome of this work has been to show that Sackur's theory of the reaction is incorrect, for we were able to obtain yields corresponding to a conversion of over 98 per cent of the manganese dioxide into the manganate by use of the methods of work and of the proportions of the reacting substances which are discussed below.

I.—THE COURSE OF THE REACTION BETWEEN MANGANESE DIOXIDE, POTASSIUM HYDROXIDE AND OXYGEN

In our experiments we decided to follow the procedure of Askenasy and Klonowski.⁵ This procedure consists, briefly stated, in mixing the finely ground ore with a concentrated solution of caustic potash, drying the mix in a current of air to such a consistency that when cool it can be well powdered and will no longer become soft on raising it to the higher temperatures to which it is next exposed, and finally heating this powdered material in a current of air in an apparatus in which the mix can be continually ground while being heated. This apparatus consisted of a

rotating drum, fitted with iron ribs parallel with the axle and with openings for removing material for analysis. The drum was rotated in an iron housing and was heated by gas. The axle was hollow and broken in the middle of the drum. Through one end of the hollow axle preheated air was introduced and into the other end a thermocouple was loosely fitted. The charge, prepared as above, was placed in the drum and with it a fairly large number of $\frac{3}{4}$ in. steel balls. As the drum rotated slowly (20 r. p. m.) the balls were lifted by the ribs in the sides of the drum and dropped back on the material, thus pulverizing the latter thoroughly throughout the process. That this continuous pulverization, which is recommended by the authors named above, considerably improves the yield was corroborated by our own results, which need not be recounted here. In only two particulars did we depart from the method of Askenasy and Klonowski. In the first place in making the mix we used ore and alkali in varying proportions as described below while they used mixtures containing approximately equal parts by weight only. In the second place we used a somewhat lower temperature, keeping our mixes in the rotators at about 450° C. In one minor matter we also departed from the older investigation referred to. The preliminary drying was carried out in an electrically-heated oven instead of over a free flame, but this was merely a matter of convenience in regulating the temperature at this stage and in avoiding too great a contamination with carbon dioxide, which is likely to occur when the heating is carried out over the free flame. The heat was so regulated in this part of the process that when the mix was completely dry its temperature remained in the neighborhood of 300° C.

The preliminary heating, while it results in the absorption of some oxygen and in some experiments to quite a large amount, is in general carried out merely to prepare the material for the treatment in the rotary kilns in which the chief absorption usually takes place. The mass was usually analyzed after the preliminary heating was completed and, after it was placed in the kilns, analysis was repeated every few hours until oxygen absorption seemed to cease. This could be done without cooling off the whole mass because material could be withdrawn from the cylinders through the openings mentioned. The method of analysis was that employed by Askenasy and Klonowski.

Before proceeding to the discussion of the final results of this part of the investigation one important detail must be taken up. In one of our earlier experiments a mix was heated in the rotary kiln, as described, first in an atmosphere of dry air and then in oxygen. The potassium manganate content in air rose to 54.6 per cent, which is about 60 per cent of the yield possible according to the equation given above. Further heating in air caused a slight lowering of the yield. In oxygen the content of manganate rose to 63 per cent, at which point absorption of oxygen came to an end. The mass was then treated with enough

¹ *Z. Elektrochem.*, **16** (1910), 104, 170.

² *Ber.*, **43** (1910), 381, 448; **44** (1911), 777; *Z. Elektrochem.*, **16** (1910), 649; **18** (1910), 718; *Z. anorg. Chem.*, **73** (1912), 101.

³ *Compt. rend.*, **151**, 69.

⁴ It will be noted that the highest yields obtained by Sackur are a little higher than permitted by his theory. Sackur gives an explanation of this which the work herein reported shows to be incorrect. Askenasy in one experiment obtained very much higher results than Sackur. The experiment, however, has not been cited in refutation of Sackur's criticism of Askenasy and it is, therefore, likely that the result was never confirmed.

⁵ *Loc. cit.*, p. 175.

water so that the mixture could be well stirred. It was then dried as described above and reheated in oxygen in the kilns at 450° . The manganate content now rose to 77.9 per cent and a repetition of this procedure finally raised it to 81 per cent, representing a yield of 92 per cent of the theoretical on the assumption that manganate and not mangani-manganate is the product obtained. Frequent repetitions of analogous experiments showed that it was the moistening with water which raised the final yields, as merely by this treatment and without the use of oxygen we have been able to reproduce these and higher yields. Two questions were raised by this result. In the first place it would seem as if manganate is not as sensitive to moisture as usually stated. To bear this out the following may be cited. Steam was passed over a product containing 78.6 per cent of potassium manganate for 20 min. while the mass was kept at 450° . At the end of this time the manganate content had fallen only to 76.8 per cent. In the second place there is a possibility that moisture is necessary to obtain the highest possible yields. It is to be noted that in the experiment cited above the absorption of oxygen from dry air stopped at about 60 per cent of the amount of manganate possible on the assumption that it is the product formed. This accords with Sackur's theory of the reaction. In a similar experiment the absorption of oxygen from dry air stopped at the same point. In two other experiments in which manganese dioxide from a different source was used the same thing was observed. But in a fifth experiment the content of manganate rose in dry air until a maximum yield of 87 per cent was reached without remoistening. On the other hand we find that if instead of using dry air we employ air that has been moistened by passing it through water there is much less likelihood that the reaction will stop before the maximum possible oxidation has been attained. The bearing which these results may perhaps have on the theory of the reaction will be taken up below; the experimental results have been introduced at this point to explain how the maximum yields reported in the next paragraph were obtained. Based on the results described above our procedure was invariably to allow absorption of oxygen to proceed as far as it would in air, then to remoisten and reheat the material in air, and finally to reheat in oxygen. The latter treatment seems merely to hasten the absorption of the last part of the oxygen and not to raise the yield above that which could be reached in air if enough time and repeated remoistening were employed.¹

The fact that a yield of nearly 100 per cent of the theoretical can be attained—a fact that is important because of its practical aspect and because it proves Sackur's theory of the course of the reaction incorrect—was discovered as the result of a series of experiments in which the relative amounts of manganese dioxide and of potassium hydroxide were varied within wide

¹ Askensay and Klonowski (*Loc. cit.*, p. 111) describe one experiment in which they moistened the material from time to time with a few drops of water. They seem to lay no stress on this point and our experience is that a few drops of water would be quite ineffective. Attention may also be called here to the German Patent 266,347 (1912) issued to Bergius and Sackur in which moist mixes and oxygen under pressure are used.

limits.¹ The experimental data of this series are given in Table I and are reproduced graphically in Fig. 1.

TABLE I—SHOWING THE INFLUENCE OF VARYING THE RELATIVE AMOUNTS OF POTASSIUM HYDROXIDE AND MANGANESE DIOXIDE ON THE YIELD OF MANGANATE

Ratio Per cent K_2MnO_4 Per cent yield	1.20	1.55	2.11	2.28	2.43	2.49	2.62	2.79	3.12	3.62	4.21
K_2MnO_4	35.1	51.2	73.8	77.2	79.8	81.1	76.5	68.9	57.4	41.7	36.4
yield	29.5(a)	47.6(a)	79.4	86.4	95.0	98.4	94.3	87.8	75.5	61.0	57.9

(a) In the experiments in which 1.2 and 1.55 moles of potassium hydroxide, respectively, were used for each mole of manganese dioxide, there is not enough of the former to convert all of the manganese dioxide into manganate. If the yield is calculated on the basis of the amount of potassium hydroxide converted into manganate the results are 49.2 and 60.4 per cent, respectively.

In the table the first row gives the value of the ratio moles of potassium hydroxide to one mole of manganese dioxide; the second row, the final content of potassium manganate contained in the masses; and the third row, the per cent yield. The last set of data was obtained by determining for the final sample the content of potassium manganate and the total manganese,² and calculating what per cent the manganate found was of that possible if all of the manganese had been converted into manganate. In Fig. 1 the ratios mentioned above are plotted against the percentage yield.

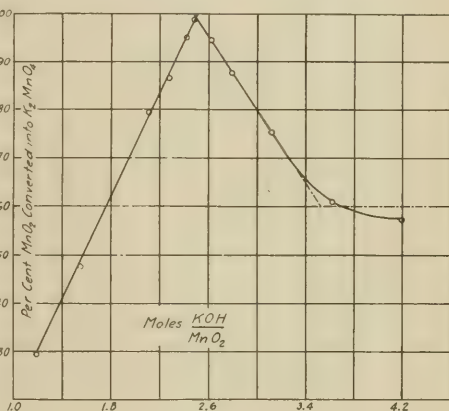


FIG. 1

Inspection of the table and the curves shows that the yield of manganate varies with the relative amount of caustic potash used. From the curve it can be seen that the percentage of manganese converted into manganate is directly proportional to the relative amount of the alkali since the curve representing the relationship is a straight line. It is furthermore seen that this line intersects the abscissa representing complete conversion when there are $2\frac{1}{2}$ moles of potassium hydroxide for each mole of manganese dioxide. The equation for the reaction given above, which is the one that was accepted before Sackur's work and is the simplest one for the reaction, requires only 2 moles of the alkali. A number of hypotheses might

¹ The manganese dioxide was in the form of commercial pyrolusite containing from 80 to 87 per cent of manganese dioxide in various samples. Each sample was of course analyzed and amounts suitable to produce the desired proportions were taken. The potassium hydroxide was taken from various sources and was also analyzed before use.

² This was determined by Sackur's modification of Volhard's method. *Ber.*, 43, 382.

be advanced in explanation of this phenomenon. In the first place the manganese dioxide used for these experiments was pyrolusite containing about 87 per cent of the dioxide. Some of the impurities like silica are capable of reacting with the caustic, thus decreasing the amount of free alkali in the mix. The same effect would be produced by carbonate originally contained in the caustic and by carbon dioxide absorbed during the unavoidable manipulation of the materials. In this connection it is interesting to note that the amount of alkali, uncombined as potassium manganate, is very nearly half a mole per mole of manganese dioxide in mixes of every composition. Against this hypothesis the following facts must be raised: In the first place, the amount of alkali which would have to be used up by impurities is larger than the impurities contained would be expected to combine with. In the second place, the amount of alkali uncombined as potassium manganate is not quite constant but increases steadily, if slightly, with decrease in total alkali. Finally, the results of Sackur's experiments contradict this view as can be shown by the following: In experiments in which 2.0 moles of alkali were used, every one of pure manganese dioxide, he obtained yields as high as 66 per cent without repulverizing or remoistening the material. We should, therefore, expect that his yields would be low. The curve reproducing our results indicates that for this composition of mix a yield of 72 per cent is to be expected—a value not far from that obtained by Sackur in view of his experimental method. If, on the other hand, we assume that half a mole of the alkali in our experiments is withdrawn from reaction by impurity we should compare Sackur's result with our data for the ratio $1\frac{1}{2}$ moles of alkali to one of the dioxide. For this the yield would be only 45.5 per cent. It is seen, therefore, that Sackur's work on pure dioxide agrees quite well with ours on pyrolusite, thus indicating that the impurities in the latter are without great influence. It is, however, not possible to give any adequate explanation for the phenomenon until the work has been repeated at other temperatures in order to ascertain whether the necessity of using an excess of half a mole of the alkali has theoretical significance. At all events, it is certain that Sackur's conclusion that mangani-manganate is the sole product of the treatment of mixes of potassium hydroxide and manganese dioxide in air and that, therefore, the maximum attainable yield is 60 per cent, is incorrect.^{1,2,3}

While the curve shows that it is possible to convert

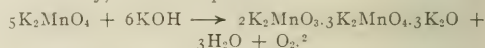
¹ That the products are not mangani-manganates is borne out by their appearance. Mangani-manganates are green; solid manganates are of a very dark violet, almost black hue, not unlike permanganates. All of the products corresponding to the portion of the curve now under discussion had this color. They were free from permanganate.

² It is manifest that since excess of alkali is required, the yield can never reach 100 per cent if the amount of alkali used is taken as a basis. The maximum yield on this basis would be 80 per cent since $\frac{1}{2}$ mole of excess is required over the 2 moles demanded by the simplest equation. Even this arbitrary way of calculating departs very greatly from the maximum of 60 per cent demanded by Sackur.

³ It is interesting to consider the possibility presented by the experiments on the effect of moisture cited above. In view of the fact that quite a number of the experiments showed cessation of oxygen absorption when the yield was 60 per cent, one might be led to believe that the mangani-manganates are formed in the absence of moisture and that the catalytic action of water is required to effect their oxidation to manganates. This

all of the manganese into manganate by the use of an excess of very nearly one-half a mole of potassium hydroxide over that required by the simplest equation for the reaction, it also shows very clearly that a larger excess of the hydroxide again lowers the yield. It will be noticed that of the points representing the larger excess of caustic, three lie on a straight line. The fourth point no longer is on this line but corresponds to a yield of very nearly 60 per cent. The fifth point is also fairly close to a 60 per cent yield. Now it is practically impossible to attain equilibrium at the temperature of these experiments (450°) with mixes containing a very large excess of potassium hydroxide because the material becomes soft and sticky and is soon so firmly attached to the walls of the cylinder in which it is heated that its removal for analysis and pulverization in the cylinders are alike impossible. This was particularly noticeable in the experiment in which the ratio was 4.2 moles of the hydroxide to one of the dioxide and the heating had to be interrupted before absorption of oxygen had stopped.¹ Consequently we have indicated by the dotted line the course which the curve would probably take had equilibrium been established in every case.

The interpretation of the curve is simple. Calculation, based on the data presented, shows that between 2 and 3 moles of potassium hydroxide are required beyond the excess of $\frac{1}{2}$ mole needed for the complete conversion of manganese dioxide into manganate for the decomposition of one mole of potassium manganate. This corresponds fairly well, though not exactly, with the equation



It seems that the mangani-manganate described by Sackur is the final product of the reaction when a large excess of alkali is used. It is not, however, the sole product of the reaction as Sackur thought and is not formed unless there is an excess of alkali greater than $\frac{1}{2}$ mole. It therefore plays no rôle in the manufacture of manganate by the method discussed in this

is not borne out by the one experiment in which in dry air a yield of over 60 per cent was obtained, but it is difficult to exclude the possibility of the presence of water retained in mixes prepared as these are. On the other hand, the dark violet color of the mixes containing an excess of alkali not greater than $\frac{1}{2}$ mole indicates that manganates are formed even when the yield is only 60 per cent and that the cessation of oxygen absorption is due to incomplete mixing of the components before remoistening. Why the cessation of oxygen occurs so often at 60 per cent yield can probably be explained as follows: In the first place, the absorption of oxygen after 60 per cent of the possible amount has been taken up is slow. In the second place, as will be seen from the curve, excess of alkali decomposes the manganate into mangani-manganate. As the alkali is the soluble component, it is likely that certain portions of the dioxide are coated in the drying process with an excess of the alkali and these portions, therefore, are likely to become converted into mangani-manganate. Other portions of the dioxide, therefore, are deficient in alkali and do not get oxidized to a maximum. That the oxidation should appear to stop at 60 per cent is not, after all, very surprising, and we incline at present to the view that this phenomenon is a coincidence and not evidence that water is required to oxidize the mangani-manganates.

¹ It is interesting to note that in the other experiments the data presented represent true equilibrium conditions, inasmuch as the final values have been obtained both by decomposing mixes high in manganate by adding excess of alkali or of manganese dioxide and by starting with potassium hydroxide and manganese dioxide.

² Of the 5 moles of manganate only 2 are decomposed to manganite. Hence 3 moles of KOH are needed according to this equation for one of the manganate.

paper.¹ This conclusion is borne out by the appearance of the mixes after the reaction is complete. The mixes which are deficient in alkali have the dark violet, almost black hue, characteristic of the manganates even though the reaction has gone only half way to completion as, for example, in the experiments in which 1.2 and 1.5 moles of caustic were used per mole of manganese dioxide. On the other hand, those mixes which contain an excess of alkali and which show a similarly low yield have the deep green color of mangani-manganates.²

It is self-evident that the results thus obtained are of great practical interest in addition to the purely theoretical interest they possess, for they mean that in order to obtain good yields of manganate in this process the manufacturer must regulate very closely his proportions of manganese ore and caustic, as either a deficiency or an excess of 10 per cent of alkali will lower the yield by 10 to 15 per cent. In the second place the curve shows exactly what yield should be obtained for whatever ratio may be employed for any given mix and will give to the manufacturer a criterion for judging whether recourse to remoistening will be profitable or whether recausticizing of the alkali is necessary.

II—THE INFLUENCE OF IMPURITIES, ESPECIALLY SODIUM, ON THE COURSE OF THE REACTION

While the part of the investigation reported in the first section of this paper makes clear why previous investigators have not succeeded in converting all of the manganese dioxide into manganate, it sheds no light on the question raised by the fact, reported to us by a manufacturer, that new caustic and new manganese dioxide may give very much higher yields than are obtained when the residual and recovered materials are mixed with the new. It is manifest that there can be only two possible causes for the deterioration—either impurities are introduced into the materials in the course of the process or the manganese dioxide must become changed into a less active modification.

¹ It must be explicitly stated that the conclusions we have reached refer only to the conditions obtaining at 450°. Many of Sackur's experiments were carried out at nearly 900°. It is possible that at temperatures as high as this manganates decompose into mangani-manganates even without an excess of alkali, since the decomposition temperature of pure potassium manganate in an atmosphere of air is approximately 600°. Sackur would nevertheless not have been justified in applying his deductions to conditions at lower temperatures. The reason why at lower temperatures he was unable to obtain yields corresponding to the formation of manganate is that, as inspection of his data reveals, he used either too little or too much alkali.

² There is an apparent contradiction in the statements that potassium hydroxide can decompose the manganate and that at the same time manganate is not formed unless an excess of the hydroxide is present. Thus in the early stages of the treatment there is only a little of the manganate formed and there is, therefore, a large excess of alkali. Or, take for example, the result in the experiment in which the ratio of alkali to dioxide is 1.55 moles of the former to 1.0 of the latter. Here the yield is only 47.5 per cent. The final mix, therefore, contains 0.476 mole of the manganate and 0.6 mole of alkali, or an excess of about 1.2 moles of alkali for each mole of manganate, and it might be thought that this excess ought to decompose the manganate. This contradiction disappears, however, if the very logical assumption be made that the potassium hydroxide and manganese dioxide combine initially to form potassium manganite and that this is subsequently oxidized to the manganate. In this connection it is interesting to note that when the components are first mixed and dried the mass has a green color. When the excess of alkali does not exceed 1/5 mole, this color rapidly changes to that of the true manganates. Apparently then manganate and manganite do not combine to form the double compound postulated except in the presence of excess of alkali.

In order to clear up this point we proceeded, after we had determined what yields might be expected as has been described, to work with the recovered alkali and the residual dioxide. While a few experiments were carried on in which both were used, the yields obtained were so very low that we abandoned this line and attacked the question by working with new manganese dioxide ore and recovered alkali in one set of experiments and with residual manganese dioxide and new caustic in another set.

The first of these two sets of experiments was the one in which new ore and recovered caustic were used to make up the mixes. The caustic was furnished us in the form of a fairly concentrated solution. It was colored green by a small amount of unconverted manganate. After analysis¹ of the solution it was mixed with enough of the ore to produce a mix of the desired proportions. This was then treated exactly as has been described in the earlier portions of the paper.

The mixes were made up to contain from 2.17 to 2.33 moles of potassium hydroxide to one mole of manganese dioxide—a proportion chosen because it conformed to that used by the manufacturer with whom we were coöperating and from whom we obtained all of the recovered or regenerated materials. Reference to the curve will show that with new caustic and new ore we should have obtained with these proportions yields of about 85 per cent. When we substituted the recovered alkali for the new a very striking lowering of the yield resulted, for we were not able to obtain one better than about 27 to 30 per cent and repeated remoistening and treatment with oxygen even under a pressure of 40 lbs.² produced no improvement. There is, therefore, no doubt that these solutions contain some impurity which interferes with the success of the reaction. The foreign substances present in greatest amount were carbonate, chloride, manganate, silicate, and sodium. It was found that the first four named had no appreciable effect on the yield when they were separately added to new materials. Likewise, no other impurities removable by calcium hydroxide could have been responsible for the difficulty, since careful causticization of the liquor did not improve it.³

The case was found to be quite different when the effect of sodium was investigated. Analysis of the liquors furnished us showed in different samples that from 25 to 40 per cent of the alkali was in the form of sodium hydroxide. When mixes were made up from

¹ Before analysis of the solutions, they were freed from manganate by reducing it to manganese dioxide by the addition of a drop or two of formaldehyde solution. After the manganese dioxide had been filtered off, the clear solution could be titrated for free alkali or carbonate by any of the customary methods. The use of formaldehyde, while not entirely free from objection, introduced no error large enough to be of importance for this work.

² A series of experiments was conducted to determine the effect of oxygen under pressure (20 to 40 lbs.). So far as we have been able to determine up to the present such treatment merely hastens the oxidation but does not affect the final yield.

³ The recovered alkali must of course be causticized from time to time since the carbonate is apparently quite inert at the temperatures best employed for the manufacture of manganate. How often this should be done can easily be determined by use of the curve, which shows how great a reduction in yield a given decrease in free alkali will cause.

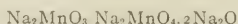
new material in which we used pure sodium hydroxide and pure potassium hydroxide in these same proportions the yields resulting were, respectively, 38 and 27 per cent. It was clear at once that here lies the source of the difficulty. In view of the fact that, even if the original caustic contains only a small amount of sodium (the latter is bound to accumulate as the caustic is used over and over again),¹ it seemed advisable to subject the influence of sodium to a systematic study, the results of which are discussed in the following paragraphs.

For this purpose we made up a series of mixes from the pyrolusite and sodium and potassium hydroxides in which the mole ratio of the alkali to manganese dioxide was kept at 2.28 to 1.0, but in which the proportion of sodium hydroxide was varied in successive experiments from 0 to 100 per cent of the total alkali. The results of this series are reproduced in Table II. In the table the first column contains the amount of sodium hydroxide in the total caustic expressed in weight per cent; the second column, the relative amount of sodium hydroxide in mole per cent; the third column, the per cent by weight of manganate obtained by the first heating in moist air; the fourth column, the per cent of manganate obtained after remoistening and reheating in moist air as previously described; the fifth column, the per cent of manganate obtained when oxygen was passed over the mixes which no longer took up oxygen from air; and the sixth column, the percentage yield determined as already described.²

TABLE II—SHOWING THE EFFECT OF SODIUM HYDROXIDE ON THE YIELD OF MANGANATE

Weight Per cent NaOH	Mole Per cent NaOH	MnO ₂ in air Per cent	MnO ₂ Remoistened Per cent	MnO ₂ in O ₂ Per cent	Yield Per cent
0.0	0	45.0	45.0	45.9	85.0
19.5	25	33.5	35.6	39.0	71.1
41.5	50	15.8	19.2	26.0	44.0
68.2	75	16.7	15.3	16.7	26.5
100.0	100	15.2	15.0	15.5	23.4

The depressing effect which substitution of sodium for potassium hydroxide exerts on the yield of manganate is strikingly shown by the table. There are two possible hypotheses which may be used to explain the phenomenon. The first is based on the work of Sackur³ who found that the mangani-manganate which he obtained at high temperatures had the formula



and therefore represents a lower stage of oxidation than does the potassium mangani-manganate of the formula $2\text{K}_2\text{MnO}_3 \cdot \text{K}_2\text{MnO}_4 \cdot 3\text{K}_2\text{O}$. We have shown, however, that at the temperatures used in this investigation, as well as in practice, the manganate and not the mangani-manganate is formed when potassium hydroxide alone is used. If the explanation

¹ This is due to the fact that sodium permanganate is extremely soluble and that therefore only the potassium is removed when the permanganate is crystallized out.

² The reader must note that the percentages given in the third, fourth, and fifth columns refer to per cent by weight of MnO₂ and not to the amount of the sodium or the potassium salt. We have made this change because in those cases in which both sodium and potassium hydroxide are used, both the sodium and the potassium salt are probably formed. The relative amount of the two is not known and therefore the method of expressing the results here used is the only one free from objection.

³ *Ber.*, 44 (1911), 777.

based on Sackur's interpretation of the reaction is to be used, we must assume that sodium manganate is much less stable than is the corresponding potassium salt. This assumption is not borne out by some preliminary experiments made by us on a fairly pure sample of sodium manganate prepared from sodium permanganate according to the directions of Auger.¹ Our experiments indicate that sodium manganate is fairly stable unless an excess of sodium hydroxide is present, under which conditions the sodium salt, like the potassium salt, decomposes into the mangani-manganate. It seems much more likely, then, that the behavior of mixtures of sodium hydroxide and manganese dioxide will prove to be similar to that of mixtures of potassium hydroxide with the dioxide. It is, therefore, quite possible that the peak in the curve for sodium hydroxide might correspond to a different composition than for potassium hydroxide, or that the angle at the peak is a much smaller one.² The final interpretation must await the completion of experiments on sodium manganate which will be reported in a later paper.

III—DETERIORATION OF THE RESIDUAL MANGANESE DIOXIDE AND VARIATIONS IN THE BEHAVIOR IN MANGANESE DIOXIDE FROM VARIOUS SOURCES

Although we have shown in the preceding section of this paper one of the causes of the decrease in the efficiency of the process when recovered material is used, there is still the possibility that the recovered manganese dioxide also may not be as satisfactory as the new ore. Manufacturers agree that ores from various sources may differ greatly in the ease and completeness with which they can be converted into manganate although they may contain equal amounts of manganese dioxide. In this connection one of our experiences is of interest. A second series like that described in the second section of this paper was performed with a different ore containing approximately the same amount of manganese dioxide. The results of the two series are compared in Table III in which the first row gives the mole per cent of the total alkali present as sodium hydroxide, the second row the final yield obtained with the first ore, and the third row the final yield obtained with the second ore.

TABLE III—SHOWING THE BEHAVIOR OF DIFFERENT ORES

Mole per cent NaOH	0	25	50	75	100
Yield with first ore, per cent	85.0	71.1	44.0	26.5	23.4
Yield with second ore, per cent	56.3	53.7	39.0	25.6	21.5

It is seen that the second ore gave very much lower yields when the alkali was all in the form of potassium hydroxide and that the difference becomes smaller as more sodium is introduced. After many ineffectual efforts to improve the yield with the second ore we finally found that if it was remoistened more than once as described in the first section of the paper the yield

¹ *Compt. rend.*, 151 (1910), 69.

² The only indications we have at the present as to whether the ratio, 2.28 moles of sodium hydroxide to 1.0 of manganese dioxide, lies on the upward or downward portion of the curve if such a curve exists, are contradictory. On the one hand a single experiment in which we used a larger amount of sodium hydroxide gave a considerably higher yield, but on the other hand the final mixes of the composition given above are green in color, whereas sodium manganate like potassium manganate is of a very dark violet hue.

for the mixture with no sodium was raised to the same value as was obtained with the first ore. By this time, however, the mixes had been rotated for many hours in the kilns and had, therefore, become thoroughly pulverized. When we, therefore, ground the ore very fine before using it the results were likewise improved. The state of division is not, however, the sole factor in the difference between the two ores for we have worked with ore coarser than the second and obtained excellent results. A more important factor appears to be the ease with which the ore becomes pulverized in the kilns (hardness).

In view of the facts stated, we therefore made another set of experiments in which we used recovered and residual manganese dioxide with new potassium hydroxide. The former was obtained from the same manufacturer who had furnished us with the recovered alkali described in the second section. The ratio of alkali to manganese dioxide was again 2.28 moles of the former to one of the latter. When the old manganese dioxide, as we may call the material for brevity, was used just as it was received, it gave uniformly low yields—from 25 per cent to 35 per cent of the theoretical—while we should have obtained about 85 per cent. Since it is well known that manganese dioxide absorbs (or perhaps combines with) relatively large amounts of caustic alkalies, we suspected that the old dioxide might be contaminated with considerable sodium hydroxide. We therefore washed it very thoroughly with water and in some cases boiled it with dilute nitric acid. When the recovered and residual dioxide was fresh it responded very well to this treatment; material which had been kept for some time, and especially material which had dried out, was not much improved. These results point to the conclusion that it was the absorbed sodium hydroxide which was responsible for the deteriorating of the dioxide and which becomes more difficult to remove as the material dries out. Since the first section of the paper shows how large amounts of residual dioxide can be avoided and as it is not necessary to convert the manganate into permanganate by processes in which large amounts of dioxide are reprecipitated, it did not seem necessary for us to follow up this point further.

SUMMARY

1—It is found that when manganese dioxide is heated with potassium hydroxide in a current of air to produce potassium manganate, the reaction frequently stops before the maximum oxidation stage has been reached. This can be avoided by remoistening and reheating the mix; the use of moistened air also is helpful.

2—The yield of potassium manganate varies greatly with the proportion of potassium hydroxide in the mixes. At the temperatures at which these experiments were carried out and with the pyrolusite used, practically all of the manganese dioxide is converted into manganate when 2.5 moles of potassium hydroxide are used for each mole of manganese dioxide.

3—The conclusions of Sackur that in this reaction mangani-manganates and not manganates are obtained

and that the maximum yield attainable is, therefore, only 60 per cent, is thus proved to be incorrect.

4—Larger amounts of alkali, however, cause the manganate to decompose into a mangani-manganate, similar to, if not identical with, that postulated by Sackur.

5—The substitution of sodium hydroxide for potassium hydroxide greatly lowers the yield if the proportions between alkali and manganese dioxide named are employed. What the effect of other proportions would be is as yet undetermined. Care must be taken, therefore, not to allow sodium to accumulate in the recovered caustic when the operation is carried out continuously.

6—It is very important to pulverize the ores very finely and to keep them finely divided in the kilns in order to obtain the highest possible yields. Some ores are more difficult to handle in this respect than are others.

7—The residual manganese dioxide sometimes deteriorates on repeated use. This may be caused by absorption of impurities from the solution. If the dioxide before it has had time to dry out is thoroughly washed with water or boiled with dilute nitric acid, its effectiveness for the process may be restored.

This work is to be continued along the lines suggested. A number of similar problems connected with the preparation of barium manganate remain to be solved and work on these has also been begun.

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THE DETERMINATION OF ZINC AND COPPER IN GELATIN¹

By GEORGE S. JAMIESON

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One method used for the determination of zinc and copper in gelatin is based upon the complete destruction of the organic matter by digestion with nitric and sulfuric acids.² After the digestion is completed, water is added, and the solution is made slightly alkaline with ammonium hydroxide. Then a measured quantity of hydrochloric acid is added. The copper is precipitated as sulfide and filtered. The filter containing the copper sulfide is digested with nitric and sulfuric acids until a colorless solution is obtained. The copper is finally titrated by the well known iodide-thiosulfate method. When the hydrogen sulfide has been removed from the filtrate containing the zinc, ammonium chloride is added along with ammonium hydroxide to make the solution alkaline. Enough hydrochloric acid is added to render the solution acid to methyl orange. After adding a large excess of sodium or ammonium acetate, the zinc is precipitated with hydrogen sulfide and filtered. The zinc sulfide is dissolved in hydrochloric acid and the resulting filtrate is boiled to remove the hydrogen sulfide. A small amount of ferric chloride is added and a basic acetate precipitation is made in the usual manner in

¹ Published by permission of the Secretary of Agriculture.

² Methods of analysis, A. O. A. C., 1916, 175.

order to separate any phosphates present from the zinc. The zinc is precipitated from the filtrate as sulfide and after filtration is ignited to the oxide. It is well known that the digestion of gelatin with nitric and sulfuric acids requires almost constant attention during the entire process which generally takes 2 hrs. and sometimes longer for completion. In addition to the digestion, the long analytical procedure makes the method unsatisfactory.

Several years ago C. R. Smith decomposed gelatin with hydrochloric acid in connection with the determination of arsenic¹ and suggested that this method of decomposing gelatin could be used to advantage for the determination of the other metals in place of the tedious digestion process. Mr. Smith and a number of other chemists have employed the hydrolysis method for the determination of zinc and copper in gelatin. Since the method of separating the zinc and copper from the hydrolyzed solution is somewhat different from that employed in the digestion method, it will be briefly described. A small amount of magnesia mixture and an excess of sodium phosphate solution are added along with enough ammonium hydroxide to make the hydrolyzed gelatin solution alkaline. Then the zinc and copper are precipitated together as sulfides and filtered. The crystalline precipitate of ammonium magnesium phosphate serves to collect the metallic sulfides so that they can be readily filtered. The precipitate is treated with a cold solution of 1 : 10 hydrochloric acid which has been saturated with hydrogen sulfide in order to dissolve the zinc sulfide and leave the copper sulfide on the filter. The zinc and the copper are determined as described above.

It is believed that the following method will be found much simpler than those now used. The size of the sample taken for analysis varies from 20 to 50 g., according to the amount of zinc and copper present. The samples are weighed into 500 cc. beakers and treated with 100 cc. of water and 15 to 30 cc. of hydrochloric acid, depending upon the amount of gelatin taken for analysis. The covered beakers are heated for an hour or two on the steam bath. During the first part of the heating, the solutions are agitated several times in order to loosen any lumps adhering to the bottom of the beakers. After hydrolysis the solutions are made very slightly alkaline with ammonium hydroxide and allowed to cool to about 40° C. Then hydrogen sulfide is passed into the solutions for 2 min. While passing in the hydrogen sulfide, the solutions should be stirred several times with the delivery tube in order to facilitate the separation of the sulfides in the form most suitable for filtration. When the sulfides have settled for about 10 min., they are filtered on a 0 cm. filter and washed several times with a very dilute solution of colorless ammonium sulfide. The wash solution is prepared by passing hydrogen sulfide for several minutes into 250 cc. of water which contains 0.5 cc. of 1 : 1 ammonium hydroxide. In the case of high-grade gelatin it is recommended that about 2.5 mg. of iron should be added to the hydrolyzed gelatin before making the solution alkaline.

It is found that the ferrous sulfide greatly facilitates the precipitation and the filtration of small quantities of zinc and copper sulfides. The iron is conveniently added in the form of a standard solution which contains 2.49 g. of ferrous sulfate in 1000 cc. (1 cc. = 0.5 mg. of iron). If the directions given above are closely followed in making the hydrolyzed gelatin solution very slightly ammoniacal, there is no danger of leaving any weighable amount of copper sulfide dissolved in the ammonium sulfide in the filtrate. The sulfides are dissolved by pouring a small quantity of very hot 1 : 1 nitric acid around the upper edge of the filters. The filters are washed very thoroughly with water at room temperature. The filtrate is evaporated with 10 cc. of 1 : 3 sulfuric acid until all the nitric acid is expelled. When the sulfuric acid is cool, 30 cc. of water are added, and the solution is filtered to remove the silica. The filtrate, which should have a volume of about 100 cc., is warmed to about 50° C. and hydrogen sulfide is passed into the solution for at least 5 min. in order to precipitate the copper completely. The copper sulfide is filtered on a Gooch crucible and washed with hot water saturated with hydrogen sulfide. During the filtration and washing of the precipitate a very gentle suction is employed, otherwise there is the danger of having some of the copper sulfide pass through the crucible. When the washings have thoroughly drained, the Gooch crucible is placed inside of a porcelain crucible and dried over a small flame for a few minutes. Then the flame is gradually increased to its capacity. At this point the outer crucible is removed and the Gooch crucible heated directly in the oxidizing part of the flame for 15 min. After cooling and weighing, the crucible is heated again as hot as possible for 5 min. more in order to be certain that all the copper is converted into the oxide. The filtrate containing the zinc is heated until the hydrogen sulfide is expelled. After adding about 5 cc. of ammonia in excess of that required to neutralize the sulfuric acid in the solution, 15 cc. of 50 per cent formic acid are added and a rapid stream of hydrogen sulfide is passed into the solution for 5 min. to precipitate the zinc sulfide. It is important to stir the solution with the delivery tube while passing in the hydrogen sulfide until the larger part of the zinc is precipitated. The solution containing the zinc sulfide is heated on the steam bath for about half an hour. The zinc sulfide is filtered on a Gooch crucible and washed with a 2 per cent solution of ammonium thiocyanate. During the filtration and washing of the precipitate, it is best to use either no suction or at most a very slight suction. When all of the precipitate is in the crucible and the wash solution has largely run through, the suction is increased until it is sufficient to drain the crucible properly. The zinc sulfide is dried and ignited to convert it into the oxide in the same manner as the copper sulfide is treated. After weighing, the crucibles containing the oxides of zinc and copper are treated with hydrochloric acid, thoroughly washed with water, and ignited in order to prepare them for subsequent analyses.

Several samples of commercial gelatins of various

¹ J. Assoc. Official Agr. Chemists, [2] 1 (1915), 244.

grades were analyzed by the hydrolysis method described above as well as by the digestion method for the sake of comparison. In the digestion analyses it should be noted that the copper was determined by weighing the oxide in place of the volumetric method given above. Also the zinc was precipitated as sulfide in the presence of ammonium formate and formic acid instead of ammonium acetate and acetic acid.

In conformity to the usual custom, the results of the analyses are stated in terms of milligrams of metal per kilo of gelatin or parts per million.

No.	HYDROLYSIS METHOD		DIGESTION METHOD	
	Cu P. p. m.	Zn P. p. m.	Cu P. p. m.	Zn P. p. m.
1.....	..	1341.0	..	1341.0
1.....	..	1341.0	..	1340.0
1.....	..	1341.0	..	..
2.....	..	126.0	..	122.0
3.....	..	128.0	..	..
3.....	32.0	96.4	32.0	96.4
3.....	26.6	104.0	32.0	96.4
4.....	20.0	64.0	20.0	68.0
4.....	24.0	56.0	20.0	56.0
5.....	24.0	77.9	24.0	80.3
5.....	22.4	80.3	24.0	80.3
5.....	20.0	80.3	..	76.0

The copper was separated but was not determined in Samples 1 and 2 because at first it was intended only to investigate the determination of zinc.

In order to test the method further, measured quantities of standard solutions of zinc and copper were added to weighed amounts of Sample 5. The hydrolysis and analyses were made as described above with the following results:

SAMPLE TAKEN Grams	Cu Added Mg.	Zn Added Mg.	Cu Found Mg.	Zn Found Mg.
20	2.5	2.8	2.5	2.7
20	3.0	3.1	3.1	3.2
20	2.5	4.7	2.4	4.7
20	2.0	3.1	1.9	3.2

It should be observed that the amount of zinc and copper in 20 g. of Sample 5 gelatin as determined by averaging the results obtained by previous analysis, has been deducted from the results given above. The results obtained with these trial analyses show that the method is accurate.

In order to obtain satisfactory results, it is most important that the directions be followed in every detail. Furthermore, great care must be taken to eliminate by filtration any non-volatile matter which may separate during the course of the analyses, before proceeding to make the final precipitation of the zinc or copper sulfides. Also, the Gooch crucibles used must be prepared so that they will not lose weight during the filtration and ignition of the sulfides.

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THE DEOXYGENATING EFFECT OF THE EFFLUENT FROM THE MILES ACID PROCESS OF SEWAGE TREATMENT

By F. W. MOHLMAN

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Experiments with the Miles acid process of sewage treatment were conducted at the New Haven Sewage Experiment Station under the direction of Prof. C. E. A. Winslow, from June 1, 1917, until May 1, 1918, in comparison with three other processes which have been considered for New Haven conditions.¹

¹ Eng. News Record, 79 (1917), 18.

Some very interesting facts were established during this work regarding the Miles acid process.

The Miles patent, No. 1,134,280 claims that the Miles process "(1) consists in introducing—an inorganic acid as the sole effective agent" and "(3) consists in introducing sulfurous acid into the sewage."

Sulfurous acid seems to have a selective toxic action on bacteria which is more intense than is obtained by the same hydrogen-ion concentration of sulfuric acid. The effect of the sulfurous acid is augmented by the germicidal power of the bisulfites formed from the bicarbonates. Therefore, from the standpoint of effective disinfection, sulfurous acid is preferable to sulfuric. It also has the decided advantage of being cheaper, when made as needed, by burning sulfur or pyrites and conducting the gas into a part of the sewage, which can then be used for acidifying the remaining sewage.

We have applied compressed sulfur dioxide to the sewage as it flowed into a settling tank through a galvanized iron pipe about 20 ft. long. The settling tank was 16 ft. long, 4 ft. wide, and 4 ft. deep. The detention period was 4 hrs. when treating 10,000 gal. of sewage per day. After acidification the sewage contains bisulfites and some free sulfurous acid. It also contains lime and magnesium soaps, which are attacked by the acid, liberating the free fatty acids. As the sewage passes through the tank, part of the bisulfites and sulfurous acid is oxidized to bisulfates and sulfuric acid. In the effluent there is a mixture of sulfurous acid, sulfuric acid, bisulfites, RHSO_3 (R indicating Na, K, Ca, Mg, or Fe), and bisulfates, RHSO_4 . The oxidation takes place at the expense of the dissolved oxygen in the sewage, and some oxygen is also supplied by absorption of atmospheric oxygen from the surface of the liquid. The oxidation may easily be followed by determining total sulfur dioxide in both bisulfites and sulfurous acid by titration, using an excess of iodine solution. By titration with standard sodium hydroxide, using methyl orange as indicator, all of the sulfuric acid but only half of the sulfurous acid is determined. This is due to the fact that the reaction $\text{H}_2\text{SO}_3 + \text{NaOH} = \text{NaHSO}_3 + \text{H}_2\text{O}$ takes place, and NaHSO_3 reacts neutral to methyl orange. To get accurate results as to the total acidity, all sulfurous acid should first be oxidized to sulfuric acid or else the sulfur dioxide in the sulfurous acid must be determined. Titration with standard sodium hydroxide using phenolphthalein as indicator includes the acidity due to bisulfites as well as that due to sulfurous acid and sulfuric acid, as NaHSO_3 reacts acid to phenolphthalein. By a combination of the three titrations the exact state of oxidation of the sulfur dioxide may be followed. These facts must be remembered in determining the acidity of the Miles effluent, as erroneous results may be reported when titrating with methyl orange when the effluent contains unoxidized sulfur dioxide. We have usually attempted to carry the free acidity to 50 p. p. m. (as CaCO_3).

Preliminary tests made on February 14, 1918, showed a total content of 118 p. p. m. of sulfur dioxide

in the effluent. In order to determine whether this sulfur dioxide would use up the dissolved oxygen in the diluting water if it were discharged into the New Haven harbor, various mixtures of the effluent with sea water from the harbor were made. No special care was taken to exclude atmospheric oxygen during the mixing. Partial analysis of the sea water and effluent is given in Table I.

TABLE I—PARTIAL ANALYSIS OF SEA WATER AND EFFLUENT

	Sea Water	Effluent
Temperature, deg. C.....	4	10
Chlorine, p. p. m.....	10,000	...
Dissolved oxygen, p. p. m.....	12.0	0.8
Sulfur dioxide, p. p. m.....	0.0	118
Alkalinity, p. p. m.....	77	—134 (acid)

As soon as possible after dilution, dissolved oxygen and sulfur dioxide were determined in the mixtures. The results shown in Table II were obtained.

TABLE II—MIXTURE OF SEA WATER AND THE MILES EFFLUENT

	Sea Water	1 Effluent 2 Water	1 Effluent 4 Water	1 Effluent 9 Water	1 Effluent 19 Water
Dissolved oxygen... 0.8	12.0	1.0	5.0	8.8	11.0
Sulfur dioxide... 118	0	8	0	0	0

A great decrease in the dissolved oxygen took place in the dilutions containing 20 per cent or more of the effluent. Table III shows the reduction in dissolved oxygen due simply to dilution, the amount required for oxidation of the sulfur dioxide in each dilution, and the difference between the latter and the former, the oxygen taken up from the air in completing the oxidation.

TABLE III—OXIDATION OF SULFUR DIOXIDE BY DISSOLVED OXYGEN

DILUTION	Dissolved oxygen immediately after dilution	Dissolved oxygen used by dilution alone	Dissolved oxygen in oxidation of SO_2	SO_2 in each dilution, none were oxidized	Dissolved oxygen required for oxidation of SO_2	Oxygen from air (Col. 5—Col. 3)
Sea Water.....	12.0	...	...	0.0	0.0	...
Effluent.....	0.8	...	...	118.0	22.5	...
1 Effluent, 2 H_2O	1.0	8.3	2.1	31.0	7.7	0.4
1 Effluent, 4 H_2O	5.0	9.8	4.8	24.0	6.0	1.2
1 Effluent, 9 H_2O	8.8	10.8	2.0	11.8	2.9	0.9
1 Effluent, 19 H_2O	11.0	11.4	0.4	6.0	1.5	1.1

From these results it is probable that there is immediate quantitative oxidation of the sulfur dioxide, according to the reaction $\text{SO}_2 + \text{O} = \text{SO}_3$. In this reaction one part per million of oxygen oxidizes 4 p. p. m. of sulfur dioxide. The oxidation takes place immediately after dilution is made. It was also determined that not only the sulfur dioxide present as sulfurous acid is oxidized, but also that present as bisulfite. The seriousness of this fact may well be imagined. If a certain sewage has an average alkalinity of 175, which is not high, and sulfur dioxide is applied to give an acidity of 50, the effluent would contain about 200 p. p. m. of SO_2 , the 25 remaining parts probably being oxidized while passing through the tank. These 200 parts of sulfur dioxide will reduce 50 parts of dissolved oxygen upon dilution, or in terms of dilutions at summer temperatures, one volume of effluent will immediately reduce all of the oxygen in 5 to 7 volumes of sea water. An oxygen demand of 50 p. p. m. is not high, as most sewages have biochemical oxygen demands of from 200 to 300 p. p. m., but the serious aspects of the discharge

of this effluent into diluting water is that the oxygen is absorbed immediately according to a definite chemical reaction, while the biological consumption does not take place nearly so quickly, allowing much longer time for dilution and dispersion. It is not improbable that there might be a distinct zone of de-aerated water at the outfall of the effluent from the Miles process.

In order to determine whether the sulfur dioxide might be oxidized before the effluent is discharged, an aerating tank was constructed by Mr. Harold G. Wynne, of the City Engineer's office, who assisted in the experimental work. This tank, as shown in Fig. 1, consisted of two concrete drainpipes 30 in. in diameter, placed one above the other, with a filter plate one foot square cemented into an iron plate at the bottom. Air was blown through this plate from a Nash hydro-turbine, the pressure being measured by a mercury manometer and the volume being measured by a gas meter.

The tank was used both on the fill-and-draw and continuous plan. When used intermittently it was filled with effluent and the air started, samples being withdrawn at intervals and analyzed for sulfur dioxide, the quantity of air being measured at the time each sample was withdrawn. Results of an average experiment of this kind are given in Table IV.

TABLE IV—AERATION OF THE MILES EFFLUENT

Date.....	March 4, 1918		
Quantity of effluent.....	220 gal.		
Quantity of air.....	21.0 cu. ft. at 6.4 in. mercury		
Quantity of free air.....	25.5 cu. ft.		
Time	SO ₂	Reduction	Air
Min.	P. p. m.	Per cent	Cu. ft. per gal.
0	78.1	...	...
10	71.7	8	0.029
20	53.8	31	0.058
30	23.0	70	0.087
40	10.2	87	0.116

Effluent mixed with sea water, before and after aeration, dissolved oxygen determined immediately.

SAMPLE	(Dissolved oxygen—Before)	After
Effluent.....	1.4	5.8
Sea Water.....	14.2	...
1 Effluent, 2 Sea Water.....	4.4	11.8
1 Effluent, 4 Sea Water.....	7.4	11.8

The results of this experiment have been substantiated by various other experiments on the fill-and-draw plan. The tank was next used as an aerator on the continuous-flow plan. The effluent from the Miles tank was passed through the tank as shown in Fig. 1, having a detention period of 31 min. Samples of the influent were taken at 3 and 9 A.M. and P.M., and of the effluent 30 min. later. The average results of these experiments are shown in Table V.

TABLE V—CONTINUOUS AERATION OF THE MILES EFFLUENT

Date	Influent	Sulfur dioxide—Effluent	Reduction Per cent	Air Cu. ft. per gal.
3/6/18.....	99.1	44.9	54	0.10
3/7/18.....	79.4	14.4	79	0.10
3/8/18.....	72.3	14.4	80	0.11
3/9/18.....	69.1	5.2	92	0.10
3/10/18.....	81.3	46.4	43	0.10
3/11/18.....	80.9	36.1	55	0.06
3/31/18.....	53.8	10.2	81	0.10
4/1/18.....	108.5	37.4	65	0.10
4/2/18.....	90.9	26.8	71	0.10
4/3/18.....	71.0	19.5	72	0.10
4/4/18.....	92.2	4.5	95	0.10
AVERAGE.....	78.1	23.6	70	0.097

These results are quite similar to those obtained on the fill-and-draw plan, with 30 min. aeration, except that slightly more air is necessary. The close agreement in sulfur dioxide content in the effluent is ac-

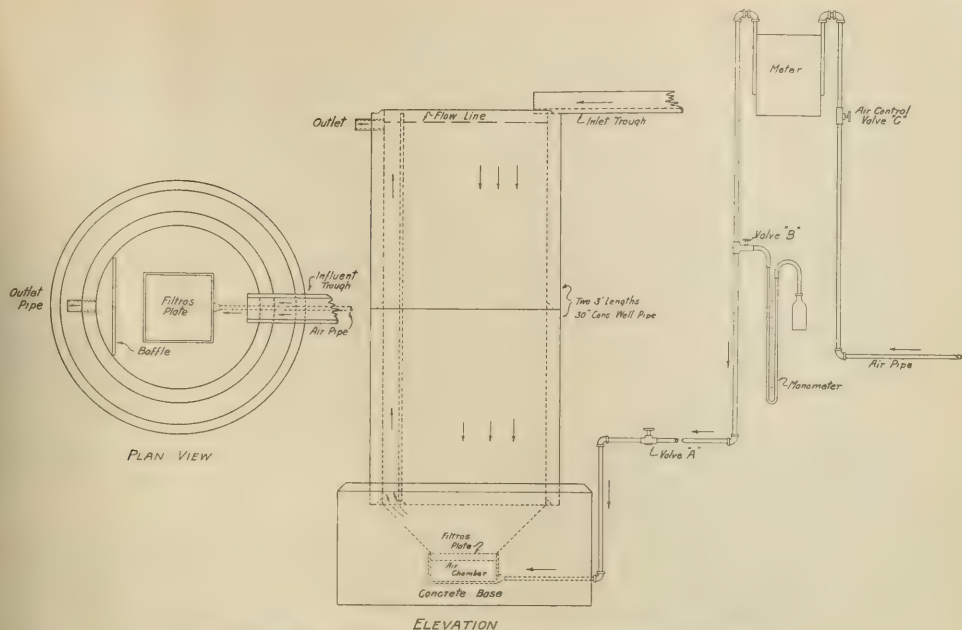


FIG. 1.—TANK USED FOR AERATION OF EFFLUENT FROM THE MILES ACID PROCESS

cidental. In each method 70 per cent of the sulfur dioxide was removed in 30 min. aëration, but with 97,000 cu. ft. of free air per million gallons of effluent when operating continuously, as compared with 87,000 cu. ft. per million gallons on the fill-and-draw plan.

The aërated effluent did not de-aërate the diluting water to an appreciable amount at any time, and thus could be discharged into the harbor with safety. Bacterial counts made by Mr. W. S. Sturges before and after aëration showed that there was practically no change in the bacterial content.

Laboratory experiments in which wood plates were used for diffusing the air indicated that the amount of air required could be reduced considerably by diffusing the air very finely. This experience is similar to that found in the activated sludge experiments at Milwaukee, but it is probable that this oxidation, which is purely chemical, is even more affected by the fineness of division of the air than is the oxidation in the activated sludge process, which is biological. The quantities of air used in the experiments with the filterose diffuser were from one-fiftieth to one-twentieth of those used in the aëration with activated sludge, so it is probable that the cost of this aëration would be low. The tank used for the aëration was too shallow to be very efficient, and it is believed that the results obtained in these experiments could be greatly improved by further work. While this aëration will make a Miles plant more complicated and the process more costly, it does not necessarily condemn the process, as the aëration period is very short and

the amounts of air necessary but a small fraction of those required in the activated sludge process.

CONCLUSIONS

I—The Miles acid effluent contains unoxidized sulfur dioxide.

II—This sulfur dioxide is oxidized at the expense of the dissolved oxygen in the water in which the effluent is diluted.

III—The sulfur dioxide may be oxidized before dilution by aëration for a short time with relatively small quantities of air. After this aëration the effluent will not de-aërate large volumes of diluting water.

DEPARTMENT OF HEALTH
NEW HAVEN, CONNECTICUT

DOUBLE SALTS OF CALCIUM AND POTASSIUM AND THEIR OCCURRENCE IN LEACHING CEMENT MILL FLUE DUST

By E. ANDERSON

Received August 13, 1918

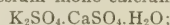
The recent development of the cement potash industry has served to direct attention to certain double salts of potassium and calcium which have heretofore been of interest chiefly to the scientific investigator. Of these the potassium mono-calcium sulfate, $K_2SO_4 \cdot CaSO_4 \cdot H_2O$, or syngenite, is perhaps most familiar, but the potassium penta-calcium sulfate, $K_2SO_4 \cdot 5CaSO_4 \cdot H_2O$, is equally important. The occurrence of these salts in the natural potash deposits and the fact that they can be easily made artificially from their simple constituents indicates the possi-

bility of the formation of such compounds in solution from potash-bearing flue dust, since such dust nearly always contains both potassium and calcium sulfates.

Numerous papers have been published during the past years by both German and American investigators discussing fully the nature and properties of these compounds, and rather complete data on the conditions necessary for their formation and existence are therefore available. A knowledge of these relationships is important in dealing with the problem of leaching potash from cement mill flue dust, and as it appears as though the original articles referred to have escaped the notice of most of the chemists now engaged in this field of potash manufacture, a résumé of the data from these papers may be of interest.

We owe much of our present knowledge about the double salts of potassium and calcium to the investigations carried on by J. H. van't Hoff from 1897 to 1908 on the formation of the Stassfurt salt deposits. Van't Hoff was assisted in this work by a number of investigators from many parts of the world. The list of names of these coworkers shows how thoroughly cosmopolitan the group was, as one reads, for example, O. Biach, W. C. Blasdale, D. Chiaraviglio, and F. G. Cottrell.

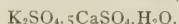
Three double sulfates of calcium and potassium appear to have been studied by these investigators. These were potassium mono-calcium sulfate,



potassium di-calcium sulfate,



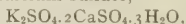
and potassium penta-calcium sulfate,



Of these, the potassium mono-calcium sulfate, to which has been given the shorter name of syngenite, seems to have been the first to be identified. This double salt was apparently first made artificially as early as 1850.¹ Shortly after this a double sulfate of potassium and calcium was found in the Stassfurt salt deposits, and was named kalusit. Later on, however, this natural salt was identified as the potassium mono-calcium sulfate, and the mean was subsequently changed to syngenite,² which name has, however, only recently become familiar to the industrial chemist.

This double salt, syngenite, may be prepared by dissolving 120 g. K_2SO_4 in 1000 cc. of water and adding to this 100 cc. of a 20 per cent solution of CaCl_2 . At first gypsum separates out and this is then converted into syngenite, which appears under the microscope as square-ended needle-like crystals. These can again be converted into gypsum by the addition of water.

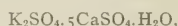
Potassium di-calcium sulfate,



has been described by Ditte,³ but later investigators seem to have failed to prepare this salt from solutions of potassium sulfate. Thus van't Hoff and Geiger⁴ investigated solutions at 83° C. while J. D'Ans and

Schreiner¹ worked at temperatures between 140° C. and 170° C. without positive results. D'Ans states, however, that a potassium di-calcium sulfate had been prepared from the fused mixture of the two salts.

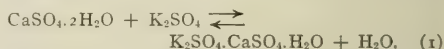
Potassium penta-calcium sulfate,



was first prepared by van't Hoff and Geiger² by boiling precipitated calcium sulfate with a 5 per cent solution of potassium sulfate. The potassium penta-calcium sulfate then forms in well defined crystals, similar in appearance to those of gypsum.

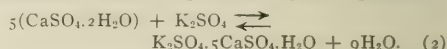
The equilibrium conditions between 0° C. and 83° C. for the formation of both syngenite and the penta-calcium salt have been determined by various investigators. Syngenite is stable in solutions of the proper concentrations at all temperatures investigated, that is, between 0° C. and 170° C. Potassium penta-calcium sulfate, however, is only stable above 31.8° C.

From 0° C. to 31.8° C. syngenite is the only stable double salt. The concentrations of potassium sulfate necessary for the equilibrium represented by the equation

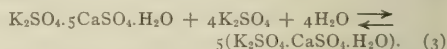


varies with the temperature, the concentration increasing with an increase in temperature.

At temperatures higher than 31.8° C. either of two double salts can exist, namely, the mono-calcium salt, or the penta-calcium salt. With lower concentrations of potassium sulfate the equilibrium may be established which is represented by the equation



With solutions of higher concentrations of potassium sulfate syngenite can be in equilibrium with the potassium penta-calcium sulfate as expressed in the equation



The concentrations for the equilibria referred to have been determined, as previously mentioned, by various investigators such as van't Hoff and his coworkers in Germany³ and Cameron and Breazeale⁴ in America. J. D'Ans has compiled much of these data in an article entitled, "Investigations of the Calcium Alkali Sulfates."⁵ The data given in that article, together with the concentration-temperature diagram accompanying same, show clearly the conditions necessary for the formation and existence of the two double salts, syngenite and potassium penta-calcium sulfate.

The following tables give the concentrations of potassium sulfate required to establish equilibrium with syngenite and potassium penta-calcium sulfate at the temperatures stated.

¹ *Z. anorg. Chem.*, **63**, 129-67.

² "Untersuchungen der ozeanischen Salzablagerungen," p. 275.

³ Van't Hoff, "Untersuchungen der ozeanischen Salzablagerungen."

⁴ *J. Phys. Chem.*, **8** (1904).

⁵ *Z. anorg. Chem.*, **62**.

¹ *Jahresber.*, **1880**, p. 298.

² *Ibid.*, **1880**, p. 1142.

³ *Compt. rend.*, **1877**, pp. 84-86.

⁴ "Untersuchungen der ozeanischen Salzablagerungen," p. 276.

TABLE I—EQUILIBRIUM CONCENTRATION OF SOLUTIONS OF POTASSIUM SULFATE AND SOLID SYNGENITE, POTASSIUM PENTA-CALCIUM SULFATE, OR GYPSUM

Temp. ° C.	Mols. K_2SO_4 per 1000 mols. H_2O	Mols. K_2SO_4 per 1000 g. Solution	Solid Phases
0	2.1	0.119	Syngenite, gypsum
25	3.22	0.173	
31.8	3.70	0.20	Syngenite, gypsum, penta-calcium salt
40	4.4	0.23	Syngenite and penta-calcium salt
60	6.8	0.35	
83	9.9	0.50	

TABLE II—EQUILIBRIUM CONCENTRATIONS OF SOLUTIONS OF POTASSIUM SULFATE AND SOLID POTASSIUM PENTA-CALCIUM SULFATE AND GYPSUM

Temp. ° C.	Mols. K_2SO_4 per 1000 mols. H_2O	Mols. K_2SO_4 per 1000 g. Solution	Solid Phases
31.8	3.70	0.20	Syngenite, gypsum, penta-calcium salt
40	3.8	0.203	Penta-calcium salt, gypsum
60	2.4	0.130	Penta-calcium salt, gypsum
83	1.3	0.070	Penta-calcium salt, gypsum

The data for the concentration of calcium sulfate in these solutions appear only for 0° C. and 25° C.

TABLE III—EQUILIBRIUM CONCENTRATION OF $CaSO_4$ FOR SOLID SYNGENITE AND GYPSUM

Temp. ° C.	Mols. $CaSO_4$ per 1000 mols. H_2O	Mols. of $CaSO_4$ per 1000 g. Solution
0	0.113	0.0064
25	0.223	0.012

In the following diagram by D'Ans (Fig. 1) the data from Tables I and II have been plotted so as to more clearly show the relationships expressed.

In practice, the concentration of solutions is more often given as grams per liter, or as per cent. While no data were given in the paper referred to on the densities of the solutions in question, so as to permit the calculation of the concentrations in grams per liter, a diagram (Fig. 2) has been constructed giving these values in per cent by weight, which may be of interest in comparing commercial solutions. This curve is based upon the following calculated data:

TABLE IV—EQUILIBRIUM CONCENTRATIONS OF SOLUTIONS OF POTASSIUM SULFATE IN CONTACT WITH SYNGENITE, POTASSIUM PENTA-CALCIUM SULFATE OR GYPSUM

Temp. ° C.	Per cent K_2SO_4	
	Syngenite Curve	Potassium Penta-calcium Sulfate Curve
0.0	2.07	
25.0	3.04	
31.8	3.49	3.49
40.0	4.01	3.56
60.0	6.10	2.27
83.0	8.72	1.22

A consideration of the diagrams gives a clear idea of the conditions necessary for the formation and existence of these double salts. Thus, at 0° C., gypsum is stable in saturated solutions of calcium sulfate which contain up to 2.07 per cent of potassium sulfate. If syngenite crystals were placed in such solutions they would break up into solid $CaSO_4 \cdot 2H_2O$, with simultaneous solution of potassium sulfate.

At exactly the concentration given, namely, 2.07 per cent potassium sulfate, syngenite and gypsum are stable as solid phases. If solid potassium sulfate be added to such a solution, more syngenite will form in accordance with Equation 1, and the potassium sulfate concentration will not permanently increase until all of the gypsum has been so converted.

In similar solutions of higher concentration of potassium sulfate, syngenite is the only stable solid except, of course, where the concentrations are high

enough to permit solid potassium sulfate to separate out. To make this clear the solubility curve of potassium sulfate has been added to the diagrams. If, then, gypsum be added to solutions containing over 2.07 per cent potassium sulfate it will finally all be converted into syngenite, provided that the potassium sulfate concentration be maintained.

It is evident from the diagram that the equilibrium concentration of potassium sulfate necessary for the formation of syngenite increases rapidly with the temperature. At 31.8° C., however, a new double salt can form, namely, potassium penta-calcium sulfate. This temperature and the corresponding solution concentration therefore make a triple point, where the solid phases gypsum, potassium penta-calcium sulfate, and syngenite can exist in equilibrium with the solution, this solution containing 3.50 per cent potassium sulfate and being saturated with respect to calcium sulfate.

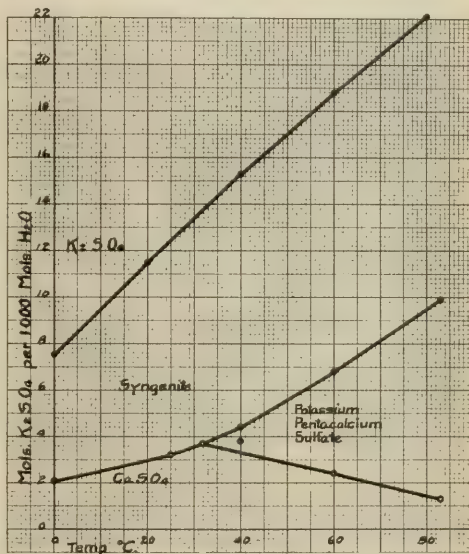


FIG. 1

The equilibrium temperature and concentration for the triple point have been determined by several different investigators and are probably very nearly correct. It is therefore likely that the value given for the concentration of potassium sulfate for the penta-sulfate-gypsum equilibrium at 40° C. is too high. This is evidently the reason why the point was not connected in the curve of the D'Ans diagram.

The equilibrium concentration for the penta-calcium salt decreases as the temperature increases from this triple point. If, then, a solution containing 3.49 per cent potassium sulfate is heated above 31.8° C. in contact with solid syngenite, penta-calcium sulfate, and gypsum, the syngenite and gypsum will be converted into potassium penta-calcium

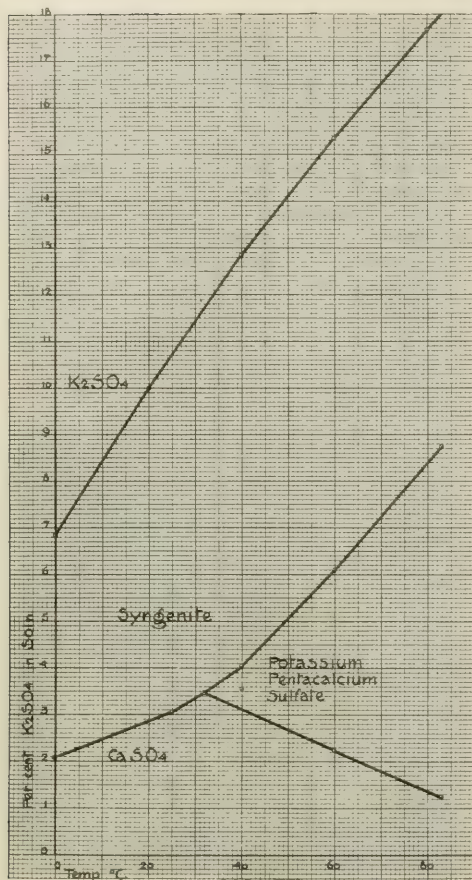


FIG. 2

sulfate, the point on the plot being moved to the right from the triple point into the potassium penta-calcium sulfate field, as indicated by the dotted line *a* in Fig. 3. On the other hand, if the solution is cooled below 31.8° C. the penta-calcium salt together with the gypsum will combine with potassium sulfate and form syngenite, the point on the plot being moved to the left from the triple point into the syngenite field, as indicated by the dotted line *b* in Fig. 3.

Similarly in solutions having a concentration of potassium sulfate of 2.27 per cent the gypsum will begin to combine with potassium sulfate at 60° C. to form $K_2SO_4 \cdot 5CaSO_4 \cdot H_2O$.

At this concentration both gypsum and the penta-calcium sulfate are in equilibrium with the solution in accordance with Equation 2. If the temperature is raised above 60° C. and the solution concentration maintained with respect to potassium sulfate, all of the gypsum will combine with potassium sulfate to form $K_2SO_4 \cdot 5CaSO_4 \cdot H_2O$, the point on the plot lying inside

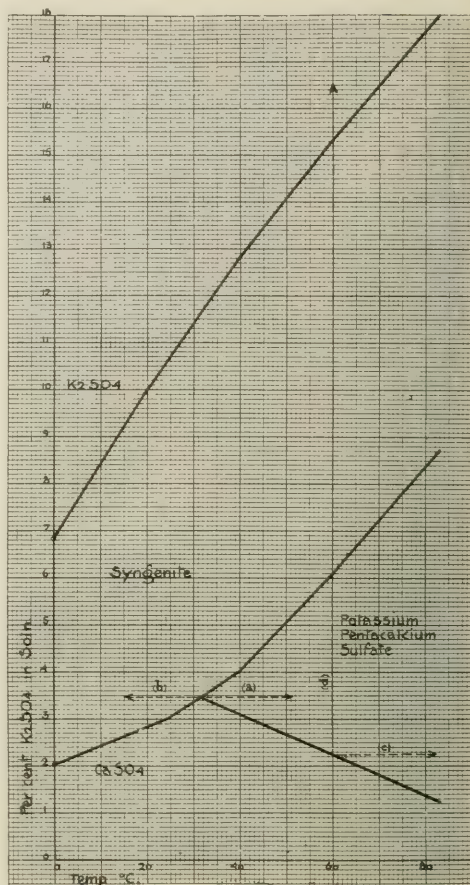


FIG. 3

the potassium penta-calcium field along the dotted line *c* (Fig. 3).

On the other hand, if we start at the same point, namely, potassium sulfate concentration of 2.27 per cent and temperature of 60° C., and if the concentration of potassium sulfate be then increased, the equilibrium will shift along the dotted line *d* (Fig. 3). On increasing the concentration the gypsum will all be converted into potassium penta-calcium sulfate, this being the only stable solid phase, until a solution concentration of 6.1 per cent potassium sulfate has been attained. At this point syngenite may form, both potassium penta-calcium sulfate and syngenite being in equilibrium with the solution, in accordance with Equation 3, and as indicated in the plot.

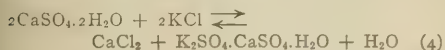
If the concentration of potassium sulfate be increased beyond this point and temperature maintained at 60° C. all of the potassium penta-calcium sulfate will be converted into syngenite, and this latter salt will then be the only stable phase until the

solution becomes saturated with respect to potassium sulfate, which will occur at a concentration of 15.38 per cent potassium sulfate.

It appears from the published literature that 83° C. is the highest temperature at which equilibrium concentrations were accurately determined. D'Ans and Schreiner, however, obtained both syngenite and potassium penta-calcium sulfate from solutions at between 140° C. and 170° C. Some tests are now under way in the laboratories of this company to determine the equilibrium concentrations at 100° C., for the two double salts, syngenite and potassium penta-calcium sulfate. The information so far obtained indicates that the curve representing the equilibrium concentration for gypsum and potassium penta-calcium sulfate does not change its direction to any great extent up to the temperature of 100° C. However, the data obtained will not permit stating this with absolute certainty until the investigations are completed.

According to D'Ans¹ it is probable that at some higher temperature another triple point will be found where potassium sulfate, syngenite, and potassium penta-calcium sulfate will be the three stable phases and that above this temperature the penta-calcium sulfate will be the only stable double salt. However, no accurate data seem to have been obtained with respect to this question.

The presence of other salts, such as chlorides of sodium and magnesium, necessarily affects the formation of these double salts. For example, D'Ans states² that syngenite and calcium chloride may be formed by the interaction of gypsum and potassium chloride according to the reaction:



Potassium penta-calcium sulfate and calcium chloride may also be formed from anhydrite and potassium chloride. Sodium chloride retards these double decompositions and at 25° C. the syngenite formation according to Equation 4 does not take place in solutions saturated with sodium chloride. It is evident, therefore, that the comparatively simple relations described in the case of solutions containing practically only the sulfates of potassium and calcium may become very complicated when many other salts are present, as is the case, for example, in the natural brines.

It will be seen from the data presented that the crystallization of the different simple and double salts of calcium and potassium can be controlled by properly regulating both temperature and solution concentration. It will also be apparent that the separation of one salt or the other from solution is dependent upon equilibrium conditions, which shift gradually with change in temperature and solution concentration, and that consequently there is no so-called "critical point" or "critical temperature" at which the double salts break down into their sim-

ple components, as some recent discussions would lead the casual reader to assume.

In leaching the ordinary cement-mill flue dust with water, solutions may be obtained which will contain calcium and potassium sulfate of the necessary concentration for the formation of either or both of the double salts mentioned. Practically all fuel used in cement burning contains sulfur which leads to the formation of sulfates, so that the collected flue dust contains both calcium and potassium sulfates. In addition to these, however, there may also be present other sulfur compounds, carbonates, and hydroxides as well as smaller quantities of magnesium salts. It is, nevertheless, unlikely that the equilibrium conditions found by the investigators referred to will be appreciably affected by the presence of such other compounds as long as the requisite amounts of potassium and calcium sulfates are present.

Of course, in cement mills where the potassium in the collected dust is largely in the form of chloride and where sodium chloride is also present, the reactions may differ, as indicated by the conclusions of D'Ans just referred to.

In considering the present discussion it should be remembered, however, that the time factor involved in the formation of these double salts is exceedingly important. All figures discussed above indicate equilibrium conditions, which in some cases are only reached after a considerable period of time, as the velocity of the reactions involved is apparently rather slow. For instance, the investigators referred to in some cases allowed 2 to 3 weeks for the preparation of the double salts and for the establishment of equilibrium conditions. In applying the data contained in this paper to commercial operations the time factor must be borne in mind, for the time allowed for such operations will usually be too short to establish even an approximation to equilibrium conditions. If operations are carried on rapidly it would be possible, due to the slowness of the reactions involved, to pass completely over certain fields, as for example the penta-calcium sulfate field, without forming any appreciable amount of that salt.

Some tests have been made at these laboratories to determine the time necessary to form these double salts from appropriate solutions. The following experiment will serve to illustrate the importance of the time factor involved: A 6 per cent solution of potassium sulfate saturated with calcium sulfate and in contact with this salt was kept 22 hrs. at 70° C. without any visual evidence of potassium penta-calcium sulfate formation, and with no loss of potassium sulfate from the solution. The same solution was then cooled to 20° C. After 43 hrs. at this temperature syngenite crystals were first noticed, but only after 66 hrs. standing at 20° C. had a sufficient amount of potassium sulfate been precipitated as syngenite to make an appreciable difference in the potassium concentration of the solution.

Identical results were also obtained with solutions of similar concentrations made from cement mill flue dust, where the dust was left in contact with the

¹ *Loc. cit.*

² *Kali*, 17 (1911).

solutions. Under especially favorable conditions as regards concentration and temperature, syngenite has been observed after 3 hrs.' agitation in solution from flue dust. Continuous leaching operations have, however, been carried on with practically saturated potash solutions, where the time of contact averaged one hour, with no sign whatever, either visual or analytical, of the formation of any of the double salts referred to.

From the above it will be seen that during the leaching of cement mill flue dust for the recovery of potash, the operations may be so adjusted as regards time of contact and solution concentration that the formation of double salts can be avoided at whatever temperature is chosen as being the most desirable for the leaching operation.

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THE EFFECT OF MANGANESE ON THE GROWTH OF WHEAT: A SOURCE OF MANGANESE FOR AGRICULTURAL PURPOSES¹

By J. S. McHARGUE

The object of the experiments in this paper was to demonstrate the effect of manganese on the growth of wheat under different conditions and to point out a source of this element for agricultural purposes.

In a study of the work of previous investigators on the relation of manganese to agriculture and its probable function in the vegetable economy one is impressed with the lack of agreement in the results of the several investigators and, especially, with the variety of their conclusions. In seeking a plausible explanation of the wide variations in the conclusions reached by the many investigators on this subject one must give attention to the object to be attained and to the various conditions under which the different investigations were carried on. In regard to the object to be attained, one class of investigators apparently have been interested in determining whether or not manganese has any commercial value from the standpoint of a necessary fertilizer, whereas the other class have sought to determine whether or not manganese is an essential element in the vegetable economy and, if so, its functions. Since the end to be attained by each of these different classes of investigators was not one and the same thing it is only natural that considerable contention has arisen as to whether or not manganese plays a definite rôle in agriculture.

For example, an investigator having the commercial viewpoint in mind may add a manganese compound to a soil already containing enough of this element and when he observes no effect on the growth of the crop he arrives at the conclusion that manganese has no important function in the growth of crops, thus failing to take into consideration the amount of this element already contained in the normal soil.

The most productive soils of Kentucky contain as

much as 0.40 per cent of manganese,¹ whereas some of the least productive soils contain as little as 0.005 per cent.² In all probability the latter soils would respond to an application of this element, whereas preliminary experiments show that the former do not. It is, therefore, evident that the failure on the part of those having the commercial viewpoint to recognize the importance of manganese from an agricultural standpoint is due to the fact that no consideration has been given to the amount of this element already contained in normal soils.

Apart from the work of Bertrand, very little has been done to prove whether or not manganese is an essential element in the vegetable economy. After extended researches on the effect and function of manganese in the vegetable economy, this investigator arrives at the interesting conclusion³ that manganese is, apparently, not to be replaced by another element, not even by iron, and the small quantity of it occurring is no reason for regarding it as a secondary element in the composition of plants. As a result of his investigations on laccase, an enzyme occurring in plants, the activity of which seems to be in some way associated with manganese, Bertrand concludes that this element can no longer be considered as a non-essential, but that it is a substance of vital necessity to the functions of plant life. In a more recent investigation he insists on the rôle of manganese in the functioning of the oxidizing enzymes, and still later investigations led him to the conclusion that manganese intervenes as a catalytic agent, in the material changes of which plants are the seat, and that it participates in an indirect manner in the building up of the tissues and in the production of organic matter.

An earlier investigation by the writer,⁴ on the manganese content of various seeds, revealed the unsuspected and interesting fact that the manganese was not uniformly distributed in the different parts of the seed but was confined almost entirely to the thin, brown seed-coat which envelops the cotyledons and forms the inside lining of the outer epidermal layer or hull of certain seeds and nuts. For example, in case of the almond we find the greater part of the manganese, not in the hard outside shell nor in the cotyledons, but in the brown seed-coat that surrounds the cotyledons. Again, in the case of the seed of wheat, we find only traces of manganese in either the chaff or the flour, and relatively large concentrations in the bran. The observation that the greater part of the manganese contained in seeds is confined to the seed-coat affords food for thought in regard to the function of this element in plants and whether or not it is essential in the growth and normal development of their seeds.

EXPERIMENTAL

The following experiments suggested themselves as a possible means of throwing further light on the question whether or not manganese is an essential element in the

¹ McHargue, unpublished results.

² Shedd, *This Journal*, **6** (1914), 660.

³ W. E. Brencley, "Inorganic Plant Poisons and Stimulants," Cambridge, 1914.

⁴ *J. Am. Chem. Soc.*, **36** (1914), 2532.

¹ Read before the Division of Agricultural and Food Chemistry, Cleveland Meeting, American Chemical Society, September 12, 1918.

growth of wheat. The plan of attack was first to obtain, if possible, a medium free from manganese in which to grow plants. The most desirable medium would be clean quartz sand containing no manganese, to which the fertilizing constituents necessary for the growth of the plants could be added. After testing a number of specimens of sand and sandstones for manganese, only one was found which was free from this element, but, unfortunately, that one was not obtainable in sufficient quantity. The next best was a sandstone from which, by carefully selecting the whitest portions, a product was finally obtained which contained only



FIG. 1.—A NEW PIECE OF APPARATUS FOR WATER-CULTURE EXPERIMENTS

traces of manganese. The selected material was crushed in a Wedgewood mortar and, after thoroughly mixing, approximately 8.5 kg. of the sand were transferred to each of seven well-glazed, 2-gal. pots. To the contents of each pot were added 5 g. of calcium carbonate, 5 g. of tricalcium phosphate, 2 g. of magnesium carbonate, 2 g. of potassium nitrate, 1 g. of potassium chloride and 1 g. of sodium thiosulfate, which were thoroughly incorporated with the sand. Three pots were the checks and received no manganese other than the mere traces that were in the sand. To the remaining four pots were added 5, 10, 15, and 20 g. of manganese carbonate, respectively, corre-

sponding to 0.028, 0.056, 0.084, and 0.112 per cent of manganese calculated on the weight of sand per pot. It required about 1200 cc. of water per pot to bring the sand to the right degree of wetness. Each of the pots was sown with wheat and kept in the greenhouse. After the plants were about 10 in. high they were thinned to the same number in each pot and these were allowed to grow, receiving no further treatment other than the addition, from time to time, of enough distilled water to keep the sand moist. Upon reaching maturity the wheat thus grown was harvested and, after thoroughly air-drying the grain and the straw, were separated and the weight of the grain and straw produced in each pot determined. The average weight of the grain and straw produced in the three check pots was compared with that produced in each of the pots receiving manganese. The blades and stalks of the plants in the pots receiving manganese showed a normal development of chlorophyll, whereas the blades and stalks of the plants receiving no manganese were of a pale green and decidedly less vigorous during their growing period.

TABLE I.—YIELDS OF WHEAT AND AVERAGE WEIGHT OF ONE GRAIN

	Weight of Grain Grams	Weight of Straw Grams
Pot No 1, no Mn added.....	3.00	19.00
Pot No 2, no Mn added.....	5.00	30.00
Pot No 3, no Mn added.....	3.00	23.00
AVERAGE.....	3.66	24.00

Pot No.	MnCO ₃ Added Grams	Weight of Grain Grams	Weight of Straw Grams	Increase due to Grain Per cent	Mn Straw Per cent
4	5	7.7	31.12	110.4	29.7
5	10	7.1	30.34	94.0	26.4
6	15	6.14	27.53	67.8	14.7
7	20	4.20	27.75	14.8	15.6

	Gram
Average weight of grains from 3 pots to which no Mn was added.....	0.0224
Average weight of grains from the pot to which 5 g. MnCO ₃ were added.....	0.0361
Average weight of grains from the pot to which 10 g. MnCO ₃ were added.....	0.0322
Average weight of grains from the pot to which 15 g. MnCO ₃ were added.....	0.0356
Average weight of grains from the pot to which 20 g. MnCO ₃ were added.....	0.0251

The grains of the wheat grown in the check pots were pale brown in color and were not plump; whereas the grains grown in the pots receiving manganese were dark brown in color and were well developed.

Analyses of the grain grown in this experiment gave the following results for the determinations made:

TABLE II.—ANALYSES OF THE WHEAT GRAIN

	Check Pots 1, 2, 3 Per cent	Pot No. 4 Per cent	Pot No. 5 Per cent	Pot No. 6 Per cent	Pot No. 7 Per cent
Nitrogen.....	1.61	1.68	1.75	1.69	1.64
Protein.....	10.06	10.50	10.94	10.56	10.25
P ₂ O ₅	0.97	0.77	0.83	0.82	0.84
K ₂ O.....	0.64	0.54	0.54	0.51	0.54
Mn.....	0.0032	0.0055	0.0077	0.0083	0.0083

It is to be noted that there is a slight but consistent increase in the nitrogen content of the grains from those pots which received manganese, that the grain from the pots which received MnCO₃ contained more manganese than that from the checks and that even the grain from the checks contained an appreciable amount of manganese, most of which, however, may have been in the seed planted.

The results in this experiment were so striking that it was thought advisable to demonstrate the effect of

manganese on the growth of wheat in some other way, and the method of water-cultures suggested itself as suitable for a further demonstration. Since this plant lends itself readily to conditions met with in the greenhouse, a series of experiments was planned in which wheat plants were to be grown to maturity, if possible, in nutritive solutions, both with and without the addition of manganese.

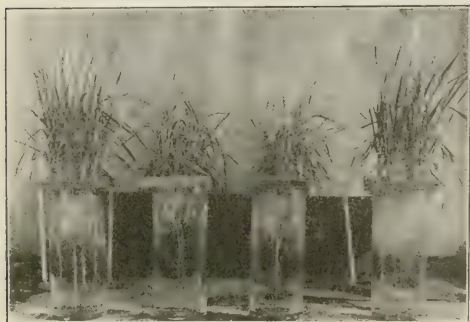


FIG. 2

One important detail to be considered was a proper support for the plants during the time of their growth. A device having some novel features suggested itself and has proved very convenient for this particular method of experimentation. Squares sufficiently large to cover half-gallon earthenware jars were cut from $7/8$ in. white pine boards and recessed on one side to the depth of $1/4$ in. in a circle, to fit the top of the jar, to prevent the cover from readily sliding off. The area of the board corresponding with the mouth of the jar was perforated with holes equal distances apart and of $3/8$ in. diameter, of sufficient size to take care of the increase in the size of the stalk during growth. A hole for carrying a rod for the further support of the plants after they had reached some height, was made in each corner of the cover. The covers were then water-proofed by being submerged in boiling paraffin for several minutes.

Grains of wheat were sprouted and grown on moist cheese-cloth until the roots and sprouts were each about 2 in. in length. The young plants were then transferred to the holes in the covers and held in place by small bunches of cotton. The jars were filled with distilled water to which were added the mineral constituents necessary for plant growth. When the covers holding the young plants were placed on the jars the roots were submerged in the solution. With frequent changing of the nutrient solutions the plants were brought to maturity. With the arrangement described it was easy to lift off the cover carrying the plants, empty the jar, refill it with fresh solution, and replace the cover.

There were two series of experiments of fifteen pots each that were carried to maturity in the manner just described. In the first series ten of the jars of plants

were grown in a modified Hopkins¹ nutritive solution containing calcium, magnesium, phosphorus, potassium, nitrogen, sulfur, iron plus one part of manganese to 2,000,000 parts of the solution. The remaining five pots in the series received like amounts of the basal nutritive solution but no manganese compound.

After the plants had been growing 4 or 5 weeks, differences in the growth of the two sets were apparent. Fig. 2 shows the differences observable in the growth of the plants at that time. The jars on each end were the ones receiving manganese while the two in the center received none. It will be observed that even at this early stage of the plants' growth there are notable differences in tops and roots of the plants receiving manganese and those receiving none. Fig. 3 represents the stage of growth attained 6 or 8 weeks later and shows a more marked difference in the growth of the plants which received manganese. The blades of the plants receiving no manganese were of a yellowish green color at this stage of their growth, showing a lack of chlorophyll development. The blades also exhibited weakness, in that they were less rigid and there was a tendency for them to droop over the supporting cords. This tendency to droop was quite characteristic of all the plants where manganese was omitted, and not to be observed at any time in those receiving manganese. The blades of the latter plants were of a dark green color until they began to mature.

Fig. 4 represents the plants after they had reached maturity and were ripe. The two sets of plants on each end in the photograph are those which received

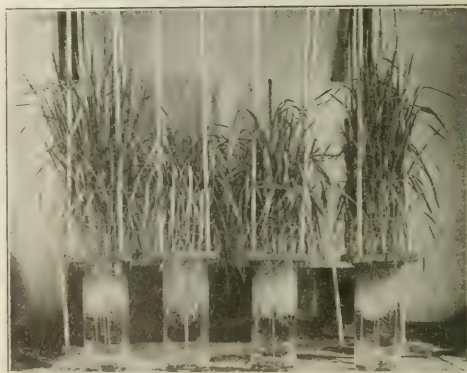


FIG. 3

manganese during their growth, the four sets in the center being the ones to which no manganese compound was added.

Hopkins' nutritive solution contains:	
200 g. $\text{Ca}(\text{NO}_3)_2$ in 2500 cc. water	Equal volumes to be mixed for use
50 g. K_2SO_4 in 2500 cc. water	
20 g. MgSO_4 in 2500 cc. water	
25 g. $\text{CaH}_2(\text{PO}_4)_2 \cdot \text{H}_2\text{O}$ in 2500 cc. water	
2.5 g. Fe as FeCl_3 in 2500 cc. water	

In the experiments, 10 cc. of each of these solutions were added to the water in each jar, about 2 liters.

After reaching maturity all of the plants were harvested and thoroughly air-dried and their several weights determined in the air-dry condition. The average weight of the 10 different sets of plants receiving manganese was 143.8 g., while the average weight of the 5 sets that received no manganese was 61.3 g., or an increase in the growth of the plants receiving manganese of 135 per cent.



FIG. 4

The second series of cultures, which was a repetition of the first, showed similar relative differences in growth, although the growth was not as luxuriant as in the first series.

The difference in growth shown in these experiments can be attributed only to manganese, because every precaution was taken to carry them out under as nearly similar conditions as possible, in other respects. The reagents from which the basal nutritive solutions were made were tested and found free of manganese. From the standpoint of growth produced in the plants, the experiments confirm the conclusion reached by Bertrand: that manganese performs an important function in the vegetable economy.

In this connection, the manganese content of certain materials commonly used as fertilizers was determined. A number of different agricultural limestones were examined, but their manganese content was found to be so small that the amount of manganese added to the soil by an application of 2 to 4 tons to the acre would be negligible. One sample of raw rock phosphate was examined which showed only 0.0176 per cent of manganese, or less than 0.4 lb. per ton.

It occurred to the writer that basic slag might be a probable source of considerable amounts of manganese. Determinations in 6 samples of this material from different sources gave an average of 4.8 per cent of the element manganese, the range being from 3.30 to 6.16 per cent. Therefore a ton of basic slag, containing the average amount, or 96 lbs., of manganese, when applied to an acre of land and rendered available, would probably supply all the manganese necessary for any crop.

Basic slag has found considerable use in agriculture as a source of phosphorus and calcium. Since this

material contains a noteworthy amount of manganese it is quite likely that, on soils poor in that element, the manganese contained therein may play an important part, in addition to that of calcium and phosphorus, in promoting the growth of crops.

SUMMARY

1—A convenient support is suggested for growing plants in water cultures.

2—Manganese, in suitable dilution, stimulates the growth of wheat, increases the size and the nitrogen content of the grain, and evidently performs an important function in the normal growth and development of the plant.

3—Basic slag contains about 100 lbs. of manganese to the ton and it is possible that some of the benefit to crops resulting from the use of this fertilizer, on certain soils, may be due to this element.

ACKNOWLEDGMENT

The writer desires to acknowledge helpful suggestions from Dr. A. M. Peter in connection with this work.

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SCAMMONY AND ITS SUBSTITUTES¹

By W. L. SCOVILLE

There was recently received from a New York broker a sample of a Mexican plant known as *Resina drastica*, with the statement that several hundred pounds of it were available, and asking for an offer for the lot. The drug so closely resembled that known as Mexican scammony, *Ipomoea orizabensis*, as to be mistaken for that drug on quick inspection by our botanist.

On extracting the ground drug with alcohol it was immediately evident that something different from Mexican scammony was at hand, for the percolate was a deep yellow in color, and when it was concentrated and poured into acidulated water a bright lemon-yellow resin was obtained. This resin amounted to 19.2 per cent of the drug taken. The alcoholic solution showed 23.5 per cent of total extractive from the drug.

A comparison of the chemical characters of the resin with true resin of scammony, *Convolvulus scammonia*, and with the resin of Mexican scammony disclosed the following:

	Resin of Scammony	Resin of Mexican Scammony	Resin of <i>Resina drastica</i>
Yield, per cent.....	About 8	9 to 20	19.2
Color.....	Yellowish brown	Straw	Lemon-yel- low
Ash.....	Practically none	Practically none	Practically none
Solubility in.....			
Petroleum ether.....	3.5 per cent	2.5 per cent	1.0 per cent
Ether.....	Soluble	Soluble	72.6 per cent
Acetic ether.....	Soluble	Soluble	Soluble
Chloroform.....	Cloudy soln.	Cloudy soln.	94 per cent
10 per cent ammonia.....	Cloudy soln.	Cloudy soln.	Cloudy soln.
10 per cent potassium hydroxide solution.....	Cloudy soln.	Cloudy soln.	Cloudy soln.
Acid number.....	20	23.5	28.0
Saponification number.....	198	140	136
Optical rotation.....	-17.3	-24.8	-32.4
Color with FeCl ₃	Dark green	Faint green	Dark green

¹ Presented before the Division of Pharmaceutical Chemistry, Cleveland Meeting, American Chemical Society, September 10 to 13, 1918.

The optical rotation of true scammony resin obtained from the root is reported by P. Guigues to vary from $-18^{\circ}30'$ to $-23^{\circ}30'$ and the upper limit of natural scammony resin as -25° . Resins having a rotation of -23° to -25° are considered to be derived from *Ipomoea orizabensis*.

The resin of *Resina drastica* is less soluble in ether and in chloroform than is true scammony resin or the Mexican scammony resin. It is more slowly soluble in alkalis than is true scammony resin, as also is that of the Mexican scammony. All three gave markedly cloudy solutions in ammonia and in potassium hydroxide solution, but the insoluble portions were so fine that the solution passed through an analytical filter without clearing and without collecting an appreciable residue on the filter. Acidulating the alkaline solutions did not precipitate the resin in any case.

The alcoholic solution of *Resina drastica* reduced Fehling's solution both before and after heating with weak sulfuric acid. It is thus uncertain whether the resin has a glucosidal character or not.

The supply was limited and a separation plan could not be carried out.

In general character, this resembles both true and Mexican scammony resins. It is slightly more acid and is more strongly levorotatory. Its color alone would distinguish it, and treatment with decolorizing

charcoal does not take out the color appreciably. When freshly precipitated it has an agreeable tea-like odor which disappears on drying. Probably a small amount of volatile oil is present in the drug. The powdered resin resembles scammony resin in odor.

The special distinguishing features of the three resins are (1) the brownish color of true scammony resin, and the very deep green color which it gives with iron salts, (2) the light color of Mexican scammony resin, producing a colorless alcoholic solution, and giving almost no color with iron salts, and (3) the deep lemon-yellow color of the *Resina drastica*.

The iron test distinguishes quite sharply between true and Mexican scammony when a ferrous salt is used. If 0.5 g. of the resin be dissolved in 10 mls of alcohol and 0.5 ml of a 10 per cent aqueous solution of ferrous sulfate added, the Mexican scammony resin shows only a very faint green while the others become dark green and on standing deposit a dark mass, leaving an olive-green supernatant liquid.

Subsequent efforts to obtain another sample of the *Resina drastica* for botanical study have failed, though samples of drugs having a different character were sent. It seems probable that several botanical species, closely allied, are seeking a market as scammony or scammony substitutes.

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LABORATORY AND PLANT

AN INVESTIGATION OF STENCHES AND ODORS FOR INDUSTRIAL PURPOSES^{1,2}

By V. C. ALLISON AND S. H. KATZ

The Bureau of Mines recently made an investigation of the use of stench as a warning in mines. Odors are put to various other industrial uses; principal among these are the testing of boilers for leaks with either air or water under pressure and the testing of plumbing or pipe lines. Ether, oil of peppermint, and oil of wintergreen are used mostly for these purposes. It has also been suggested that some strongly odoriferous gas or vapor, free of sulfur, be mixed with water gas to indicate its presence in case of leaks or other accidental escape into the air of a room.

During the work described in this paper a considerable number of chemicals were examined to determine their applicability to the mining needs and conditions. It was desired to use stench, that is, unpleasant rather than pleasant odors; and those most powerful at low concentrations were to be preferred. Of the chemicals examined those most useful were adopted for mine warnings. However, those which were less satisfactory for mine use may find other applications. For that reason the results are given in this paper.

APPARATUS AND PROCEDURE

The apparatus used, the "odorometer," is shown in Fig. 1. A number of Venturi type flow meters were so arranged that a measured volume of air could be passed at a uniform rate through or over the chemical, and this air then mixed with another measured volume of pure air also flowing at a uniform rate. The concentration of the chemical was measured by determining its loss in weight after a measured volume of air had passed through or over it. From this loss in weight and the total volume of air with which the chemical was mixed, the concentration in milligrams per liter of air and in parts of vapor per million parts of air were determined. The mixture of air and chemical passed through a rubber tube with a glass funnel at the open end. The funnel was placed over the nose when smelling to prevent contamination of the issuing mixture by room air.

The apparatus was placed in a good hood and the room was well ventilated to protect the operator from the effect of continually smelling the chemical, which might reduce his sensitivity to the odor.

An arbitrary scale for odors of five degrees was adopted. The degrees are designated:

- 1—Detectable
- 2—Faint
- 3—Quite Noticeable
- 4—Strong
- 5—Very Strong

¹ Published by permission of the Director, Bureau of Mines.

² Read at the 56th Meeting of the American Chemical Society, September 10 to 13, 1918.

TABLE I—RESULTS OF MEASUREMENT OF THE INTENSITY OF VARIOUS STENCHES
VOLUMES OF THE CHEMICAL, AS A PERFECT GAS, PER MILLION VOLUMES OF AIR

CHEMICAL	INTENSITY OF ODOR				INTENSITY OF ODOR				INTENSITY OF ODOR			
	Detect- able	Notice- able	Very Strong	Very Strong	Detect- able	Notice- able	Very Strong	Very Strong	Detect- able	Notice- able	Very Strong	Very Strong
Amyl acetate.....	7	10	13	90	246	1.1	1.5	2	14	38	0.039	0.053
Ethyl acetate.....	190	339	615	1236	1753	19.4	34.6	63	126	191	0.686	1.224
Amyl alcohol.....	63	83	123	439	601	6.4	8.5	13	45	61	0.225	0.300
Valeric acid.....	2.4	6	18	91	161	0.3	0.6	1	9	16	0.009	0.021
Valeric acid.....	1923	3352	4927	5825	19982	165.1	287.7	423	500	1715	5.833	10.167
Ethyl ether.....	6	12	18	38	56	0.5	1.0	2	3	5	0.018	0.037
Butyl mercaptan.....	3.5	5	6	16	16	0.2	0.5	0.7	1	12	0.008	0.018
Ethyl mercaptan.....	18	35	73	141	198	1.3	2.5	5	10	14	0.046	0.088
Propyl mercaptan.....	2	7	9	14	17	0.2	0.6	0.8	1.2	1.6	0.006	0.020
Amyl thioether.....	0.2	1.2	1.6	1.7	2.2	0.04	0.2	0.3	0.4	0.5	0.001	0.007
Ethyl thioether.....	3	12	29	61	74	0.3	3.2	3	6	8	0.012	0.047
Allyl isothiocyanate.....	2	3	6	8	50	0.2	0.5	0.7	0.9	6	0.008	0.012
Methyl isothiocyanate.....	5	13	23	36	48	0.4	1.1	2	3	4	0.015	0.039
Amyl isovalerate.....	1.7	3	6	10	12	0.4	0.5	1	2	2.3	0.012	0.018
Carbon tetrachloride.....	718	1461	1508	4964	6091	128	262	383	886	1087	4.533	9.222
Chloroform.....	674	1389	2600	5887	9528	93	192	360	816	1321	3.300	6.800
Iodoform.....	1.1(a)	...	...	...	...	0.5(a)	...	...	...	...	0.018(a)	...
Artificial musk.....	...	...	...	...	...	0.001(a)	...	...	...	...	0.00004(a)	...
Nitrobenzene.....	20	36	44	114	296	4	6	16	42	4	0.146	0.178
Phenyl isocyanide.....	0.5	1	3	10	25	0.06	0.1	0.4	1	3	0.002	0.005
Pyridine.....	10	45	93	700	1764	0.9	4	9	64	162	0.032	0.146
Methyl salicylate.....	16.1	23	29	244(a)	...	2.8	4	5	43(a)	...	0.100	0.145
Oil of peppermint.....	...	...	...	...	...	0.68	0.9	3	9.5	9.9	0.024	0.032

(a) Maximum concentration obtainable.

TABLE II—PHYSICAL AND PHYSIOLOGICAL PROPERTIES OF CHEMICALS USED AS STENCHES

CHEMICAL	Boiling Point °C.	Freezing Point °C.	Character of Odor	Physiological Properties of Vapor	REMARKS
Amyl acetate.....	148	-75 (thick)	Banana oil	Harmless	Pleasant to most people; disagreeable to some
Ethyl acetate.....	77.4	-83.8	Fruity, pleasant	Harmless	...
Amyl alcohol.....	137.8	...	Alcoholic	Harmless	...
Butyric acid.....	162.3	-7.9	Very disagreeable	Harmless	...
Valeric acid.....	186.4	-58.5	Very disagreeable	Harmless	...
Ethyl ether.....	35	-112.6	Pungent	Soporific	...
Phenyl isocyanide.....	165	...	Very disagreeable	Unknown	...
Allyl isothiocyanate.....	151	...	Mustard oil, disagreeable	Lachrymatory and toxic	...
Methyl isothiocyanate.....	119	34	Mustard oil, disagreeable	Lachrymatory and toxic	...
Amyl isovalerate.....	190	...	Very disagreeable	Harmless	...
Butyl mercaptan.....	97	...	Very disagreeable	Harmless	...
Isobutyl mercaptan.....	88	...	Very disagreeable	Unknown	Probably harmless
Ethyl mercaptan.....	37	-144.4	Very disagreeable	Harmless	...
Propyl mercaptan.....	67	...	Very disagreeable	Unknown	Probably harmless
Methyl salicylate.....	222.2	-8.3	Oil of wintergreen, pleasant	Harmless	...
Amyl thioether.....	95-98	...	Very disagreeable	Unknown	Probably harmless
Ethyl thioether.....	92	99.5	Very disagreeable	Unknown	Probably harmless
Carbon tetrachloride.....	76.74	-19.5	Sweet, unpleasant	Harmless	...
Chloroform.....	62	-63.2	Sweet, agreeable	Soporific	...
Iodoform.....	Decomposes	119	Unpleasant	Harmless	Unpleasant in higher concentrations
Artificial musk.....	...	...	Pleasant	Harmless	...
Nitrobenzene.....	209.4	5.71	Almonds, pleasant	Toxic	...
Oil of peppermint.....	...	...	Pleasant	Harmless	...
Pyridine.....	115.2	-42	Very disagreeable	Toxic	...

tory nerves. Table II gives the physical and physiological properties of the chemicals.

SUMMARY

The Bureau of Mines had need of a suitable stench for use as a warning in mines. For this purpose an apparatus, or "odorometer," was developed for measuring the intensity of odors in varying concentrations in air. The odors of 24 different chemicals were examined with the apparatus. Since other industrial applications may be made of these results, they are given in this paper.

ACKNOWLEDGMENT

Acknowledgment is made of the valuable assistance given by Mr. A. C. Fieldner, chemist in charge of the gas mask research of the Bureau of Mines, in devising laboratory apparatus, and in selection and securing of suitable chemicals.

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THE USE OF STANDARD DIES IN MAKING GROUND GLASS JOINTS

By S. F. ACRRE

Received December 21, 1918

It is perhaps not too much to say that one of the most important mechanical aids in the development of chemistry has been the use of ground joints for glass

or metal stoppers, stopcocks, and other similar means of enclosing gases, liquids, and solids. While mercury seals and similar devices are often used for holding liquids and gases in confined spaces, these are in general far more troublesome than ground glass stopcocks or stoppers, and find only limited application. When such ground glass joints are broken it often happens that the entire apparatus is lessened in value because such joints are not easily accessible for re-grinding or replacement. The glass apparatus must then be sent to a glass blower who makes new ground glass joints which are inserted in place of the broken ones. This means, of course, expense and delay in the work for which the apparatus is used. In view of the importance of such ground glass joints in routine and research work in chemistry, physics, and other sciences, and in the industrial and daily life, it seems strange that chemists and manufacturers of glass apparatus have not established a uniform set of dies having a standard angle. An agreement could be reached on standard sizes of stopcocks, stoppers, etc., for regular apparatus such as 100, 200, 500, and 1000 cc. flasks and bottles, for various sizes of one-way, two-way and three-way stopcocks and other similar apparatus, which could be furnished as stock articles or made on short notice. We have found that the glass blower can make joints much more easily and accurately with these standard dies, and his income is

not diminished by such standardization because broken apparatus must be replaced. When a needed article is not in the laboratory stock, it would be easy, with such a set of dies in the chemical laboratory, to replace any standard size ground glass stopper, stopcock, or other apparatus at any time by having the mechanic use the suitable dies to grind down a standard glass blank. The broken parts of an odd size stopper might be returned to the glass blower who would measure the length and larger diameter, for example, and would then be able to make such a new stopper, from either standard or new blanks in a very short time. If either part of the ground glass joint or stopper were entirely destroyed, the other part could be measured and the length and larger diameter sent to the glass blower with instructions for placing holes at the proper places.

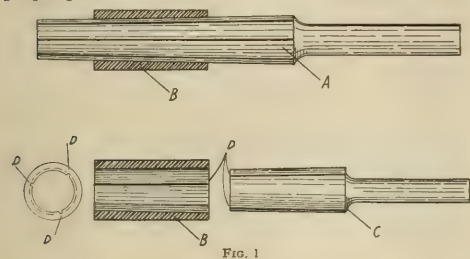


FIG. 1

On account of the frequent inconvenience arising from broken glassware of odd sizes and because of the necessity for planning standard joints in the apparatus used in connection with our investigations on conductivities, hydrogen electrode measurements, etc., we made arrangements several years ago with Mr. Otto Sterling, Bureau of Standards, to make up standard sets of dies which enable us to replace broken apparatus very quickly with the assurance that the new joints will fit as well as the old ones. These dies can be made very conveniently from the standard Morse or Brown and Sharp tapers which can now be bought in the market at a reasonable price. These tapers vary in diameter all the way from $\frac{1}{4}$ in. to over 3 in. and one similar taper for giving diameters between $\frac{1}{4}$ in. and $\frac{1}{8}$ in., for example, can be easily made in any shop. The angle of the Morse taper corresponds in general to a decrease in diameter of 0.625 in. per ft. and is nearly ideal for ground glass joints. Three of these tapers, however, which were made earlier by the Morse people before they began to manufacture a complete set, had an angle corresponding to about 0.600 in. per ft., and it is therefore clear that even the Morse standard is not quite as perfect as it should be. This slight objection has no practical disadvantage, however, because two stoppers made by these two tapers one inch long and having the same middle diameter differ only 0.001 in. in diameter at the ends. This difference is a "perfect match" in comparison with existing practice. Furthermore, the 8 tapers now available do not completely overlap, but the missing gaps are so short that practically any diameter of ground glass joint desired can now be secured.

The following table shows the angle of the taper, the length, the large and small diameters, and other data:

TAPER No.	Diameter of Plug at Small End In.	Diameter of Plug at Large End In.	Standard Taper per Plug Depth In.	Taper per In.
0.....	0.252	0.356	2	0.625
1.....	0.369	0.475	2 1/8	0.600
2.....	0.572	0.700	2 3/8	0.602
3.....	0.778	0.938	3 1/8	0.602
4.....	1.020	1.231	4 1/8	0.623
5.....	1.475	1.748	5 3/8	0.630
6.....	2.116	2.494	7 1/8	0.626
7.....	2.750	3.270	10	0.625

The Brown and Sharp tapers vary about $\frac{1}{2}$ in. per ft. although there are a few odd-size tapers with slightly different angles. The tapers do not exactly overlap but meet practically all needs.

It is hoped that in time every glass blower will adopt some fixed standard so that it will not be necessary for each chemical laboratory to have its own dies. The firm of Otto Hask & Sons, 545 North 5th St., Philadelphia, Pa., is now using Morse taper dies in making all of their apparatus and could doubtless be induced to use them for anyone else.

The following suggestions are offered to show how we have our standard dies and ground glass joints made: The Morse taper A (Fig. 1) having the desired large and small diameters and lengths for the ground joint is employed for making the tool steel "collar" B, which is used for grinding the outside of the stopper. When the desired taper is not at hand it is very easy to insert the blank "collar" in a lathe and turn out the interior at the desired angle. A piece of tool steel rod is then put into the lathe and turned down at the same angle so that this steel "stopper," C, fits the collar as indicated in the figure. The grooves D in B and C hold the emery, etc., during grinding.

Three sets of each die are made and labeled 1, 2, and 3. No. 1 is used with wet, coarse emery, carborundum, or other hard material for grinding down the glass forms so that the ground surfaces are practically uniformly conical. There is, consequently, far greater wear on this first die than on Nos. 2 and 3. No. 2 is then employed with fine carborundum, emery, etc., to make the two parts of the joint fit satisfactorily. No. 3 is used with the finest rouge for making the glass stopper and the outer glass joint fit practically perfectly. If so desired, a final grinding of the glass joint itself with rouge and water or oil can be made. As No. 1 becomes worn too badly it is replaced by No. 2; No. 3 then becomes No. 2, and a new set of dies is made to replace No. 3. These dies do not wear out rapidly under erosion of the carborundum and can be counted upon to last several years. The dies can be kept in the laboratory and sent to the glass blower when new joints are desired, or can be left with the glass blower. When covered with vaseline they do not rust. We have a large number of ground glass joints made in diameters varying from $\frac{1}{8}$ in. up to 2 in. and have found this method so satisfactory that we advise its use by others.

THE DECARBONATION OF DOLOMITE LIMESTONE IN THE ROTARY KILN

By E. E. EAKINS

Received October 16, 1918

To determine if possible the points at which decarbonation of our stone commences and the point at which it is complete, it was decided to investigate the contents of our rotary kiln during a recent shutdown. This work was undertaken with no intention of making a scientific research, but merely as a matter of general plant information. Results alone are given, and these are published only as a matter of general information for those who may be calcining limestone in a rotary kiln.

The limestone used in our kiln is the well known Cedar Hollow stone crushed to pass a 1 in. screen. All fine material (screenings) is removed.

The rotary kiln is of the usual type used in cement practice, 150 ft. long by 6 ft. 6 in. inside the lining, which is of clay brick well grouted with cement. The inclination is $3/4$ in. per ft.¹ The kiln rotates normally at the rate of one revolution in 1 min. 40 sec. The feed is continuous, and the output of the kiln averages 100 tons of burned lime per 24 hrs.

Firing is by producer gas from two Chapman producers rated to gasify 18 tons of coal each per 24 hrs. The fuel used is a low sulfur semi-gas coal, averaging about 30 per cent volatile combustible matter.

It has been impossible to secure accurate temperature measurements inside the kiln proper. The temperature of the gas taken at the port just before its entrance to the kiln varies from 1500° F. to 1600° F., while the temperature of the stack gases, taken in the dust chamber at a point where they are undiluted by cold air, varies from 1100° F. to 1300° F.

The stone was present in the kiln to a depth of 12 or 14 in., and samples were taken from a point about 3 in. below the surface to the bottom of the mass. Only clean lumps $1/2$ in. or larger were taken for the sample. Samples were taken at the intervals specified below, starting at the discharge end of the kiln. Each sample was analyzed for carbon dioxide, and was examined macroscopically and microscopically.

CHEMICAL ANALYSIS

Distance Ft.	CO ₂ Per cent	Distance Ft.	CO ₂ Per cent
0	1.02	50	42.20
10	2.35	75	42.92
20	4.68	100	42.96
30	21.46	125	43.09
40	37.12		

MACROSCOPIC EXAMINATION

The sample taken at 0 ft. (discharge end) showed no evidence of core when the lumps were broken open. The carbon dioxide content is apparently due to recarbonation from the air.

The sample taken at 10 ft. showed slight evidence of core. The quantity of core increased in each sample up to the sample taken at 40 ft., which was hard, like stone, but lacked the full crystalline character of limestone.

From 40 ft. to 75 ft. the similarity in appearance of the samples to limestone progressively increased, and at the latter point the material was apparently unchanged limestone.

¹ This is greater than is usual in cement practice.

MICROSCOPIC EXAMINATION IN POLARIZED LIGHT

In addition to the chemical analysis recorded above, all samples were examined under the microscope, with very interesting results.

The sample taken at 125 ft. was completely crystalline in character, excepting a small amount of impurities, and corresponded in all respects to our raw stone.

At 100 ft. the quantity of non-crystalline amorphous matter showed a slight increase, due to the decomposition of some magnesium carbonate.

From 100 ft. to 30 ft. the amorphous material progressively increased in quantity, and at 30 ft. the first evidence of free calcium oxide was obtained.¹ The quantity of free calcium oxide then increased rapidly to the 0 ft. mark where it reached its maximum.

At 10 ft. there was very slight evidence of crystalline calcium carbonate.

At 0 ft. there was no evidence of crystalline calcium carbonate.

COMPARISON OF RESULTS

The results of the microscopic examination and chemical analysis check reasonably closely.

An average analysis of the stone supplied the rotary kiln would be as follows:

	Per cent
CaO.....	29.12
MgO.....	19.40
CO ₂	44.22

This percentage of calcium oxide requires 22.88 per cent carbon dioxide for conversion into calcium carbonate, while the magnesium oxide requires 21.34 per cent carbon dioxide for conversion into magnesium carbonate.

At 40 ft. from the discharge end, the contents of the kiln show 37.12 per cent carbon dioxide present, or more than enough to satisfy all the calcium oxide.

At 30 ft. from the discharge end, the contents of the kiln show 21.46 per cent carbon dioxide present or less than the quantity necessary to satisfy all the calcium oxide.

The microscope shows that no free lime is present 40 ft. from the discharge, but that considerable free lime is present 30 ft. from the discharge.

CONCLUSIONS

1—The first decomposition of the stone takes place about 100 ft. from the discharge end of the kiln.

2—This decomposition is entirely of magnesium carbonate, and increases gradually until a point is reached between 30 and 40 ft. from the discharge, where the calcium carbonate first decomposes and free lime is obtained.

3—The production of calcium oxide in our rotary kiln takes place entirely in the last 30 or 40 ft. of the length of the kiln, and is not complete until the last 10 ft. of the kiln is reached.

CHARLES WARNER COMPANY
DEVAULT, PENNSYLVANIA

¹ The presence of free lime was determined by refractive index and also by treatment of sample on the slide with White's solution, and the subsequent production of strongly double refracting needles of calcium phenolate.

STANDARD ALKALI FOR MIXED ACID CONTROL

By EVELYN HEARSEY AND C. M. JOYCE

Received August 15, 1918

Standard alkali for the titration of mixed acids usually consists of normal sodium hydroxide standardized through normal sulfuric acid, standardized in turn by sodium carbonate with methyl orange as an indicator. This procedure has several disadvantages, which are discussed in the "Standardization of Alkalimetric Solutions," by Francis D. Dodge,¹ who recommends potassium acid phthalate as a standard. The accuracy of this method has been established by W. S. Hendrixson in his careful experimental study of the subject.²

The advantages of direct standardization with potassium acid phthalate over titration with normal acid which must be standardized by a troublesome process, are so obvious that it seems strange that the new method has not come into more widespread use. The reason may be contained in the fact that phenolphthalein, in spite of its sensitiveness, is not as desirable an indicator as methyl orange when carbonates are present in the standard alkali. By following the procedure described in "Preparation of a Solution for Making Standard Solutions of Sodium Hydroxide,"³ the interference of carbonates with the indicator can be easily eliminated. A standard solution prepared in this manner may be titrated against potassium acid phthalate in the cold using phenolphthalein as an indicator.

A standardization along these lines, performed in

this laboratory, differed from the result of a titration against *N*/5 acid standardized with sodium carbonate by less than 0.05 per cent.

STANDARDIZATION OF *N*/5 SODIUM HYDROXIDE WITH ACID POTASSIUM PHTHALATE

Wt. KHC ₈ H ₄ O ₄ Grams	Vol. NaOH (1) Cc.	<i>N</i> /5 NaOH Equivalent to 1 g. KHC ₈ H ₄ O ₄	<i>N</i> /5 Grams
1.750	42.81	24.49	✓ 1.750 ÷ 42.81 = 1.001
1.754	42.95	24.49	× 1.754 ÷ 42.95 = 1.000
1.745	42.66	24.49	× 1.745 ÷ 42.66 = 1.001
1.741	42.61	24.49	× 1.741 ÷ 42.61 = 1.001

AVERAGE, 1.001

STANDARDIZATION OF *N*/5 SULFURIC ACID WITH SODIUM CARBONATE

Wt. Na ₂ CO ₃ Gram	Vol. H ₂ SO ₄ (a) Cc.	<i>N</i> /5 H ₂ SO ₄ Equivalent to 1 g. Na ₂ CO ₃	<i>N</i> /5 Gram
0.5000	47.44	94.33	× 0.5000 ÷ 47.44 = 0.9942
0.5005	47.49	94.33	× 0.5005 ÷ 47.49 = 0.9942
0.4995	47.41	94.33	× 0.4995 ÷ 47.41 = 0.9939
0.4995	47.40	94.33	× 0.4995 ÷ 47.40 = 0.9941

AVERAGE, 0.9941

<i>N</i> /5 SULFURIC ACID VS. <i>N</i> /5 SODIUM HYDROXIDE			
<i>N</i> /5 H ₂ SO ₄ (a) Cc.	× <i>N</i> /5 Gram	<i>N</i> /5 NaOH Cc.	<i>N</i> /5 NaOH
42.33	× 0.9941	÷ 42.03	= 1.001
42.45	× 0.9941	÷ 42.15	= 1.001
42.34	× 0.9941	÷ 42.05	= 1.001
42.33	× 0.9941	÷ 42.05	= 1.001

AVERAGE... 1.001

(a) Corrected for calibration, temperature, and run back.

These data were obtained in connection with ordinary control work and without unusual precautions, except that all the burettes used for alkali were freshly calibrated as they change appreciably every few months from solvent action. The potassium acid phthalate used was prepared from Merck's phthalic anhydride by Dodge's method.¹ The sodium carbonate used was Kahlbaum's "for analysis."

LEOMINSTER, MASSACHUSETTS

¹ Loc. cit.

ADDRESSES AND CONTRIBUTED ARTICLES

OUR OPPORTUNITY

By BERNHARD C. HESSE¹

Since the early days of the war, exhortations to coöperation as a remedy—in fact the only remedy—for the then suddenly revealed, although long known, lack of self-containedness and of industrial independence in many countries and especially in what have since been grouped as "key" or "pivotal" industries have been numerous, widespread, and persistent. Our own country and our own business and profession have by no means escaped those exhortations. In fact, our profession has been made the special target for unfounded, vehement, and indiscriminate charges of inexcusable backwardness in development and of conspicuous want of courage in operation and expansion; in corresponding measure we have been urged and have ourselves repeatedly promised coöperation as a cure for those alleged conditions.

While the war was on, all our industries bent all their energies towards accomplishing the heavy tasks imposed upon them in the shortest possible time, regardless of any and all refinements as to efficiency and exquisiteness of workmanship. Consideration of measures of development or of coöperation to be followed upon the return of peace had to be put to one side until the immediate and pressing war needs were out of the way. With the signing of the armistice opportunity for such consideration

came measurably closer. The Council of the AMERICAN CHEMICAL SOCIETY then took immediate steps to formulate a coöperative policy for after-the-war conditions.

THE CHEMIST IN THE LIFE OF THE NATION

Before discussing our opportunity it will be serviceable to review what the probable general position of our business and profession is in the national economic life of our country. Those who follow chemical pursuits of whatever kind in this country made up, before the war, 1/10000 of our population; those of us then engaged in industrial activities, as distinguished from educational and like activities, were engaged in industries which employed 1/6 of the industrial wage-earners of the country, produced 1/4 of the value of all manufactures in the country, created 1/5 of the total value created by manufacture in this country, in their trade with one foreign country alone made up 1/20 of our total foreign business and produced 1/7 of our balance of trade. The forthcoming census will, no doubt, show a decided growth of our importance, both relative and actual, in our national economic life.

RECIPROCAL RESPONSIBILITIES

Bulking so large in the economic life of our country as do the industrial activities of this 1/10000 of the country's population it is clear on the one hand that the nation owes it to itself to see to it that the activities of this 1/10000 are interfered with as little as possible and are enhanced to the utmost, and on the

¹ Read before the Lehigh Valley Section, American Chemical Society, at Easton, Pa., March 14, 1919

other hand that this 1/10000 owes it to the nation and to itself to leave nothing undone that will enable it to live up to the needs, requirements, and just expectations of the other 9999/10000. Under these circumstances, I think it requires no extended argument to show that it is primarily and solely the duty of the 1/10000 to make up its mind definitely what it should do, do as much as it can, formulate the help it may need from the other 9999/10000, and then bend its efforts to attending to it that such aid is forthcoming. Whether such aid is ultimately forthcoming or not in no way relieves the 1/10000 from its duty of setting its own house in order and keeping it so. In our own particular case this duty of setting and keeping our house in order is all the more compelling because our calling normally requires of us a degree of education and of intellectual equipment far above the average; we are in daily contact with complex and puzzling problems which we must solve as a part of our daily routine and therefore by training and by daily vocation we are peculiarly well positioned to determine conclusively, fairly, and equitably what we *should* do, *how* we should do it, and to what extent and how we are *entitled* to help from the other 9999/10000. Likewise, it requires no extended argument to show that if the 9999/10000 habitually and continuously refrain from showing any interest in or from giving any encouragement to the 1/10000, the latter's work can only become more self-centered, and as time goes on, less and less concerned with the needs and expectations of the 9999/10000, as a whole.

MORE THAN FIFTY YEARS OF PUBLIC EFFORT

It can be truthfully said that as a body American chemists have for more than 120 years and particularly in the past 50 years made not only all reasonable effort but very creditable sustained effort, and with a very good measure of success, to put and to keep their own house in order. They have recognized their duties and their opportunities and have very intelligently set about the creation of organizational machinery to perform those duties and to embrace those opportunities. The Manufacturing Chemists Association of the United States, the oldest of these organizations, the AMERICAN CHEMICAL SOCIETY, the American Electrochemical Society, the American Institute of Chemical Engineers are each and all entirely volunteer organizations for the ultimate purposes above mentioned, and the good they have accomplished, not only for the business and profession of chemistry but also for the general public welfare in national as well as international matters, can safely challenge comparison with what has been done in any other country, confident that the American chemist, all things considered, can well feel proud of his record even when so compared.

There are now sufficient signs that the world as it was before August 1914 was a decidedly easy-going affair when compared with the world that we may reasonably expect when the peace treaty becomes operative. That being reasonably certain, what is the American chemist to do then that he has not heretofore done? For this evening's purpose that question will be narrowed down to: What is the AMERICAN CHEMICAL SOCIETY and its individual membership then to do that has not heretofore been done?

WHAT NEED NOT BE CHANGED

The constitution of the AMERICAN CHEMICAL SOCIETY needs no modification to enable it to do all needful things, within its proper sphere, suitably to advance the welfare and interests of chemistry in the nation or the several states of the Union as well as in international relations.

The general plan of organization of the AMERICAN CHEMICAL SOCIETY needs no changes that require specific action by the Society; its mechanism is so elastic and so comprehensive that it can without difficulty be effectively and rapidly adapted to all new conditions. On neither of these two points is there any disagreement of consequence among our members.

PRESENT RESPONSIBILITIES DELIBERATELY ASSUMED

As to *how* the different parts of our organizational mechanism shall be joined up there has been in the past considerable difference of opinion. Two of the most divergent views were considered by our Council for more than a year and finally, in 1916, one view was adopted and the other rejected. The rejected view contemplated, in general, a concentration of the executive offices and officials in one city and in one building for the purpose of closer-knit cooperative effort in the administrative and routine activities of our Society in the expectation that thereby all our other efforts would be provided with machinery promptly to detect and to embrace new opportunities of Society endeavor. The adopted view contemplated the present relation of our organizational parts with a large measure of the responsibility for new endeavor lodged with the membership as expressed in local sections. Theoretically, at least, the President of our Society is supposed to appoint all necessary committees, except a certain specified few, to look after all relevant interests of American chemists. But in an organization of 12,000 members in 54 sections in 33 states of the Union and the District of Columbia, it is clear that theory and practice simply cannot coincide, even with the help of the recently appointed Advisory Committee to the President of our Society. The rejected plan aimed at relieving that situation. That being so, the membership and the sections of the Society cannot, even if they would, escape the responsibility that they have thus explicitly retained to themselves.

THE RESPONSIBILITIES

Now, what are these responsibilities?

To be on the lookout for new developments of all kinds that may work good or harm to American chemistry and to find ways and means effectively and promptly to aid or to check them, as the case may be. Obviously, that makes it imperative and inescapable that each local section must, in theory at least, be on guard not only as to the good or harm of chemistry in its own immediate locality or its own state but in every state of the Union as well and not forgetting our national and international interests of any and all kinds whether relating to the industrial, the educational, the commercial, the scientific, the technical, or the research aspects in their manifold ramifications and developments; thereupon, ways and means must be found and operated. In practice, the results are bound to be smaller, of course.

INDIVIDUAL MEMBERS THEMSELVES RESPONSIBLE

Local sections, in turn, are dependent upon their executive committees and their councilors, and these in turn upon the section members. Therefore, in the last and the final analysis, each and every member has thus deliberately and inescapably had placed upon him and by his own voluntary act his fair and equitable share of the burden thus laid upon his own local section. In my view, every member of our Society gave an implied promise, at the time he qualified for membership, to carry that burden, and I have the greatest confidence that each member so understands the situation; if there are any members who are unwilling to carry that burden they must be in very great minority, and that due to misapprehension entirely.

From this it is clear that each member must maintain a receptive mind and must at all times be watchful of chemistry's good so that when opportunity offers he can place his suggestions for improvement where they may become most effective. The society machinery offers him a great many avenues for giving effect to his views and these are, among others, the committee, if any, of the Society that is charged with general care of his subject; should there not be any such committee he can send his communication to the Secretary of the Society who will put it where it will receive appropriate attention; local councilors and local executive committees should be consulted where

possible as to such communications, to the end that when they reach the committee or the Secretary they may be as definite, comprehensive, well thought out, and precise as circumstances will permit or call for, otherwise much ill-considered matter may be brought forward; finally, there are the councilors-at-large who are likewise available. There are plenty of ways and means for members to become articulate in the Society's affairs, and if members do not avail themselves thereof, those in office cannot conclude otherwise than that their work is being satisfactorily performed.

WHEN PEACE RETURNS

There is every reason to believe that upon the actual return of peace our Society will have to act promptly in a large number of new matters, will have to speed up action on old matters, and will make a large number of new connections both at home and abroad, governmental and non-governmental. Speed and comprehensiveness will more than ever be the essence of our problems. Action without opportunity for consultation with local sections in many matters and especially in such as are new or radical, may easily be abortive or unsatisfactory. Certainty that in any and all such matters any action taken is reasonably representative of our Society as a whole calls for response from all the local sections.

RECENT POLLS EXPERIENCE

During the past four years I have had several occasions to take a poll of our local sections on Society matters which had been assigned to me. In the very nature of things these polls had to be taken by circular letter and it is probably that which accounts for the slowness of returns and failure to notify me that certain sections would not file returns. In all of these polls a time limit had to be set for receipt of replies; nevertheless, it does seem automatic to go ahead, even on the expiration of the time limit when, say, two-thirds and more of the sections have not in any way responded. Any one of a number of things may have happened to prevent reply and anyone's spirit or sense of fairness revolts at doing anything that has even the appearance of being high-handed. We are all in the same boat and it is hard to believe that any one is "holding-out" on the work, and for that reason I have felt called upon to delay procedure until I absolutely had to go ahead. Our sections must acquire the habit of taking circular letter polls quite as seriously as personal letter matters, if the best interests of our Society are to be safeguarded and developed. However, there has been encouraging improvement in the returns from the polls and I am confident that before long replies will be received to future polls with great promptness and celerity. There is no reason whatever to believe that my experience with slow returns from polls is due to any lack of willingness on the part of any appreciable proportion of our members. I am inclined to charge non-returns to an assumption that if not heard from the program will go forward as scheduled; if all could agree to that, well and good. Ought not the poll taker, however, be advised that a return will not be filed, if such is to be the case, in order that injustice be not done? How about a case where the circular letter for a section went astray or was never delivered?

Slow or incomplete returns I am inclined to charge to unfamiliarity with the subject matter or inability to assemble the reply promptly. As to these, it is my view that not all sections can be interested in or acquainted with every topic that may be of importance to the Society as a whole, yet each section should be given an opportunity to be heard on all such occasions and each section, in turn, should let itself be heard from, one way or another, but with promptness and completeness. No doubt, each section knows pretty well what subjects are of direct interest to it and as to these promptness of reply should be the rule; on these topics the local councilors and the executive committee should keep in close touch with each other and per-

haps twice a year each section could devote at least a half-hour to the general discussion of those subjects for the guidance of its local councilor or councilors, as the case may be. For such meetings, it might be a feasible program to discuss the problems assigned to the various and then active special committees and the divisions of our Society, and their published reports, if any, and thereafter to call for proposals outside such committees and divisions. Such comprehensive treatment of the Society's activities by each section once or twice a year, I believe, cannot help but react favorably all around; when the local councilors report at home what was or was not done at the General Meeting of that spring or that fall the membership will then be able to follow the Society's activities in closer touch and hence with greater interest and to greater mutual benefit.

THE DECEMBER 1918 POLLS

Going back now to the Council Meeting of December 1918. Two polls were taken in preparation for that meeting, one by the Philadelphia Section and one by the secretary of our Society. The results of both were placed in my hands for coordination, in the expectation that a program for that Council Meeting could therewith be worked out. A number of sections communicated their inability to participate in that poll within the time limit set, for one good reason or another; some sent their recommendations in duplicate as requested and most of these were in numbered paragraphs. A few put their recommendations in narrative form. This heterogeneity of form of reply probably more than quadrupled the labor thrown upon me and under the circumstances on account of the stress of time the assembly work had to be done under high pressure and hence not as well as it could or would have been done had there been uniformity of reply form as requested by the Philadelphia Section. The additional work thrown upon me because some one forgot to have a carbon copy sent along was out of all proportion to the slight additional cost of providing me with that carbon copy. I did not have time nor opportunity to have copies of them made and therefore I was compelled to do a large amount of longhand note-making that should have been spared me.

Then there were the communications in narrative form which caused me a great deal of added labor and, what is worse, much uncertainty on my part in the result as to whether or not I had correctly grasped and paraphrased the meat of the various proposals so narrated. Of course, a recommendation in narrative form is better than no recommendation at all. One or more sections overcame the difficulty encountered by those resorting to narrative, by writing out as a numbered paragraph in the general form of the body of a resolution or motion what they considered the meat of their situation and then elaborating upon that text by suitable narrative; much the same as presenting a motion orally in meeting and then speaking to the motion. That was a big help to me in my work. In short, the thoughtful ones made me no more work than I had bargained for; the less thoughtful made me many times more work than I had bargained for. If those who answer polls would follow the plan of reply suggested in the original circular calling the poll they will save the poll taker a very large amount of labor; generally the poll taker has a very definite plan of assembly of answers in mind when he sends out his poll and if any considerable proportion of answers deviates from the reply form suggested, his whole plan may be knocked to smithereens. It is easier for fifty men to do one thing in just one way, even if a new one, than it is for one man to unravel fifty different ways of doing one and the same thing.

The only object in my mind in referring to these details is to call attention to the need of cooperation that really cooperates to the utmost. These matters appear insignificant by themselves, but they are important, since they delay accomplishment

and everything that delays or tends to delay must be eradicated from our operations, if speed, accuracy, and comprehensiveness are to be attained. What, under other circumstances, is mere innocent thoughtlessness or harmless oversight may through cumulative action really have, in our case, the ultimate effect of "throwing a monkey wrench into the machinery" and that, I know, is wholly absent from the minds of our members.

In laying out the work to be undertaken by our Society we should endeavor to restrict it, at first, to those items which our Society can by itself do better than any other and then we can expand into those fields wherein we can cooperate effectively with other agencies, being throughout the whole mindful of such things as are specifically chemical and not of general nature, in and of themselves; that is, if we feel that we must have our heads in the clouds, our feet, nevertheless, should always be on the solid ground of chemistry.

There are a number of classes of our Society activities that must, in the very nature of things, proceed simultaneously such as setting and keeping our own house in order on the one hand and on the other hand the appropriate education of the general public and of government officials to the importance of our business in the life of the nation to the ultimate end that thereby the reciprocal obligations of the nation to its chemists and to those activities in which chemistry, in any of its varied phases is an essential or vital factor, will be fully recognized and properly discharged.

OUR OPPORTUNITY

For more than 120 years the chemists of this country have been telling our people and our Government over and over again to what extent and how chemistry is essential to national welfare and growth, and why the nation should foster chemistry. They have backed their faith by their own efforts. But somehow or other the country, as a whole, paid, or seems to have paid, little heed to them. It took this colossal nightmare of a war effectively to impress the cogency of those truths upon the public mind. The present is, therefore, particularly "Our Opportunity" so to cooperate in every direction as to clinch the advantages thus gained and to bring one step nearer to realization the vision our chemist forefathers had of the beneficial influence of chemistry upon our national life and greatness. Some of this clinching will be done by our Society and while it had organizational machinery fully capable of carrying such a load it cannot properly carry it unless we, either as individual members or as committee members or other Society officials, attend to it that that carefully planned and thoughtfully built organization shall function without delay, without friction, and at top speed at all needful times. We have reserved to ourselves, as members, in large measure the initiative in new matters and the execution of routine matters. Ours is, therefore, not only the sole responsibility but the golden opportunity, as well.

CONCLUSION

It must be clear to you that the main point of what I have said this evening is aimed solely at increasing the interest and the direct participation of our individual members and all our sections in all our Society's activities. I am convinced that such an increase is vital to the continued success of our Society. Nor do I pretend to have indicated, much less enumerated, all the ways in which our membership can display its interest and give wholesome effect to its participation. I am wholly confident that once the membership is satisfied that increases in those directions are necessary, these will be forthcoming, enthusiastically and promptly, any and all pessimists and doubting Thomases to the contrary, notwithstanding.

THE DISTRIBUTION AND CHARACTERS OF SOME OF THE ODOROUS PRINCIPLES OF PLANTS¹

By FREDERICK B. POWER

The substances which impart to many plants a particular and often characteristic odor are almost infinite in their variety, and comprise some of the most interesting compounds in the domain of organic chemistry. Many of them possess a cyclic structure, while others belong to the class of so-called aliphatic or open-chain compounds, which may be either saturated or unsaturated, and they include representatives of such various groups as the hydrocarbons, alcohols, aldehydes, ketones, phenols and phenol ethers, acids, esters, and lactones. Hydrocyanic acid, which may be regarded as the nitrile of formic acid, occurs among the products of distillation of many plants, and other nitriles represent the principal constituent of some essential oils, such, for example, as that of the nasturtium, *Nasturtium officinale*, Linné, which consists chiefly of phenylpropionitrile, $C_6H_5CH_2CH_2CN$. It is well known that by the distillation of bitter almonds benzaldehyde and hydrocyanic acid are obtained, and that these substances, by prolonged contact, unite to form phenylxyacetone, $C_6H_5CH(OH)CN$, which is therefore contained in varying amounts in the essential oil of bitter almonds. Other nitrogen compounds which are represented among the odorous constituents of plants are, for example, indole, C_8H_7N , which is a constituent of the essential oil of jasmine and of orange flowers, and its methyl derivative, skatole, C_9H_9N , which has been found in the wood of an East Indian tree, *Celtis reticulosa*, Miq. or *C. cinnamomea*, Lindl. Notwithstanding the fact that skatole possesses a strong fecal odor, it is employed, as is also indole, in the preparation of synthetic perfumes. Another interesting nitrogen compound, which appears to be somewhat widely distributed in nature and imparts to many floral products a quite distinctive odor, is the methyl ester of anthranilic acid, $C_6H_4(NH_2)CO_2CH_3$. This has been found in the essential oils of orange flowers (neroli), tuberose, jasmine, gardenia, and ylang-ylang, and also in the oils of sweet orange peel and bergamot leaves. A methyl derivative of methyl anthranilate, $C_6H_4(NH_2)CO_2CH_3$, has been found in the essential oils obtained from the fruit and the leaves of the mandarin orange. Compounds containing sulfur as a characteristic constituent, the so-called mustard oils, are yielded by many plants belonging to the family of *Cruciferae*. Numerous sulfur compounds are likewise contained in lilaceous plants, such as the onion and garlic, as also in the gum resin, asphaltum, a product obtained from various species of *Perula*, belonging to the family of *Umbelliferae*.

Although the odorous principles of plants are frequently developed in some particular part or organ of them, such as the petals of the flower, of which examples are afforded by the rose and other fragrant blossoms, they are sometimes found in both the flowers and fruit, as in the orange tree, while in other instances they are contained chiefly in the foliage. It is also of interest to note that when totally distinct parts of a plant, such as the leaves and root, possess odorous or aromatic properties, the substances to which these properties are due may be quite different in character and have little or no direct chemical relationship. A particularly striking instance of this peculiarity is afforded by the essential oils obtained from the root and leaves, respectively, of the saffras tree, *Sassafras variifolium* (Salisbury), O. Kuntze. The oil distilled from the root, especially the bark of the latter, contains among other substances safrol, camphor, and eugenol, which are not found in the leaves, while on the other hand the leaves contain the olefinic terpene, myrcene, together with citral, linalool, and geraniol, no one of which is contained in the root. Another instance of similar variations is that of the products from the Ceylon cinnamon tree, *Cinnamomum zeylanicum*, Breyne, the oils distilled from the root, leaves, and bark, respectively, being quite different in composition. In the oil from the root camphor is a characteristic constituent, whereas the oil from the leaves contains chiefly eugenol, and in that from the bark cinnamic aldehyde predominates.

It can naturally not be expected that such volatile products of plants as are comprehended under the designation of essential oils should be constant in composition, but, nevertheless, some remarkable differences, other than those already described, have been observed in oils distilled from the same species. Thus the phenol contained in the oil from the common garden thyme, *Thymus vulgaris*, Linné, as is a rule thymol, or isopropyl-methyl-cresol, $C_6H_4CH_3(1).OH(3).C_2H_5(4)$, but this is sometimes re-

¹ Address of the retiring president of the Chemical Society of Washington. Delivered before a joint meeting of the Chemical Society and the Washington Academy of Sciences, January 9, 1919.

placed partially or even entirely by the isomeric, liquid compound, carvacrol, which is isopropyl-*ortho*-cresol, $C_9H_8CH_3(1)-OH(2).C_9H_7(4)$. The conditions upon which the formation of one or the other of these compounds depends are not known, but variations in soil and climate certainly have in many cases a marked influence upon the constituents of a plant, and important changes often likewise take place on drying. The oil of lavender flowers, which is distilled in France from wild-growing plants (*Lavandula vera*, DC.) is characterized by containing a large proportion of the fragrant alcohol, linalool, $C_{10}H_{18}O$, and its esters, together with geraniol, whereas the oil distilled in England from cultivated plants contains a much smaller proportion of esters and a relatively large amount of cineol, $C_{10}H_{18}O$, a substance having a camphor-like odor, which occurs only in traces in the French oil.

The more or less characteristic odor which many plants possess rarely depends upon the presence of a single substance, but is usually due to a complex mixture of substances, in which, however, some one compound may largely predominate. These odorous principles are generally obtained by a process of steam distillation, and as such products are for the most part in the form of liquids which are sparingly soluble in water, they are comprehended under the broad title of essential oils or volatile oils, in French *essence*, an expression which serves in a way to differentiate them from the so-called fatty or fixed oils, which, however, differ appreciably in their physical and chemical characters. In cases where the oil does not pre-exist in the plant, but is formed by the hydrolysis of a glucoside, as in the mustard seed, bitter almond, gaultheria leaves, and sweet birch bark, a preliminary digestion with water is necessary before distillation. Some of the essential oils which become somewhat impaired by heat are obtained by expression, notably those of the citrus fruits, such as the orange, lemon, and bergamot. In other instances the odor of certain flowers is of so delicate a nature that it can only be obtained in a tangible form by extracting the material with a volatile solvent or by maceration with a fixed solvent, such as an oil or fat, either with or without the aid of heat. The use of heat in the process of maceration appears to be desirable for extracting the perfume from the violet and rose, as also from orange and cassia flowers, and this method of procedure is known by the French expression of *enfleurage à chaud*. For still more delicate flowers, such as those of the jasmine, tuberose, jonquil, lily of the valley, and mignonette, a process of cold maceration or *enfleurage à froid* is employed. This operation is conducted by spreading a specially prepared fat on both sides of a sheet of glass contained in a wooden frame, the apparatus being termed a *châssis*, and upon the upper surface of the glass the flowers are then strewn. These *châssis*, 35 to 40 in number, are placed one above the other in such a manner that the flowers are not only immersed in the fat but have a layer of fat above them to absorb any of the volatile substance exhaled. The length of time during which the flowers are allowed to remain in the *châssis* is said to be about 24 hrs. for jasmine, 48 hrs. for jonquil, and 72 hrs. for the tuberose, and the operation is usually repeated about 30 times in order that the desired degree of absorption or concentration of the perfume may be obtained. With each repetition of the process the arrangement of the *châssis* is reversed, the fresh flowers being strewn on the layer of fat which was previously on the under side of the glass, but which now becomes the upper side, in order to effect an equal distribution of the perfume. The reason for employing the cold method of extraction for certain flowers depends upon the interesting observation that the essential oil to which their fragrance is due does not exist ready formed, or at least in only very insignificant amount, but is continually produced during the life of the cells. If this vital activity were destroyed by means of a volatile liquid or the use of a warm fat the amount of perfume developed would be very greatly diminished. From the fat which has been more or less saturated with the perfume of the flowers—the so-called pomade—the odorous principles may be extracted by treatment with strong alcohol, and by exposing this extract to a low temperature the last portions of fat are separated. In this way many of the concentrated extracts are obtained which constitute the most highly esteemed floral perfumes.

On account of the exceedingly large number of odorous substances contained in plants, as already intimated, it would not be practicable to attempt to enumerate them or to present any classification in accordance with the various groups of organic compounds to which they belong. Such a plan would, moreover, be quite far removed from the purpose of the present paper, which is to indicate somewhat broadly the distribution of some of the more important of these substances in nature, and also to draw attention to some of the points of chemical interest connected with them. With this object in view a con-

sideration based chiefly upon the usual botanical classification of plants would appear to be the most practicable, and such a classification has indeed been adopted by some of the standard works which treat of the essential oils.

The *cryptogamous* or *flowerless* plants do not, as a rule, possess any very marked or distinctive odor, although in a few instances such properties have been observed in certain algae, fungi, lichens, and ferns. The essential oil or other individual substance to which this property is due is, however, always present in very small amount, and as the chemical character of these products is as yet but little known, they cannot be considered to possess any particular interest. The *phanerogamous* or *flowering* plants, on the other hand, contain such a variety of interesting odorous compounds that the selection of such a very limited number as can be considered at this time, and which may be deemed most appropriate for the present purpose, is rendered rather difficult.

CONIFERAE

In pursuance of the proposed plan, some of the more important odorous products which are yielded by the family of *Coniferae* may first be considered, and in connection therewith a few of the interesting compounds which are derived or prepared therefrom will be noted.

One of the essential oils which has been longest known, and which on account of its extended technical applications is generally familiar, is the oil of turpentine, a product obtained by steam distillation from the oleo-resinous exudation of various pines. Several varieties of this oil are known, but the two more important ones are of American and French origin. The American oil is obtained chiefly from *Pinus palustris*, Miller, and *P. heterophylla* (El.) Sudworth, and is usually dextrorotatory, while the French oil is yielded by *Pinus pinaster*, Solander, and is levorotatory. The chief constituent of these oils is pinene, $C_{10}H_{16}$, in either the *d* or *l* form, or a mixture of them, and this terpene is also found in a large number of other plants. It is now known, moreover, that the optical isomerism may occur in two distinct forms, which are designated as α and β , and as these differ in their structure they show marked differences in their chemical behavior. In contact with dilute mineral acids pinene is readily converted into the handsomely crystalline compound terpin hydrate, $C_{10}H_{16}(OH)_2.H_2O$, a primary product of this reaction being terpineol, $C_{10}H_{17}OH$. The terpineol of commerce is usually prepared by the action of dilute sulfuric acid on terpin hydrate, and the liquid product so obtained is the basis of the lilac perfumes. This liquid is, however, not a homogeneous substance, but a mixture of isomeric, crystallizable compounds which are designated as α and β terpineol, and the presence of a liquid terpinol, $C_{10}H_{18}O$, has also been established. Terpinol is found in nature, but apparently only in the active or inactive α form. In the dextrorotatory modification it occurs in cardamom and linaloe oils, and in the oils of sweet orange, neroli, and lavage root. The levorotatory modification has been found, among other sources, in camphor oil, in the oil from the leaves of the camphor tree, linaloe oil, and the oil of Canada snake root, while in the inactive form it has been obtained in the solid state from cajuput oil, and as a liquid from the oils of nutmeg and boldo leaves.

By the action of concentrated sulfuric acid on oil of turpentine the preparation known as terebene is obtained, which is used to a considerable extent medicinally. This is not an individual substance, but a mixture of hydrocarbons, consisting chiefly of camphene, dipentene, terpinene, and cymene.

In connection with oil of turpentine a brief reference may be made to the subject of synthetic camphor, since it forms the starting point for the technical production of this substance. A number of different methods have been suggested or employed from time to time, which have mostly been the subject of patents, and only one or two illustrations of them need here be given. By leading dry hydrogen chloride into completely dry and cooled pinene, the so-called pinene hydrochloride, or more properly bornyl chloride, $C_{10}H_{17}Cl$, is obtained. As this is a crystalline compound having a camphor-like odor, it formerly received the incorrect appellation of "artificial camphor." By the subsequent elimination of hydrogen chloride from bornyl chloride there is obtained the terpene, camphene, which is of interest as being the only solid hydrocarbon of the formula $C_{10}H_{16}$, which occurs in nature. On treating camphene with glacial acetic and sulfuric acids isobornyl acetate is formed, which on hydrolysis, and subsequent oxidation of the isoborneol, yields camphor. Another method consists in forming an ester of borneol by the action of anhydrous oxalic acid on oil of turpentine, and then subjecting the ester successively to hydrolysis and oxidation.

The essential oils distilled from pine needles differ markedly in character from the proper turpentine oils, as in them the

pinene is replaced to a considerable extent by other terpenes, such as camphene, limonene or dipentene, phellandrene, sylvestrene, and cadinene, and they also contain especially notable proportions of the acetic ester of borneol, amounting in the oil of the hemlock-spruce, *Abies canadensis*, Michaux, or *Tsuga canadensis*, Carr, to as much as 50 per cent. This ester possesses the characteristic fragrant odor of the pine and is used in perfumery.

The resinous balsam obtained from the so-called "Nut Pine" or "Digger Pine," *Pinus sabiniana*, Douglas, is of particular interest inasmuch as it yields on distillation an essential oil which differs completely in composition and properties from the turpentine oils. It is stated to have been first prepared in California during the Civil War, when the production of turpentine in the southern states had ceased, and was brought into commerce for cleansing purposes under various fanciful names, such as abietene, erasine, etc. This oil, like that from *Pinus jeffreyi*, Murray, a pine growing at higher altitudes in the Sierra Nevada mountains, has been found to consist almost entirely of normal heptane, C_7H_{16} , identical with that found in petroleum.

Another product from a coniferous plant is the oil of juniper, which is distilled from the berries of *Juniperus communis*, Linné. This has been found to contain, among other substances, pinene, borneol, and isoborneol, terpinol, and cadinene. It is chiefly employed in the manufacture of Holland gin, which is said to owe to its peculiar flavor and diuretic properties.

The wood of the so-called red cedar, *Juniperus virginiana*, Linné, has long been used in the manufacture of cigar boxes, lead pencils, and other articles, and its odor is due to a viscid essential oil, which is considerably used for perfuming soap. This oil contains a sesquiterpene, termed cedrene, $C_{15}H_{24}$, and a sesquiterpene alcohol, cedrenol, $C_{15}H_{26}O$. The leaves of this tree yield on distillation a limpid essential oil which differs entirely in its composition and properties from that obtained from the wood, its constituents being pinene, limonene, borneol, both in the free state and as an ester, and the sesquiterpene, cadinene, $C_{15}H_{24}$. The oil of cedar leaves of commerce appears to be distilled chiefly from the leaves of *Thuja occidentalis*, Linné, commonly known as the *arbor vitae* or white cedar, and consists chiefly of pinene, *l*-fenchone, and thujone. The leaves of *Juniperus sabinia*, Linné, or savin, yield an essential oil which is used to some extent medicinally. Its most important constituent is an alcohol, sabinol, $C_{17}H_{34}O$, which is present both in the free state and as an ester, and it has also been found to contain citronellol, geraniol, and a dihydromyrcinyl alcohol, $C_{16}H_{32}O$. The latter two compounds likewise occur together in ginger-grass oil.

GRAMINEAE

The Gramineae (grass family) yield a number of fragrant essential oils which are used to a very large extent in perfumery, and are therefore of great commercial importance. Among this class of products the following oils and their botanical sources may briefly be noted:

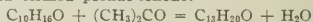
Palmarosa oil, also known as East Indian geranium oil, is obtained from *Cymbopogon martinii*, Stapf, a plant which was formerly referred to the genus *Andropogon*, and under this botanical name it has many botanical synonyms. A variety of the same plant yields the so-called ginger-grass oil. Lemon-grass oil is likewise obtained from species of *Cymbopogon*, which differ according to the source of production of the oil. *Cymbopogon flexuosus*, Stapf, which is distilled in the East Indies, yields the lemon-grass oil of commerce, whereas on the Malabar coast an oil of somewhat different character is distilled from *C. citratus*, Stapf. Citronella oil is distilled in Ceylon and Java from the grass *Cymbopogon nardus*, Rendle. Vetiver oil, unlike the other grass oils, is distilled from the root of the plant, which in India is known as "Cus-cus" or "khas-khas," meaning an aromatic root. The plant is now botanically referred to as *Vetiveria zizanioides*, Stapf. In India the roots of the vetiver have long been employed for making baskets, as also for screens and mats, which are placed in doorways or hung over windows, and in hot weather are frequently sprinkled with water, when they serve to cool and perfume the air.

With regard to the chemical constituents of the grass oils, it may be noted that palmarosa oil, which has a pleasant rose-like odor, consists to a large extent of the aliphatic terpene alcohol, geraniol, $C_{15}H_{26}O$, together with a relatively small proportion of its esters. The name geraniol was in fact first applied to the compound obtained from this source, but it has since been found to be a predominating constituent of the otto of rose, and is contained in numerous other essential oils. The commercial importance of palmarosa oil may be indicated by the fact that the amount annually exported from Bombay has been estimated to be about 50,000 lbs. This, however, is considered to

relate only to the oil produced in Bombay and the central provinces of India, for in the year 1902-3 the actual amount exported was 125,000 lbs., and this is attributed to the greatly increased production of the southern provinces. In the year 1905-6 the total amount of essential oils exported from Bombay was 23,436 gals., representing a value of approximately \$250,000. This consisted chiefly of palmarosa oil, only about one-fourth having been ginger-grass oil.

Ginger-grass oil consists chiefly of a mixture of geraniol and a dihydromyrcinyl alcohol, the odor of the latter recalling that of both linalool and terpinol. Besides these compounds there are relatively small amounts of *d*-phellandrene, dipentene, *d*-limonene, isocavone, and other substances.

Lemon-grass oil, which possesses a strong lemon-like odor, contains as its most important constituent the aliphatic aldehyde, citral, $C_{10}H_{16}O$. This compound, which is an essential constituent of lemon oil and is quite widely distributed in nature, is the aldehyde corresponding to geraniol, from which it may readily be obtained by oxidation. Citral, apart from its individual value as a constituent of many fragrant oils, is of particular interest and importance from the fact that from it, by condensation with acetone, there is produced the substance known as ionone, which is the basis of the artificial violet perfumes. In the first step of this process citral and acetone, in the presence of alkalies, condense with the elimination of water to form a compound termed pseudo-ionone:



The pseudo-ionone, when heated with acids or acid salts, is converted into an isomeric, unsaturated, cyclic ketone, termed ionone, $C_{15}H_{20}O$, which possesses a characteristic violet odor. This interesting compound will subsequently be further considered.

Citronella oil is largely employed for perfuming the cheaper kinds of soap, and is of very complex composition. The constituent to which its characteristic odor is most largely due is an aldehyde of the formula $C_{10}H_{16}O$, which has been termed citronellal. Other oxygenated compounds contained in the oil are *l*-borneol, nerol, geraniol, esters of geraniol and citronellol, and eugenol methyl ether, together with the terpenes camphene, dipentene, *l*-limonene, and one or more sesquiterpenes. The amount of citronella oil exported from Ceylon in 1911 was 1,524,275 lbs., and in 1917 Java exported 1,137,051 lbs.

Vetiver oil, which is used in perfumery, is more or less viscid in character and possesses a high boiling point. Its constituents have not been sufficiently studied as yet to render their consideration of special interest.

PALMAE

The palm family does not contain many odorous substances. It may be considered of interest to note, however, that by treating crude coconut oil with steam under pressure for the purpose of rendering it edible an essential oil of unpleasant odor is obtained. This has been found to contain methylheptylketone, $CH_3CO.C_7H_{15}$, and methylonylketone, $CH_3CO.C_8H_{17}$, and the corresponding carbinols, $CH_3CH(OH).C_7H_{15}$ and $CH_3CH(OH).C_8H_{17}$. These compounds also represent the chief constituents of an Algerian oil of rue, but while the alcohols obtained from coconut oil are dextrorotatory, those from rue oil are levorotatory. It has recently been ascertained that palm kernel oil, when subjected to similar treatment, yields an essential oil which consists to the extent of 90 per cent of methylonylketone.

LILIACEAE

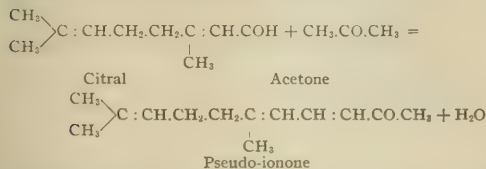
It has already been indicated that several plants belonging to the family of *Liliaceae* yield essential oils which consist to a large extent of sulfur compounds, such, for example, as the garlic, *Allium sativum*, Linné, and the common onion, *Allium cepa*, Linné. It was for a long time assumed that the chief constituent of the oil of garlic is allyl sulfide, $(C_2H_5)_2S$, but it has more recently been shown that this is not contained in either the oil of garlic or that of the onion, both of which consist of mixtures of much more complex sulfur compounds. The same family is represented by plants with such fragrant blossoms as the hyacinth, *Hyacinthus orientalis*, Linné, and the lily of the valley, *Convallaria majalis*, Linné. The substances to which the perfume of the last-mentioned flowers is due have not as yet been fully investigated, but it is known that the hyacinth contains benzyl benzoate, with probably free benzyl alcohol, and also esters of cinnamic alcohol. The odors have been well imitated in various artificial oils and extracts, the exact composition of which is generally a trade secret, but it may be noted that phenylacetic aldehyde, $C_6H_5CH_2COH$, possesses an intense hyacinth-like odor, and is considerably used in perfumery. The fragrance of the lily of the valley appears to be due, at least in part, to the presence of the aliphatic sesquiterpene alco-

hol, farnesol, $C_{15}H_{26}O$, which is also contained in cassia flowers (*Acacia farnesiana*, Willd.) in those of the common or false acacia (*Robinia pseudacacia*, Linné), linden (*Tilia europaea*, Linné), lilac (*Syringa vulgaris*, Linné), and mignonette (*Reseda odorata*, Linné).

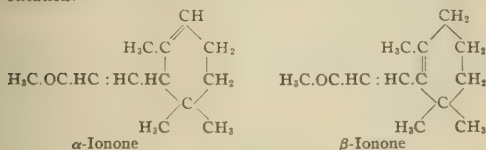
The tuberose, *Polianthus tuberosa*, Linné, which belongs to the family of *Iridaceae*, possesses, as is well known, very fragrant blossoms. This fragrance, as in practically all cases, is not due to a single substance, but to a combination of odorous compounds. The flowers have been found to contain methyl anthranilate, benzyl alcohol, benzyl benzoate, with apparently other esters of benzoic acid, and a very small amount of methyl salicylate.

IRIDACEAE

The family of *Iridaceae* is of particular interest on account of the fact that the rhizomes of several species of the genus *Iris*, especially after drying and being kept for some time, possess a distinctly violet-like odor, which is familiar in the so-called orris root. The species of *Iris* which are chiefly cultivated for commercial purposes in the province of Florence and other parts of Italy are *Iris germanica*, Linné, *I. pallida*, Lam., and *I. florentina*, Linné. The odor of the rhizomes is due to the presence of a very small amount, 0.1 to 0.2 per cent, of an essential oil, which at ordinary temperatures is a soft solid, and consists to the extent of 85 per cent of the perfectly inodorous myristic acid. The constituent of the oil which imparts to it the characteristic violet odor is a liquid, cyclic ketone, termed irone, $C_{15}H_{26}O$. It was the isolation and investigation of this compound that led to the synthetic production of the isomeric ketone, ionone, which, together with its homologues, is now so largely used in the preparation of violet perfumes. As previously indicated, this substance is obtained by the condensation of the aldehyde, citral, with acetone, a substance termed pseudo-ionone being first formed, which, through inversion by means of acids, is converted into ionone.



The ionone, as obtained by the method described, is always a mixture of the α and β forms, which possess the following constitution:



ZINGIBERACEAE

The family of *Zingiberaceae* includes a number of plants, the roots or rhizomes of which possess aromatic properties. Among these there may be noted the curcuma (*Curcuma longa*, Linné), which, although yielding from 3 to 5 per cent of an essential oil, is cultivated more especially in India and China on account of the yellow coloring matter contained in the rhizome. Zedoary, from *Curcuma zedoaria*, Roscoe, is cultivated in India, where the leaves are used to some extent as a pot herb. The essential oil obtained from the root is said to resemble in odor that of ginger, but differs by being also somewhat camphor-like, which is due to the presence of cineol.

The most familiar representative of the *Zingiberaceae* is ginger, from *Zingiber officinale*, Roscoe, which is cultivated in the Far East, as well as in the West Indies and Africa. The aromatic properties of the rhizome, but not its pungent taste, are due to an essential oil, which contains the terpenes, camphene and phellandrene, also citral, cineol and borneol, and the sesquiterpene termed zingiberene. The constituents of ginger upon which its pungency depends have recently been the subject of extended investigations, but these would not be appropriately considered here.

The very aromatic seeds of the cardamom yield essential oils which differ in composition according to their source. Thus the oil distilled from the Malabar cardamom, *Elettaria carda-*

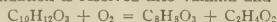
momum, Maton (var. α minor), contains *d*- α -terpineol and terpinylacetate, together with cineol, whereas the oil from the long Ceylon cardamom *E. cardamomum*, Maton (var. β), contains the terpene known as terpinene, and a terpinol which is isomeric with the ordinary α -terpineol. The Siam cardamom oil is at ordinary temperatures a sensiloid mass, the crystalline constituents of which consist of *d*-borneol and *d*-camphor in approximately equal amounts.

ORCHIDACEAE

The members of the orchid family are of much botanical interest on account of the form and beauty of the flowers, but there is one plant of this group which yields a product possessing both chemical interest and economic value, namely, the vanilla. The so-called vanilla bean, which was formerly used to a much larger extent than at present for flavoring purposes, represents the cured, full-grown, but immature fruit of *Vanilla planifolia*, Andrews, a plant which is a native of the forested valleys of the eastern Mexican Andes, but is now cultivated in nearly all tropical countries.

The most important constituent of vanilla, being that to which its odor and taste are chiefly due, is the crystalline substance known as vanillin, $C_8H_8O_3$, which is the methyl ether of protocatechuic aldehyde, $C_6H_3(OH)(OCH_3).COH$. It has long been recognized, however, that this substance does not completely represent the flavor of the vanilla bean, as contained in extracts prepared from it, and it has therefore been assumed that other aromatic substances are associated with it. It has indeed been shown that by extracting Tahiti vanilla with ether, and removing the vanillin from the extract, an oily product of characteristic, agreeable odor is obtained, which contains both anisyl alcohol, $C_8H_9(OCH_3).CH_2.OH$, and anisaldehyde, $C_8H_9(OCH_3).COH$.

Vanillin is not now obtained to any extent from its natural source, but is produced on a large scale synthetically. Its first artificial production, although not a complete synthesis, was an achievement of great chemical interest. It was found, for example, that the glucoside coniferin, $C_{10}H_{12}O_8$, which is contained in the sapwood of pine trees, when hydrolyzed by acids or emulsin is converted into the crystalline coniferyl alcohol, $C_{10}H_{12}O_3$ or $C_6H_5(OH)(CH_2)(C_3H_7OH)$, and dextrose, and the coniferyl alcohol on oxidation is resolved into vanillin and acetic acid:



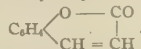
Vanillin is now produced technically from eugenol, $C_{10}H_{12}O_2$, which is found in the largest proportion in clove oil, although also a constituent of numerous other essential oils. The eugenol is first converted into an ester of isoeugenol, and the latter then subjected to oxidation. It is of interest to note that vanillin is quite widely distributed in nature, although usually occurring in very small amounts. It has been found in the oil of meadow-sweet (*Spiraea ulmaria*, Linné) and in clove oil, in the flowers of fragrant orchids, and in crude beet sugar, while its presence has been assumed in a considerable number of other vegetable products of the most diverse character.

Another related compound, which may appropriately be considered here on account of its extended use in perfumery, is the so-called heliotropin, $C_8H_8O_3$, which chemically is known as piperonal or the methylene ether of protocatechuic aldehyde,



This handsome, crystalline substance, which possesses in a marked degree the sweet odor of the heliotrope, was first obtained by the oxidation of piperic acid, $C_{10}H_{10}O_4$, the latter compound being formed, together with the base piperidine, $C_8H_{11}N$, when piperine, $C_{17}H_{25}O_2N$, the alkaloid of black pepper, is heated with alcoholic potash. It is now produced much more cheaply by the oxidation of isosafrol. The occurrence of piperonal in an essential oil has been observed in but one instance, it having been found in exceedingly small amount, together with salicylic aldehyde and methyl salicylate, in the oil of spiraea. Its presence in the heliotrope or in other flowers having a similar odor has not as yet been established.

An interesting and important odorous substance, which is quite different in chemical character from the crystalline substance just described, is the lactone known as coumarin, $C_9H_6O_2$, or the anhydride of orthohydroxycinnamic acid,



It was first found in the tonka bean, the fruit of *Dipleryx odorata*, Willd., from which it often separates in the form of a crystalline efflorescence on the surface, but has since been observed to occur in a very large number of plants. In some cases it appears not to exist ready formed in the plant, but to be produced through a fermentative action on drying. It is the substance

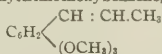
which imparts to various species of *Melilotus* or sweet clover the familiar fragrant odor, and is also found in considerable amount in the leaves of *Tristitia odoratissima*, Cass. (*Liatris odoratissima*, Willd.), the so-called deer's tongue or hound's tongue, an herbaceous composite plant which is common in the low pine barrens of Virginia and southward.

Coumarin is largely used in perfumery, and it is said to be the principal ingredient in the artificial extract of new-mown hay, the odor of which it closely resembles. It is probably now produced entirely by synthetic methods, one of which, known as the Perkin synthesis, consists in the action of acetic anhydride and anhydrous sodium acetate on salicylic aldehyde.

Another crystalline synthetic compound, which has been considerably employed for perfuming soap, was introduced into commerce some years ago under the fanciful name of "nerolin." This is the methyl ether of β -naphthol, $C_{10}H_7OCH_3$. Although its odor somewhat resembles that of the oil of neroli or orange flowers, it bears no chemical relationship to any of the constituents of this fragrant oil. The corresponding ethyl ether, which differs somewhat in odor from the methyl compound, has been used for a similar purpose.

ARISTOLOCHIACEAE

The family of *Aristolochiaceae* is represented by a few plants which possess aromatic properties, and among these there may be noted some species of *Asarum*. The rhizome and roots of the very unpretentious American plant, *Asarum canadense*, Linné, commonly known as Canada snakeroot, yield on distillation with water a highly aromatic essential oil, which has been used to a considerable extent in perfumery. This oil is of very complex composition, containing, besides a small amount of pinene, the fragrant alcohols *d*-linalool, geraniol, *l*- α -terpineol, and *l*-borneol, both in the free state and as esters, eugenol, and a large amount of eugenol methyl ether, together with an oil of a deep blue color, and other substances. Another American species of *Asarum*, namely *A. arifolium*, Mich., yields an oil which possesses a saffras-like odor, and consists chiefly of safrol, with smaller amounts of eugenol and its methyl ether, *l*-pinene, and asarone. The crystalline compound asarone, $C_{12}H_{16}O_2$, is a propenyltrimethoxybenzene,



and was first found more than a hundred years ago in the essential oil of *Asarum europaeum*, Linné, from which it separated in the solid state. In accordance with a custom of that time it was designated as "*asarum camphor*," the term camphor having formerly been applied to a great variety of solid substances which were obtained in this manner, such, for example, as menthol, which was known as "peppermint camphor." It is remarkable that the oil of *Asarum europaeum* appears to contain none of the fragrant alcohols which are present in the *Asarum canadense*, since the two species are botanically so closely related, and on the other hand the oil from the last-mentioned American plant contains no asarone.

A Chinese species of *Asarum*, namely *A. blumei*, Duch., is said to yield an essential oil possessing a saffras-like odor, and in which the presence of safrol has been determined.

ANNONACEAE

One of the essential oils of most exquisite fragrance is that distilled from the flowers of *Cananga odorata*, Hooker f. et Thomson, a tree belonging to the family of *Annonaceae*, which is distributed throughout the entire tropical portion of eastern Asia. In Manila the tree is known as "ylang-ylang," but in most of the provinces of the Philippines as "atangilang," a word which is said to denote something loosely pendent and fluttering, for the flowers as well as the branches of the older trees are drooping and readily stirred by the wind.

The finest ylang-ylang oil, which is used in the preparation of some of the choicest perfumes, is obtained from the Philippines, although the tree has also been cultivated in the islands of Java and Réunion for the production of the essential oil. The composition of the oil is exceedingly complex, and its constituents do not appear as yet to have been fully determined. It is, however, known to contain *l*-linalool and geraniol, which are probably present in part in the form of acetate and benzoate esters, eugenol and eugenol methyl ether, methyl benzoate and salicylate, benzyl acetate and benzoate, and free benzyl alcohol. A constituent which also contributes to the characteristic odor of the oil is the methyl ether of *p*-cresol, $CH_3.C_6H_4.OCH_3$. Formic acid and safrol have also been found, and a small amount of methyl anthranilate has been assumed to be present. The terpenes *d*- α -pinene and cadinene are likewise contained in the oil.

The oil distilled in Java, which is known in commerce as cananga oil, has been found to contain the aliphatic alcohol nerol, $C_{10}H_{18}O$, and the sesquiterpene alcohol farnesol, $C_{15}H_{26}O$, which has already been mentioned as a constituent of several fragrant flowers.

MYRISTICACEAE

The family of *Myristicaceae* yields the familiar products known as nutmeg and mace, which, on account of their aromatic properties, are largely employed for flavoring purposes or as a spice. The essential oil of nutmeg has in recent years been very completely examined, and has been shown to be very complex in composition, since more than twenty distinct chemical compounds have been identified among its constituents. The more important of these substances may be briefly enumerated, without consideration of the proportions in which they occur in the oil, as follows: α - and β -pinene, camphene, dipentene, *p*-cymene, *d*-linalool, terpinolene, borneol, α -terpineol, geraniol, safrol, eugenol and isoeugenol, eugenol methyl ether, myristicin, and various volatile acids. The substance termed myristicin, $C_{11}H_{18}O_2$, is 3-methoxy-4,5-methylene dioxy-*r*-allyl benzene. It represents the highest boiling constituent of the oil, and to it are due the narcotic effects of the nutmeg, such as have been observed in cases of so-called "nutmeg poisoning." It is also of special chemical interest from the fact that by a complicated series of reactions it has been found possible to pass from it to the basic substance known as cotarnine or stypticine, $C_{12}H_{15}O_2N$, which is an oxidation product of the opium alkaloid narcotine, $C_{22}H_{25}O_2N$.

LAURACEAE

The family of *Lauraceae* includes a number of plants which afford products that are not only of exceptional chemical interest but also of great economic importance. There may be mentioned in the first place the camphor tree, *Cinnamomum camphora*, Nees et Ebermayer, which is indigenous to southern China, Formosa and Japan. This tree affords the well known commercial products, camphor and camphor oil, which are at present produced most largely in Formosa and are obtained by the distillation of the wood with steam. Relatively small amounts of camphor have also been found in a considerable number of essential oils.

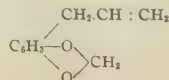
The ordinary camphor or *d*-camphor, which is chemically a ketone, $C_{10}H_{16}O$, or, as it may be written, $C_8H_8 \begin{array}{c} \diagup CH_2 \\ \diagdown CO \end{array}$, is too

well known to need description. It belongs to the class of hydroaromatic compounds, and there are probably few substances which have been the subject of such extended chemical investigation, more especially for the purpose of determining its constitution, which has now been definitely established.

Enormous amounts of camphor are consumed in the arts, especially in the manufacture of celluloid, and it enters into the composition of some smokeless powders, while considerable quantities are likewise used for disinfecting and medicinal purposes.

Camphor oil is a by-product in the Japanese camphor industry, and is of exceedingly complex composition, as no less than twenty-five distinct chemical substances have been identified among its constituents. It contains several terpenes, such as pinene, camphene, fenchene, phellandrene, dipentene, and limonene, together with a number of oxygenated compounds, among which camphor and safrol may be considered the most important. Safrol, $C_{11}H_{16}O_2$, is the chief constituent of saffras oil, which will presently be mentioned, and it was first obtained from this source, but it can be produced much more cheaply from camphor oil. It is largely employed for perfuming soaps, and also, after its conversion into isosafrol, for the production of piperonal or heliotropin, as has already been mentioned.

The saffras tree, *Sassafras varifolium* (Salisbury) O. Kuntze, is distributed throughout the greater part of the United States, and is particularly abundant in the eastern and southeastern sections. The bark of the root is highly aromatic, and yields on distillation with steam from 6 to 9 per cent of essential oil, whereas the woody portion yields less than 1 per cent. The oil contains about 80 per cent of safrol, together with terpenes, *d*-camphor, and a small amount of eugenol. The characteristic odor of the oil is due to safrol, which is the methylene ether of *m*-allyl catechol:



and has been found in relatively small portions in several other oils. This substance, which seems to have first been observed

as early as 1738, was formerly known as "sassafras-camphor." At low temperatures it separates from the oil in crystals which are sometimes as much as 4 in. in length and an inch in diameter, and which melt at 8° C. It is of interest to note that camphor oil contains the same constituents as sassafras oil, and when carefully fractionated to remove the portions of lower density and boiling point a product may be obtained which is scarcely distinguishable from genuine sassafras oil. Such a product has indeed been brought into commerce under the incorrect and rather misleading appellation of "artificial sassafras oil." The remarkable difference in composition of the oils obtained from the root and the leaves of the sassafras tree has already been indicated.

Another American plant which is deserving of mention in this connection is the California laurel or mountain laurel, *Umbellularia californica*, Nutt. The leaves of this tree yield from about 2 to 3 per cent of an essential oil, the odor of which is at first agreeably aromatic and somewhat camphoraceous, but when strongly inhaled is exceedingly pungent, affecting particularly the mucous membranes of the nose and eyes and causing a flow of tears. These properties are due to the presence of a ketone of cyclic structure, which has the empirical formula $C_{10}H_{16}O$, and has been designated umbellulone. When heated in a sealed tube for several hours at 250°, umbellulone is converted quantitatively, through a simple molecular transformation, into thymol. Besides umbellulone, which is the chief constituent, the oil contains pinene, and small amounts of eugenol and safrol, together with eugenol methyl ether.

Some plants of the laurel family that are indigenous to the Far East yield aromatic products of considerable commercial importance, such as the essential oils of cinnamon and cassia. The true oil of cinnamon is distilled from the bark of Ceylon cinnamon, *Cinnamomum zeylanicum*, Nees, whereas cassia oil, which is sometimes known as the oil of Chinese cinnamon, is obtained from *Cinnamomum cassia*, Blume, and for its production both the leaves and twigs appear to be employed. Although both of these oils contain cinnamic aldehyde, $C_9H_7CH:CH.CO_2H$, as their chief and most important constituent, that from the Ceylon cinnamon possesses the more delicate odor, and is therefore more highly esteemed, especially for use in perfumery. The other compounds which have been found to be contained in Ceylon cinnamon oil are pinene, phellandrene, methylamylketone, benzaldehyde, nonylic aldehyde, cumic aldehyde, linalool, eugenol, and the sesquiterpene caryophyllene. The constituents of cassia oil, other than cinnamic aldehyde, are cinnamyl acetate, benzaldehyde, salicylaldehyde, methyl salicylaldehyde, methyl α -coumaric aldehyde, benzoic and salicylic acids, and coumarin.

Considerable amounts of cinnamic aldehyde are now produced synthetically by the condensation of benzaldehyde with acetic aldehyde.

CRUCIFERAE

It has already been noted that many plants belonging to the family of *Cruciferae* yield volatile products which consist to a large extent of sulfur compounds and are known by the generic name of "mustard oils." These oils do not generally pre-exist in the plant, but are formed by the action of a particular ferment or enzyme on a glucoside, and they consist as a rule of esters of isothiocyanic acid, HNCS. A typical example of a mustard oil that is obtained from the seeds of the black mustard, *Brassica nigra*, Koch, and *Brassica juncea*, Hooker f. et Thomson, and this oil consists almost entirely of allyl isothiocyanate, $CH_3:CH.CH_2.NCS$. It is produced by the action of the ferment myrosin on the glucoside sinigrin (potassium myronate), when besides the volatile mustard oil, dextrose and potassium hydrogen sulfate are formed:



This mustard oil is also produced on a large scale synthetically by the action of allyl iodide on potassium thiocyanate in alcoholic solution, the heat employed in the operation causing the molecular transformation of the allylthiocyanate first formed into the isothiocyanate.

The white mustard seed, from *Sinapis alba*, Linné, differ essentially in composition from those of the black mustard, and do not yield a volatile product on distillation. They contain the very complex glucoside sinalbin, which by the action of myrosin, in the presence of water, yields the so-called sinalbin mustard oil, dextrose, and the acid sulfate of a base termed sinapine:



The sinalbin mustard oil, or parahydroxybenzylisothiocyanate, $C_6H_4.OH.CH_2.NCS$, is an oily liquid which is not vola-

tile in steam or at least only in traces. It possesses a burning taste, and causes blisters when brought on the skin, but only develops a pungent odor on heating.

A volatile oil obtained from rape seed, *Brassica napus*, Linné, or *B. campestris*, Linné, by the same method as that employed in the distillation of black mustard, has been found to consist of crotonylisothiocyanate, $CH_3:CH.CH_2.NCS$.

Cochlearia officinalis, Linné, the so-called scurvy-grass or spoonwort, yields a ferment oil, the chief constituent of which is the isothiocyanate of secondary butyl alcohol, $CH_3.CH_2-(CH_2)_2.NCS$. The essential oil obtained from the root of the horse-radish, *Cochlearia armoracea*, Linné, appears to be identical in composition with the oil of black mustard seed, and, like the latter, is a ferment oil.

Inasmuch as the flowers of the garden mignonette, *Reseda odorata*, Linné, family of *Resedaceae*, possess a delicate fragrance, it is remarkable that the fresh roots of this plant, when distilled with steam, yield a product which belongs to the class of mustard oils. This oil, which has a radish-like odor, consists chiefly of phenylethylisothiocyanate, $C_6H_5.C_2H_4.NCS$.

ROSACEAE

Any attempted description of the odorous constituents of plants would certainly be incomplete without consideration of the rose, whose exquisite perfume, as well as beauty of form and color, certainly entitle it to be designated as the "queen of flowers." Although several thousand varieties of the rose have been produced by cultivation, there are but a few species employed for the distillation of the essential oil, known as the otto or attar of rose, or for the production of rose water and rose pomade.

The rose which is cultivated in the Balkans, in southern Bulgaria, where by far the largest proportion of oil is produced, is *Rosa damascena*, Mill., and the same species has been successfully cultivated in Germany, near Leipzig, for the purpose of obtaining the oil. In southern France, where the rose is cultivated chiefly for the production of rose water and the preparation of rose pomade, the species employed is the *Rosa centifolia*, Linné.

The otto of rose, as has been seen to be the case in so many other odorous products, is somewhat complex in composition. Although the aliphatic alcohol geraniol, $C_{15}H_{27}H$, is the predominating constituent, the peculiar fragrance of the oil is due in part to the presence of a number of other compounds, such as *l*-linalool, *l*-citronellol, nerol, phenylethyl alcohol, citral, *n*-nonylic aldehyde, eugenol, and an aliphatic sesquiterpene alcohol, $C_{15}H_{25}O$, which apparently is identical with farnesol.

Another important product of the rose family, although not itself imparting an odor to the plant, is the essential oil of bitter almonds. This oil, as is well known, does not pre-exist, but is formed, together with hydrogen cyanide, by the action of an enzyme on the glucoside amygdalin, $C_{20}H_{27}O_9N$. It is said that for the technical production of the oil, apricot kernels are chiefly used, since they yield an oil identical in composition with that from the bitter almond, and are available in larger quantities. In either case the fatty oil is first removed from the kernels before they are subjected to distillation.

GERANIACEAE

An oil somewhat similar in character to the otto of rose is that of the rose geranium, which is distilled from the leaves of various species of *Pelargonium*. The species of this plant, or their cultivated varieties, which have been considered to be the source of the oil, are *Pelargonium odoratissimum* (Sol.) Ait., *P. capitatum*, Ait., and *P. roseum*, Willd., but it has quite recently been stated that in Algeria *P. graveolens*, Ait., is exclusively cultivated for this purpose.

The oil of rose geranium, of which several commercial sorts are known, has a pleasant rose-like odor. Its chief constituent is the alcohol geraniol, $C_{15}H_{27}OH$, but it also contains several other alcohols, such as citronellol, linalool, terpineol, and phenylethyl alcohol, partly in the form of esters, together with small amounts of menthone, citral, and terpenes. It may be well again to recall the fact that the so-called East Indian geranium oil, known also as palmarosa oil, is not obtained from a *Pelargonium*, but from a grass belonging to the genus *Cymbopogon*.

MYRTACEAE

The family of *Myrtaceae* yields some valuable aromatic products to which at least a brief reference should here be made. One of these products is the familiar spice, the clove, which consists of the dried flower buds of *Eugenia aromaticum* (Linné), O. Kuntze. The aromatic properties of the clove are due to an essential oil, which is yielded by the variety known commercially as Zanzibar cloves to the extent of 15 to 18 per cent. The most valuable and characteristic constituent of the oil is the phenol known as eugenol, $C_{10}H_{13}O_2$, or the methyl ether of dihydroxyallylbenzene, $C_6H_5.C_3H_2(1).(OCH_3)(3).OH(4)$, of which it con-

tains from 70 to 85 per cent. Although eugenol has a strong, clove-like odor, this is modified in the oil by the presence of small amounts of other substances, such as eugenyl acetate, methyl-amyketone and a sesquiterpene, $C_{15}H_{24}$, termed caryophyllene.

Eugenol is used to some extent in medicine and perfumery, but chiefly in the manufacture of vanillin, for which purpose it is converted by the action of alkalis into the more readily oxidizable isoeugenol, the isomerism consisting in the change of the allyl to a propenyl group. Isoeugenol is of further interest, inasmuch as it is said to form the basis of the carnation perfumes, which represent the odor of the garden carnation or clove pink, *Dianthus caryophyllus*, Linné.

The oil of pimenta or allspice, distilled from the unripe fruit of *Pimenta officinalis*, Lindley, is similar in composition to clove oil, inasmuch as it consists chiefly of eugenol and a sesquiterpene.

Bay oil, which is used to a considerable extent in perfumery, and especially for the preparation of the refreshing spirit known as bay rum, is distilled from the leaves of the West Indian tree, *Pimenta acris*, Wight, and possibly other closely related species of *Pimenta*. The oil contains from about 50 to 65 per cent of the phenols, eugenol and chavicol, together with their methyl ethers, citral, phellandrene, and the olefinic terpene $C_{10}H_{16}$, which has been designated myrcene. The occurrence of this compound in bay oil is of special interest, inasmuch as it was the first representative of its class. On hydration it is converted into a fragrant alcohol having the characteristics of linalool, $C_{10}H_{17}OH$.

The essential oils distilled from the leaves of various species of *Eucalyptus* represent an exceedingly important class of natural products, which are also of great chemical interest. These oils have been distilled chiefly in Australia, where the products from more than 160 distinct species of the genus have been investigated with respect to their chemical constituents.

On account of the great variation in the character and composition of the *Eucalyptus* oils only a very brief reference can here be made to them. One of the most important constituents is the compound known as cineol, $C_{10}H_{18}O$, which is sometimes designated as eucalyptol. This is contained in large proportions in the oils from *Eucalyptus polybracteata*, *E. smithii*, and *E. australiana*, the latter having formerly been considered by botanists to be *E. amygdalina*, and these species are therefore now most extensively utilized in eastern Australia for the production of oil for pharmaceutical or medicinal purposes. Another important species which is now known as *Eucalyptus dives*, but was formerly classified as a variety of *E. amygdalina*, yields an oil which consists principally of levorotatory phellandrene, $C_{10}H_{18}$. The oil from *Eucalyptus macarthuri* is said to contain 60 per cent of geraniol and geranyl acetate, and is therefore valuable in the preparation of perfumes, while that from *E. citriodora* consists to the extent of 80 to 90 per cent of citronellal, $C_{10}H_{16}O$, and is much used for perfuming soap. *Eucalyptus staigeriana* yields an oil which possesses an odor resembling that of the lemon or verberna, and consists chiefly of citral, $C_{10}H_{16}O$, together with terpenes.

Cineol, at ordinary temperatures, is an optically inactive liquid, which possesses a camphor-like odor, but at a temperature of $+1^{\circ}C$. it forms a crystalline solid. With reference to its constitution it occupies a somewhat unique position among the constituents of essential oils, inasmuch as it represents an organic oxide. It is largely used medicinally, and possesses valuable antiseptic properties.

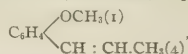
One of the most important technical uses of a *eucalyptus* oil is for the separation of minerals by the method of floatations and for this purpose an oil of the phellandrene type, such as that from the above-mentioned *E. dives*, is considered to be the best. The amount required for the treatment of the ore ranges from 1/20 to 3/4 lb. of oil per ton of ore, and the extent of its use may be indicated by a recent statement that in the De Bavy process of mineral separation upwards of 300 tons of *eucalyptus* oil are annually employed.

UMBELLIFERAE

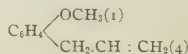
The family of *Umbelliferae* contains a considerable number of harmless aromatic plants, as well as some which possess acrid, narcotic properties. Unlike many other plants, the aromatic constituents of this group are not developed in a single part or organ of the plant, but are frequently more generally distributed. They are thus found not only in the leaves and fruit, but also in the root, as for example, in the edible roots of the carrot, celery, and parsnip, to which they impart a characteristic flavor. In the time available it will not be possible to consider more than a very few of the compounds to which the aromatic properties of these plants are due.

The fruits of the anise, *Pimpinella anisum*, Linné, yield an essential oil which consists chiefly of two isomeric compounds

of the formula $C_{10}H_{18}O$. One of these, which constitutes about 80 to 90 per cent of the oil, is anethol, or *p*-propenylanisol,



a substance which is solid at ordinary temperatures, and crystallizes in snow-white laminae. It has a strong anise-like odor, and an intensely sweet taste. The other isomeric compound is methylchavicol, or *p*-allylanisol,



a liquid which has a slight anise-like odor.

The commercial oil of anise is obtained chiefly from the fruits of the star anise, *Illicium verum*, Hooker fil., belonging to the family of *Magnoliaceae*. The tree which yields these fruits is found in the southwest provinces of China and in the French colony of Tonkin, the essential oil being distilled on a large scale in both of these countries. The oil of the star anise, like that of true anise, consists chiefly of anethol, together with some methylchavicol, terpenes, and other substances.

Anisaldehyde, or *p*-methoxybenzaldehyde, $C_9H_8(OCH_3)COH$, which is produced by the oxidation of anethol, occurs in commerce under the name of aubépine. It is of interest on account of its use in perfumery, since it possesses in a marked degree the odor of the hawthorn or May blossom, *Crataegus oxyacantha*, Linné, belonging to the family of *Rosaceae*. The so-called aubépine is in fact the basis of all the artificial hawthorn perfumes.

The essential oil distilled from the fruits of the fennel, *Foeniculum vulgare*, Miller, has been known for several centuries. As produced from the fruit grown in different countries it varies somewhat in composition, but the commercial oil, like that of anise, consists to a large extent of anethol. It also contains, however, in addition to methylchavicol and terpenes, a ketone known as fenchone, $C_{10}H_{16}O$, which is isomeric with camphor and gives a series of analogous derivatives. Fenchone is liquid at ordinary temperatures, and, as obtained from the oil of fennel, is dextrorotatory. In the levorotatory form it is a constituent of *Thuja* oil, which is distilled from the leafy twigs of *Thuja occidentalis*, Linné, or *Arbor vitae*.

The fruits of the caraway, commonly called caraway seed, from *Carum carvi*, Linné, yield an essential oil which contains as its chief constituent the unsaturated, cyclic ketone known as carvone, $C_{10}H_{14}O$. This ketone, which possesses the characteristic odor of the caraway, has the interesting property of forming a crystalline compound with hydrogen sulfide, $(C_{10}H_{14}O)_2 \cdot H_2S$, from which it may be regenerated in a pure state. It is accompanied in the oil by about an equal amount of *d*-limonene.

The oil of dill, distilled from the fruits of *Anethum graveolens*, Linné, contains about 40 to 60 per cent of carvone, identical with that contained in the oil of caraway, together with *d*-limonene.

The fruits of the coriander, *Coriandrum sativum*, Linné, yield an essential oil, of which the most important constituent is an open-chain terpene alcohol of the composition $C_{10}H_{18}O$. This substance, which possesses a fragrant odor, was first designated as coriandrol, but is now known as *d*-linalool, since its optical antipode is contained in an oil distilled from the Mexican linaleo wood, from species of *Bursera*. Both of these optical modifications of linalool, either in the free state or in the form of esters, have in recent years been observed to occur in a considerable number of plants. The acetic ester, or linalyl acetate, $CH_3COOC_{10}H_{17}$, is considered to be the most valuable constituent of the oils of bergamot and lavender.

The well-known celery, *Apium graveolens*, Linné, contains in all parts of the plant an essential oil, which, however, is particularly abundant in the fruit. The oil from the fruit consists to the extent of about 90 per cent of hydrocarbons, the chief portion of which is *d*-limonene, and it also contains small amounts of phenols and other compounds. The characteristic odor of celery is attributed to two compounds, one of which is a lactone termed sedanolol, $C_{15}H_{24}O_2$, while the other represents the anhydride of sedanic acid, $C_{15}H_{24}O_2$.

The common parsley, *Petroselinum sativum*, Hoffmann, like the celery, contains an essential oil in all parts of the plant, but which is present to the largest extent in the fruit. The chief constituent of this oil is the crystalline substance termed apiol, $C_{15}H_{24}O_4$, which is a dimethoxymethylenedioxyallylbenzene. It differs only from the myristicin of nutmeg oil in containing an additional methoxyl group, and myristicin has indeed been found in French parsley oil, which is poorer in apiol.

An umbelliferous plant which is largely cultivated in India, the *Carum ajowan*, Benth. et Hook., is of special interest and importance on account of the character of the essential oil distilled from the fruit. The oil contains from 40 to 50 per cent of thymol, $C_{10}H_{14}O$, which is used to a considerable extent medicinally on account of its antiseptic and germicidal properties.

It is well known that a number of umbelliferous plants possess poisonous properties, and attention may be called to one of these on account of its delusive character. The *Oenanthe crocata*, Linné, known as water hemlock, has a root consisting of a number of thick, whitish, parsnip-like tubers, and on account of its sweetish and aromatic taste is sometimes mistaken for the parsnip. It is therefore sometimes eaten both by children and cattle, and often with fatal results, for it is one of the most virulent of the vegetable poisons. The sweet taste of the roots is due to the presence of a considerable proportion of cane sugar, while the toxic properties are attributed to an undetermined constituent of the resinous material.

ERICACEAE

The family of *Ericaceae* contains many plants of special attractiveness as well as of chemical interest, for one is reminded of the beauty of the rhododendrons and the exquisite fragrance of the flowers of the trailing arbutus, *Epigaea repens*, Linné. In the present consideration of odoriferous compounds, a brief reference should at least be made to one of the members of this family, namely, *Gaultheria procumbens*, Linné, the leaves of which yield the highly aromatic wintergreen oil. The true oil of gaultheria is now rarely obtainable in commerce, having been almost entirely replaced by an oil distilled from the bark of the sweet birch, *Betula lenta*, Linné. These oils do not pre-exist in the respective plants, but are formed through the hydrolytic action of an enzyme upon a glucoside termed gaultherin. Both of them consist chiefly of methyl salicylate, and they have in turn been superseded to a large extent by a synthetic product, which is produced in a high degree of purity, and is known in commerce as synthetic oil of wintergreen.

The occurrence of methyl salicylate, or the glucoside yielding it, is not restricted to the sources just mentioned, since it has been found in comparatively small amounts in a very large number of plants. As examples of its distribution it may be noted that it occurs in tea and coca leaves, in the flowers of the tuberose and meadow sweet (*Spiraea ulmaria*, Linné), and in other instances may be contained in either the bark or root of the plant.

Another ester of salicylic acid, which is not known to occur in nature but is largely used in perfumery, is amyl salicylate. This is a colorless liquid, possessing a strongly aromatic odor, resembling that of the flowers of some of the orchids. It is said to form the basis of the artificial clove perfumes.

LABIATÆ

The mint family contains such an exceedingly large number of aromatic plants, that only a very few can be considered for the purpose of illustrating the character of their odoriferous constituents. There may be mentioned in the first place, as one of the more important and familiar representatives of the family, the peppermint, *Mentha piperita*, Linné. The leaves of this plant yield an essential oil which is one of the most complex in composition of this class of products, since seventeen distinct chemical compounds have thus far been identified in it. The chief constituent of the oil is the well known secondary alcohol menthol, $C_{10}H_{18}O$, which occurs both in the free state and in the form of its acetic and valeric esters.

The Japanese peppermint oil, distilled from varieties of *Mentha arvensis*, DC., is largely utilized for the production of menthol. It has quite recently been shown that this oil contains a new and interesting compound, which is a hexenylphenylacetate of the constitution $CH_3(C_6H_4).CO_2.C_6H_5.C_6H_5$. In the pure state this compound is said to possess an onion-like odor.

Spearmint, *Mentha viridis*, Linné, although botanically so closely related to the peppermint, yields an essential oil of quite different odor and composition, its chief constituent being *l*-carvone, $C_{10}H_{16}O$, which is accompanied by phellandrene, *l*-limonene, and possibly *l*-pinene. The characteristic odor of the oil has been ascertained to be due to the presence of dihydrocuminyl acetate.

The American pennyroyal, *Hedeoma pulegioides*, Persoon, yields an essential oil which possesses a highly aromatic, mint-like odor. The chief and most characteristic constituent of this oil is the ketone known as pulegone, $C_{15}H_{26}O$, but it also contains *l*-menthone, *d*-isomenthone, and methylcyclohexanone.

Several species of *Monarda* yield essential oils of chemical interest, and that from *Monarda punctata*, Linné, the so-called horse mint, is of considerable economic importance, inasmuch as it contains a large proportion of thymol, $C_{10}H_{14}O$, and is utilized for the production of this substance. The essential oil of

Monarda fistulosa, Linné, or so-called wild bergamot, appears to contain no thymol but its isomeric carvacrol. It also contains the interesting compound, thymohydroquinone, $C_{10}H_{14}O_2$, which is of rare occurrence in nature, but its dimethyl ether forms the chief constituent of the oil of arnica root, from *Arnica montana*, Linné.

The occurrence of thymol in an oil distilled from the fruit of an umbelliferous plant, *Carum ajowan*, Benth. et Hook., has already been noted, and it is also contained in a number of labiate plants other than the *Monarda*. It is a constituent, for example, of the oil of thyme, *Thymus vulgaris*, Linné, from which its name is derived, and of the oils obtained from species of *Ocimum*, *Satureja*, and *Origanum*.

A labiate plant which is highly esteemed on account of the fragrance of its flowers and the oil distilled therefrom is the lavender, *Lavandula vera*, DC. The essential oil of lavender is used almost exclusively as a perfume, especially in the form of the popular lavender water. With regard to the composition of the oil, it has already been noted that the oil distilled in England from the flowers of cultivated plants differs very greatly from that produced in France from the wild-growing plants of mountainous regions. The French oil is characterized by its large percentage of esters, chiefly linalyl acetate, together with some butyrate, and possibly propionate and valerate. It also contains free linalool and geraniol, *d*-borneol, and small amounts of several other compounds. The English oil contains a very much smaller proportion of esters, and is relatively rich in cineol.

The lavender is valued not only on account of its refreshing fragrance, but its essential oil is also considered to possess decided antiseptic properties. In this connection it has been of interest to observe that during the recent war many appeals were made in England for lavender bags for hospitals, and the flowering stalks of lavender, tied in bundles, are said to have been employed for fumigation in hospital wards.

COMPOSITÆ

The family of *Compositæ*, although an exceedingly large one, does not appear to contain so large a proportion of plants possessing odoriferous constituents as some of the smaller families already mentioned. Nevertheless, a considerable number of volatile products have been obtained from plants of this family, and some of the more important of these may be briefly considered.

In the first place there may be noted the chamomile, of which two varieties are known in commerce and employed medicinally. The so-called Roman or English chamomile consists of the flower heads of *Anthemis nobilis*, Linné, whereas the German chamomile represents the flower heads of *Matricaria chamomilla*, Linné. The essential oil of the Roman chamomile, when freshly distilled, has a pale blue color, and has been found to contain, among other substances, cumic aldehyde, and the esters of isobutyric, methyl-ethylacetic, angelic and tiglic acids, with isobutyl, amyl and methyl-ethylpropyl alcohols. The freshly distilled oil of the German chamomile, of whose composition but little is known, is remarkable for its deep blue color, a character which is possessed, however, by several other oils or fractions obtained from them, such as those of the yarrow (*Achillea millefolium*, Linné), wormwood (*Artemisia absinthium*, Linné), valerian (*Valeriana officinalis*, Linné), Canada snake-root (*Asarum canadense*, Linné), Algerian rue, and asafetida.

The constituent of the oil of chamomile to which its deep blue color is due has recently been ascertained to be a highly unsaturated hydrocarbon of the composition $C_{15}H_{18}$, which has been termed azulene. This hydrocarbon is an intensely blue, viscous liquid, having a phenolic odor. It is tricyclic, and contains four ethylenic linkings. On reduction it is converted quantitatively into a tricyclic dihydro-sesquiterpene, $C_{15}H_{26}$.

The wormwood, *Artemisia absinthium*, Linné, yields an oil which contains dextrorotatory or β -thujone, $C_{15}H_{26}O$, thujyl alcohol, $C_{10}H_{18}O$, both in the free state and in combination with acetic, valeric, and palmitic acids, together with phellandrene, cadinene, and the previously mentioned blue oil or azulene. Wormwood oil possesses toxic properties, and is used in the preparation of the liqueur known as absinthe.

The essential oil of tansy, from *Tanacetum vulgare*, Linné, contains β -thujone (tanacetone) as its chief constituent, together with *l*-camphor and borneol. It is said to be exceedingly poisonous.

Several species of *Solidago*, or golden rod have aromatic properties, the leaves of *S. odora*, Aiton, when crushed, exhaling a pleasant, anise-like odor. *Solidago canadensis*, Linné, yields an essential oil which consists chiefly of pinene, together with phellandrene and dipentene. It also contains about 10 per cent of borneol, 4 per cent of bornyl acetate, and cadinene.

The fleabane, *Erigeron canadensis*, Linné, is a common weed which yields an essential oil that has been used to some extent medicinally. The chief constituent of the oil is *d*-limonene.

A product of a composite plant which is of somewhat special interest is the Ngai camphor of the Chinese. This is obtained from *Blumea balsamifera*, DC., which is indigenous to India, and consists of nearly pure *l*-borneol. Although ordinary camphor, which is produced in Japan and Formosa, and has already been referred to, is largely used by the Chinese, the so-called Ngai camphor is highly esteemed by them for medicinal and ritualistic purposes, and is also used for perfuming the finer kinds of Chinese ink.

ESSENTIAL OILS IN COMMERCE

In the present representation of the odorous constituents of plants an attempt has been made to illustrate, by means of more or less familiar examples, their wide distribution and extremely varied chemical character. Although the limitations of time have rendered it impossible to consider more than a small proportion of the plants whose odorous constituents are known, the few that have been selected may nevertheless serve to indicate the degree of interest pertaining to investigations in this field of science.

	Weight Lbs.	Value Dollars
Oil of peppermint, crude.....	254,793	353,076
Oil of peppermint, refined.....	109,198	248,541
Oil of spearmint.....	94,209	238,074
Oil of black birch.....	41,178	67,691
Oil of wintergreen.....	6,000	24,538
Oil of wormwood.....	4,702	9,040
Other essential oils.....	.....	348,522

From a practical point of view it may be noted that the essential oils and substances related to them play a very considerable part in the world's commerce. According to the Census of Manufactures for 1914, as issued by the Department of Commerce in 1918, the number of establishments in the United States engaged in the production of volatile or essential oils was 107, and the total value of these products was \$1,289,482.¹ The

¹ These figures do not include the turpentine production of the country, which in 1914 amounted to 27,648,939 gal., representing a value of \$10,740,327.

distribution of these oils, with reference to their amounts and value, is given in the preceding tabulation.

The essential oils not enumerated include, in addition to the oils of sassafras, cedar, pennyroyal, and tansy, considerable quantities of the oils of sandalwood, camphor, cloves, parsley, patchouli, lemon, and orange.

The total value of the essential oils imported into the United States during the year ended June 30, 1916, as given in the year-book of the Department of Agriculture, 1917, was \$3,109,656. The amounts and value of the camphor imported during the same period was as follows:

Camphor, crude.....	4,374,430 lbs.	Value, \$1,236,172
Camphor, refined.....	1,866,154 lbs.	Value, \$ 619,320

These amounts, especially of refined camphor, were greatly increased during the year 1917.

As an indication of the importance of a single essential oil, it has recently been stated that before the European war the exports of sandalwood oil from India were valued at about \$500,000 per annum, but that the factories established in Mysore since the beginning of the war are alone capable of producing nearly \$100,000 worth of sandalwood oil per month.

While some of the essential oils, notably those of turpentine and eucalyptus, are used to an enormous extent for technical purposes, and a number of others in much smaller amounts medicinally, very large quantities of the more fragrant oils are used for the production of perfumes and as flavoring agents. Perfumes, although so largely employed, are generally regarded as a luxury, but, apart from the refreshing qualities of some of these preparations, many of the essential oils which enter into their composition have been shown to possess antiseptic or bactericidal properties, and they may therefore be considered to have a decided hygienic value.

PHYTOCHEMICAL LABORATORY
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REPORT OF THE ALIEN PROPERTY CUSTODIAN ON THE CHEMICAL INDUSTRY

The report of the Alien Property Custodian, A. Mitchell Palmer, was made public on March 9, 1919. On February 15, 1919, practically all known enemy alien property in the country had been seized and its total value was approximately \$700,000,000. The report divides enemy investments in America into two classes—those made in a small way by Germans attracted by the possibilities in America, and those made by combined capital in Germany having close affiliations with the great political and financial powers of the empire. Those in the first class are being treated as largely friendly and held in trust pending final action by Congress, but of the second or hostile class the report says, "No obligation is owed to their private owners to conserve or care for them with a view of ever returning them in kind." The chapter of the report entitled "The Chemical Industry" is printed in full herewith.—[EDITOR.]

The great field of chemical industry presented, at the outset, perhaps the most difficult of the many problems which the Alien Property Custodian was expected to solve. It was, or had been until importations ceased, saturated through and through with German influence. In regard to no branch of human endeavor was the myth of German invincibility more firmly fixed in the public mind. The country was flooded with German chemists; and those who were not German by origin, were mostly German, directly or indirectly, by training. A vast proportion of the persons engaged in the business bore German names. Connections more or less close between American and German houses were frequent and obvious. There was unquestionably a considerable German interest in such manufacturing as was being carried on. In view of the well known and uniform policy of the great German government-aided combinations to embark in foreign manufacture only when export from Ger-

many was not feasible, this interest seemed unlikely to be large; but, unless it could be discovered and rooted out, no substantial Americanization of the industry was possible. The German chemical industry, which had so thoroughly penetrated and permeated our own, was gigantic, perhaps the strongest, and certainly the most remunerative of all Teutonic industries. The task of identifying and taking over its property in the United States was thus a direct attack upon a most formidable opponent; while the information on which the work had to be based, had to be derived, to an exceptional extent, from men hostile by birth or tradition.

In order to give a fair understanding of the situation, it is necessary to sketch briefly the history of the German chemical industry. From about the middle of the nineteenth century, the practical application of chemical science began to occupy the attention of a constantly increasing number of the best scientific and industrial minds of Germany. A combination of natural advantages and national characteristics led to rapid advance. The industrial districts in which the necessary materials and other facilities were found or developed were exceptionally compact. Distances were short and transportation easy. Labor was cheap, docile, and stable. On the other hand, the national habit of mind was peculiarly fitted for chemical research work, and particularly for the interminable tasks presented by such research, in the way of exhausting the immensely numerous possible combinations available within a particular field. From the first, scientific attainment, and particularly accomplishment in the field of research, appealed strongly to the public mind. Men of science, and particularly research workers, were more highly regarded than in other countries. This tendency was strongly fostered by the government, which, by conferring honors and titles, did everything possible to exalt the position of the successful scientist.

As a consequence of these conditions, the universities were at an early date provided with the most elaborate and advanced equipment for research work, and attracted to themselves an extraordinary proportion of the ablest young men of the nation. They accordingly proceeded to turn out a constantly increasing number of highly trained technical men, whose services were available to the rising chemical industry. The number of these men was such that the inevitable competition between them for places made the average salaries exceedingly small. Highly skilled service was, therefore, available to the German chemical manufacturer at an extraordinarily low cost. In this respect he had a marked advantage over the manufacturers of any and every other country in the world.

These advantages were made use of to an extent nowhere else approached, because from a comparatively early date the importance of research work to practical industry was firmly grasped by both the industrial and governmental ruling classes. The alliance of the manufacturer and the university professor became constantly closer and more complete. To meet the needs pointed out by the industrial leaders, armies of plodding, but nevertheless skillful, chemists completed hundreds of thousands of separate researches. The results of these kept the German chemical manufacturers constantly in the van—always somewhat ahead of their competitors in other countries in the way of new processes and products.

While all that has been said above applies in a measure to every form of chemical activity, the German advantages were naturally less in the manufacture of the heavy chemicals than in the more difficult and complicated processes involved in other forms of the industry. Chemicals which are consumed in great quantities, like sulfuric acid or soda ash, are produced at prices so low that costs of transportation are often a controlling factor. Accordingly, in this branch of the trade the Germans never attained supremacy. The natural tendency was for each country to supply itself with these essential materials and this natural tendency had not, at least so far as the United States was concerned, been overcome.

In two other great branches of chemical industry, however, the Germans had attained not only the first place, but to all intents and purposes a world monopoly—that is to say, in the practical application of organic chemistry to the manufacture of dyestuffs and medicinals. Although the first coal-tar dye was made in England by an English chemist and the next important step in the development of the industry—the production of fuchsine, or magenta—was the work of a Frenchman, the Germans almost immediately advanced beyond the rest of the world in the development of this infinitely complex industry.

This complexity of the manufacture of dyestuffs as a business proposition is almost beyond belief. Tens of thousands of distinct dyes were produced in the German factories, and over 900 of these were actually sold in appreciable quantities in the American market alone before the war. Each of these nine hundred and odd products required a separate and distinct process of manufacture, one differing from the next, in many cases, as widely as if the products had been those of unrelated industries. While all these dyestuffs and a host of pharmaceuticals have a common source, in that they are derived originally from coal tar, they descend from this common ancestor by an enormous number of separate family lines. From the hundreds of distinct substances found in coal tar 10 so-called crudes form the starting points of substantially all the processes which result in dyes. From these more than 300 so-called intermediates are produced by a variety of more or less complex chemical reactions. Most of these reactions require the use of large quantities of acids and other chemicals not produced from coal tar. From the intermediates thus obtained an infinite number of possible dyestuffs can be produced. Many thousand such dyestuffs have been actually produced and marketed.

In carrying out the processes which result in the extraction of the crudes from coal tar, the conversion of crudes into intermediates, and of intermediates into dyes, the quantities of each substance produced depend not upon the will of the manufacturer, but upon the inexorable laws of chemistry. The proportion of the various substances obtained can be varied slightly by skillful manipulation, but only to a small extent. The manufacturer cannot avoid producing large quantities of certain materials in order to secure perhaps smaller quantities of others. Again, at the very starting point of the industry, in extracting the crudes from the original coal tar, an analogous situation arises. The tar's content of anthracene, from which the most valuable of all modern dyes are derived, is relatively small; that of naphthalene, for instance, is immensely larger. The tar distiller cannot obtain anthracene without producing or wasting much greater quantities of naphthalene, benzol, and other crudes. The same truth holds good in every subsequent step of the immensely complex processes of dye manufacture. At each step by-products are produced in addition to the products sought. The obvious result is that, unless the final product can be sold at a colossal price, uses or markets must be found for most of these innumerable by-products. Many of them, fortunately, are useful in the manufacture of intermediates and dyes. Many have been found to have important medicinal effects and have taken permanent rank as pharmaceuticals. For others no use has been found, and the unavoidable production of these represents pure waste.

The most important feature, however, of this production of by-products is the relation which it bears to the explosive industry. All the most important explosives of the present day are either coal-tar products or the result of chemical processes requiring the use of coal-tar products. In a large dyestuff factory there is an unavoidable production of considerable quantities of substances which are directly available for conversion into explosives. A still more striking example is that of paramononitrotolual. This is an intermediate necessarily made in quantities often beyond the needs of the dye makers. To the end of the last century many thousand tons of this substance had accumulated in the German dye works, which were making frantic efforts to find uses for it in dye making. About 1904 these efforts suddenly ceased. Trinitrotolual (TNT) had been adopted as a military explosive, and every pound of the accumulation was directly available for easy conversion into this most formidable of high explosives. Moreover, in addition to these by-products which can be used for manufacture of explosives, many of the materials which are not by-products but are directly useful for the production of dyes, can also, by slight alterations in the processes employed, be converted into explosives. For example, in the production of sulfur black, one of the most important black dyes, a slight variation in the final step of the long and complicated process of manufacture will transform the ultimate product into picric acid. More important still, the technical skill required for the manufacture of explosives is precisely that possessed by the chemical staff of a successful dye works and is to be found nowhere else.

Three things are apparent in regard to a business conducted under such conditions. One is that, unless limited to the manufacture of a very few carefully selected products, it must be carried out on a large scale with the aid of immense resources in the way of capital and technique. Another is that, if carried out on a large scale, one of its most important features will inevitably be the maintenance of large research laboratories to work out the infinite problems raised by the necessity of disposing of by-products. A third is that the connection with the explosive industry is so close that no government which gave any serious consideration to the possibilities of war could fail to see the necessity of aiding and controlling the industry. The truth of each of these propositions was at once demonstrated in the history of the German dyestuff industry. From an early

period, the manufacture became concentrated in a few important companies.

These companies, ultimately six in number, developed into enormous establishments producing practically complete lines of dyes and manufacturing most of their own crude and intermediates, as well as many of their acids and heavy chemicals. Several of these establishments also became large producers of pharmaceuticals in order to procure an outlet for their by-products. Outside of these very large houses, the industry was confined for the most part to small establishments producing only a limited number of carefully selected dyes, so chosen as to minimize the by-product difficulty, and so organized as to enable the owners to save most of the overhead expense by themselves furnishing the required technical skill and superintendence. These, indeed, were mostly little more than assembling plants. In the great establishments, the research laboratories became large and highly efficient institutions. In these laboratories hundreds of chemists were constantly employed. Their facilities were placed at the disposal of research chemists from universities—often men who had no connection with the dye industry whatever. Many of the manufacturers' own chemists were allowed and encouraged to proceed with researches which had no probable immediate commercial utility, but which tended to increase the existing supply of knowledge in those general regions of the world of organic chemistry in which the dyestuff concerns were operating. The result of all this inevitably was the accumulation of an immense mass of scientific data which usually afforded a quick and easy solution to each industrial problem as it arose. The results were sometimes startling. The most striking instance, perhaps, is the case of the *Pfleger* patent. The invention covered by this patent solved, by the use of sodium amide, of which an overproduction was available, the problem of producing indigo direct from aniline, and thus afforded a process far simpler than and at least as cheap as any theretofore known. As an instance of how closely such matters are followed by the German public, it may be noted that the announcement of the purchase of this patent by the great *Hoechst* works, one of the largest German dye manufacturers, advanced the company's stock 150 points on the stock exchange in a single day. The importance of this research branch of the industry is thus hard to overestimate. Finally, the connection with the explosives industry resulted, as is well known, in constant governmental assistance to and control of the dye industry. Much was done by the German government to insure the prosperity of the dye industry and its immediate convertibility to the production of munitions.

These conditions soon produced in the dye industry certain results similar to those which occurred in all the other important German industries during the great period of expansion at the end of the nineteenth century. The improvements in processes brought about by research laid heavy emphasis on the value of quantity production. Quantity production, carried on by competing houses, led to overproduction. Overproduction led to a determined effort to establish and maintain a large export trade. The natural advantages of the German industry, as compared to the industry in other countries, prevented serious competition in Germany itself. The government's tariff and other policies enabled home prices to be kept up. It was then evidently to the advantage of any manufacturer to produce far more than he could sell in the home market, even if his export trade had to be carried on at a loss, when by doing so he could use a process so economical that his profits on home trade would be largely increased. Accordingly, German dyestuffs began to appear in every country at prices which domestic manufacturers could not meet. The inevitable result was that in country after country the domestic manufacture was destroyed or stifled in its cradle. As soon as this had been accomplished, it was no longer necessary for the German exporters to sell at or below cost. Prices were immediately raised and handsome profits

realized. The tendency to this result was recognized by the German government from the first, and every facility was afforded to the growing export trade. It was fully realized by both the civil and military authorities that if a world monopoly in the dyestuff industry could be built up the military strength of Germany would be colossally enhanced, since it alone of all the great powers would then be in a position to secure immediate supplies of the vast quantities of munitions likely to be needed in a modern war.

The methods under which this dumping policy was conducted, and its extent, may be illustrated by a few specific instances. Most of these occurred in branches of the chemical industry other than the manufacture of dyes, for the simple and sufficient reason that in this country, at least, the dyestuff industry never reached a point where it required much discouragement. When, however, in 1910 the first determined effort was made in this country to establish the manufacture of an important intermediate, when, that is to say, the Benzol Products Company was organized by a group of men interested in the heavy chemical industry, to manufacture aniline oil on a large scale, the German hand was immediately shown. The price of aniline oil at the time of the establishment of this company averaged 11½ cents. As soon as its manufacture was fairly underway, the German exporters commenced to cut the price. Apparently, no definite prices were made by the Germans, but they adopted the simple policy of offering any customer of the new concern supplies at less than the price he was paying. For example, one of their most important customers refused an advantageous contract at 8½ cents, stating that he had assurance from the Germans that whatever price the Benzol Products Company made would be met and bettered by them. Accordingly, the new company struggled on, conducting its operations without profit, and only because it was supported by a group of men of exceptional determination and insight was it able to survive until the war gave it an opportunity to establish its business on a firm foundation. Among other examples are the following: In 1903, there were in the United States five manufacturers of salicylic acid. By 1913, three of these had failed. Of the two survivors, one was the Heyden Chemical Company, a mere branch of a German house, which, as such, I have since taken over. During the latter part of the decade referred to, salicylic acid was selling in Germany at from 26¼ to 30½ cents. During the same period, the German houses were selling it in this country after paying a duty of 5 cents, at 25 cents, or from 6 to 10 cents below what they were getting at home.

A similar situation developed in the manufacture of oxalic acid. In 1901, when there was no American manufacture, it was sold by the Germans at 6 cents. In 1903, when the works of the American Acid and Alkali Company were started, the price was immediately dropped to 4.7 cents, at about which figure it remained until 1907 when the American factory was shut down for a number of months. During this shutdown period the price was instantly raised to 9 cents. When the factory reopened the price was again dropped until in 1908 the company failed. It was then reorganized and in 1909 secured the imposition of a 2 cent duty on the acid, from which time up to the beginning of the war the price ran at about 7½ cents per lb. The same process was carried on in regard to bicarbonate of potash. In 1900 there was no American manufacture and imports ran about 160,000 lbs. In 1901 American manufacture began. This succeeded so well that in 1906 imports had dropped to 45,000 lbs. At this time the American manufacturer's price was 6½ cents, while the import value was given at 4.9 cents. In the following year the Germans made a determined and successful onslaught. Their import value was lowered to 2.2 cents with a result that, instead of 45,000 lbs., 310,000 lbs. were imported. Accordingly, in 1908, the American manufacturer failed. The price was immediately

raised to $7\frac{1}{2}$ cents and remained thereabouts thereafter until the war. Many similar instances might be cited, but these sufficiently indicate the method and its results.

This determined onslaught upon the competing industries of other countries, this definite attempt to secure world monopoly naturally created a strong tendency toward combination. As has been stated, by the end of the nineteenth century the real manufacture of dyes on a large scale was concentrated almost exclusively in six great firms. These were the following:

Badische Anilin und Soda Fabrik, Ludwigshafen on the Rhine, hereinafter known as Badische; Farbenfabriken vorm. Friedr. Bayer & Co. in Leverkusen, hereinafter referred to as Bayer; Actien-Gesellschaft für Anilin-Fabrikation in Berlin, hereinafter referred to as Berlin; Farbwerke vorm. Meister Lucius & Brüning in Höchst-am-Main, hereinafter referred to as Höchst; Leopold Cassella, G. m. b. H. in Frankfurt; and Kalle & Co. Aktien-Gesellschaft in Biebrich.

Each of these six great companies had attained enormous proportions long before the war. Only two other concerns have carried on manufacture on a scale in any sense comparable. These are the following: Chemische Fabrik Griesheim Elektron of Frankfurt a. M., a company which has absorbed a number of smaller manufacturers, and Chemische Fabriken vormals Weiler-ter-Meer, Uerdingen.

It will be noted that all of these establishments with the single exception of Berlin are concentrated in a narrow strip of territory near the Rhine and its tributaries. Their growth may be illustrated by a few figures as to two of the largest. Hoechst was organized in 1863 and started with five workmen. By 1880 it employed 1,860 workmen and 57 chemists, using 1,840 horsepower. It then produced 1,750 different colors. In 1912 it employed 7,680 workmen, 374 foremen, 307 chemists, and 74 engineers, and used 30,000 horsepower. The number of colors reached 11,000. The works of the Badische, which was organized in 1865, covered, in 1914, 500 acres, with a water front of a mile and a half on the Rhine. There were 100 acres of buildings, 42 miles of railway within the works, and the power plants comprised 368 steam engines and 472 motors; 11,000 workmen were employed and the company was capitalized at 54,000,000 marks. The establishment of Bayer was on a scale entirely comparable with these two giants of the industry. The works of Cassella and Berlin were slightly smaller, while those of Kalle were the least important of the six. Weiler-ter-Meer was important largely because of its connection with the great Swiss house of Geigy & Co. Griesheim Elektron, prior to the war, had enormous works chiefly devoted to the manufacture of electrolytic chemicals and became an important factor in the dyestuff business only within recent years, when by absorption of the Oehler Works and the Chemikalien Werke Griesheim its color production reached a scale approaching that of the larger houses. Of these eight great concerns each had active agent houses in the United States, which were among the most important factors in the American industry and accordingly in the work of the Alien Property Custodian in connection therewith.

The tendency toward combination, however, by no means exhausted itself in the creation of these giant enterprises. The same causes which produced the enormous concentrations of capital in other German industries in the form of cartels were also working in the chemical industry. By 1904 two such immense combinations had been formed in the dyestuff industry, each including three of the largest six houses. One of these comprised Bayer, Badische, and Berlin; the other Hoechst, Cassella, and Kalle. Indirectly, through their financial transaction with the great banks and also directly, each of these cartels was aided and guided by the imperial government. By pooling profits, by so arranging capitalization that each company held stock in the other companies of its own cartel, and by other familiar means, the risks incident to the enormous expansion

of the business and the immense increases of export trade were minimized. The centripetal tendency, however, did not stop here. In 1916 the two pre-existing cartels were combined with Griesheim Elektron, Weiler-ter-Meer, and various smaller companies in one gigantic cartel, representing a nationalization of the entire German dye and pharmaceutical industry. The combination is extremely close. Profits of the companies are pooled and after being ascertained each year on common principles are divided according to agreed percentages. Each factory maintains an independent administration, but they keep each other informed as to processes and experiences. To stimulate and keep up a spirit of competition between the factories it has been arranged that each product shall be manufactured by two or more factories. There is also an agreement that in order to circumvent tariff obstacles in other countries materials are to be produced outside of Germany by common action and at common expense whenever and wherever desirable.

At the time of the formation of this enormous organization the capitalization of each of the principal component companies was largely increased. Hoechst, Badische, and Bayer each increased their capitalization by 36,000,000 marks, bringing the capital of each up to 90,000,000 marks. The new stock was offered to the old stockholders at 107, which was a melon of some magnitude, since the last available quotations for the stock of one at least of these companies at the end of 1916 was 490. Berlin increased its capital from 19,800,000 to 33,000,000 marks. Other increases brought the total nominal capital of the group to over 383,000,000 marks. For many years a large part of the enormous profits of these concerns has been put back into the works with the result indicated by the stock quotations. The real capitalization is thus much greater than this nominal figure. In fact, it is estimated that the actual investment in the works comprising the cartel is not less than \$400,000,000. It cannot be doubted that this enormous engine of commercial warfare has been created expressly for the expected war after the war, and that it is intended to undertake still more efficiently and on a larger scale the various methods by which German attacks upon all competition were carried on.

In addition to the favorable effects of the foregoing factors, an important aid to the success of German export trade in dyes and pharmaceuticals was the advantage taken of the patent laws of the several countries. Owing to the immensely greater number of research chemists engaged in this work in Germany than in other countries, far more patentable inventions in organic chemistry were made by the Germans than by the chemists of any other nation. In the United States alone they took out patents by the thousand. For example, Bayer alone accumulated in the neighborhood of 1,200 such patents which were placed in the hands of one of its subsidiary companies. The Badische had approximately 500 such patents, while each of the other members of the cartel held patents by the score. As there was substantially no effort (with small exceptions) by any of the German concerns to manufacture in the United States, these patents were obviously obtained and held in order to prevent the formation of an American dye industry and to make impossible importation from other countries. The latter of these two purposes seems to have been the more important in the German mind. They seem to have had no fear that any American industry could be established on a competing basis. They had, however, some respect for the Swiss, French, and English industries, though at the time of the commencement of the European war Germany was supplying approximately nine-tenths of the world's needs in dyes. With the aid of the patents, especially the product patents, they could and did exclude all importations of competing dyes in the most important classes.

As if the legitimate advantages of the German industry, supplemented by the ruthless if legal tactics of dumping and destructive underselling, were not enough, the methods of the great German houses in carrying on their business in this country

were from the first honeycombed with corruption. Bribery of dyers was carried on almost universally and on a large scale. The head dyers of the various mills and other chief customers of the dye manufacturers were subsidized in many direct and indirect ways. These dyers frequently controlled the situation, since if any one of them wished to have his superiors cease, using the dye of one manufacturer and buy instead the dye made by some other company, nothing was easier than to control the complicated process of dyeing in such a way that the dyes furnished by the house which was the least liberal to the dyer would produce wretched results. It would then be an easy matter for the dyer to get the manager of his mill to try the dyes offered by the more liberal briber and with the exercise of a little care, the new dye would be sure to produce satisfactory results. So extensive was this corruption that I came across only one American consumer which had escaped its ill effects. This concern, the United Piece Dye Works, of Lodi, N. J., avoided the difficulty by having all its dyes purchased by the head of the company himself, under contracts providing that no barrel or package should show the name of the manufacturer. The company was thus able to designate the dyes which its dyers were to use solely by its own arbitrary numbers, and the dyers were thus unable to determine whose dyes they were using and to whom they should look for their graft. Against these illegitimate methods practiced by concerns having such resources and compelled by such an imperious necessity to seek and maintain supremacy in foreign fields, honest domestic competition found the utmost difficulty in maintaining itself, and it is, therefore, not strange that until the outbreak of the war the American industry was of little importance.

Besides the obstacles, legitimate and illegitimate, thus placed by the Germans in the way of the establishment of an American industry, it would appear that there was considerable organized propaganda intended to discourage American attempts. It seems to have been regarded as the duty of a good German chemist in the United States to preach the doctrine of the invincibility of the German chemical industry, the impossible difficulty of the processes involved in the manufacture of many important dyes, and the hopelessness of procuring the necessary technically trained men and skilled labor outside of Germany. How far this was an intentionally organized movement and how far merely a sample of the prevalent German megalomania, it is difficult to say, but the results were analogous to those of the well known potash propaganda, by which it would seem that the farmers, and to some extent even the scientific men, of the United States were persuaded that far more potash was required for our soil than was actually needed. Whether intentional or not, this propaganda had its effects. At all events prior to the war only a few Americans had the temerity to believe that anything could be done in this country against the German advantages in the way of technical skill, cheap labor, governmental support, and unscrupulous methods.

Indeed, up to August 1914, the American industry in dye-stuffs and medicines consisted of little more than a series of rather small assembling plants. In spite of the fact that enormous supplies of coal tar were available and that several of the crudes could be secured in this country under most advantageous conditions, hardly any of the necessary intermediates were made here, and the manufacture of dyes was almost entirely confined to working upon intermediates imported from Germany.

At one time the industry seemed to have taken a real start. Between 1879 and 1883 nine establishments had commenced the manufacture of dyes and were apparently prospering. In 1883, however, there was a sudden reversal of conditions, and within a year five of the nine shut down. The other four continued on a close margin and were still in existence at the outbreak of the war. Of these by far the largest was the Schoellkopf Aniline & Chemical Works, of Buffalo. This company, organized and maintained by an American family of German origin, which

had at its disposal very large resources derived from other business, has continuously made a strenuous and honest effort to establish a real dye industry. From time to time they commenced the manufacture of various intermediates, including at one period aniline oil, which was manufactured on a large scale. In every instance, however, the manufacture was almost immediately brought to an end by German price cutting and at the time of the war the dyes made by this establishment were the product of intermediates imported from Germany. The company, nevertheless, had established a considerable business and while operating on a very small ratio of profit supplied the greater part of the non-German dyes consumed by the trade. Of the other three concerns Heller & Merz had likewise established a fair business in a few colors also made from German intermediates. The same may be said of the Central Dye Works and the Consolidated Color & Chemical Co., which were operating on a still smaller scale. The latter of these companies, it may be noted, was owned almost exclusively by Mr. Herman A. Metz, the American representative of Hoechst, one of the largest German dye works, and since the outbreak of the war Mr. Metz has likewise become the controlling factor in the Central Dye Works. In addition to these four, a fifth plant was established a few years before the outbreak of the war, at Albany, by the American subsidiary of the great German house of Bayer.

These five concerns comprised the entire American industry, and it will readily be seen that operating as they did on German intermediates they existed purely on sufferance and were absolutely at the mercy of the German producers. They made neither alizarin nor anthracene colors nor synthetic indigo, which being the fastest known dyes are the most valuable products of the industry. The exclusive ability to provide these fast colors, most of which were protected by patents, would have placed the entire trade in the hands of the German even if no other factors favorable to them had been present. These dyes were indispensable to the textile manufacturers, and by refusing to supply them except to houses which would buy their other supplies from the German manufacturers—that is, by the familiar process of "full-line forcing"—the latter could have retained complete control of our market, even if our manufacturers had been otherwise fully able to compete in the manufacture of the simpler colors. The 30 per cent duty payable on almost all of the coal-tar colors apparently afforded no real protection, nor, as will be shown, was it possible for the American industry to secure any relief under the Sherman Act.

The condition of the other branches of the American chemical industry was, as has been stated, not quite so bad. The manufacture of acids and heavy chemicals was well established on a profitable basis, though even in this manufacture the employment of numerous German chemists and processes gave a certain Teutonic color to the industry. In the manufacture of fertilizers there was, in a measure, a balance of power. The Germans had a complete monopoly of potash and its salts owing to their ownership of the only considerable, known, easily-worked potash deposits. This was somewhat offset by our possession of phosphates of which the Germans had no considerable supply. There was a certain amount of German ownership in companies operating in the phosphate field, most of which ownership has been unearthed and taken over. In nitrates, of course, the United States, like the rest of the world, was mostly dependent upon the Chilean supply.

In the manufacture of chemicals in which electrical processes, requiring large and cheap supplies of electric power, played an important part, the situation was such that the Germans had been induced to enter to some extent into manufacture in this country. They had organized and owned the Niagara Alkali Company which, utilizing the cheap electric power of Niagara, became the largest domestic manufacturer of caustic potash, the latter produced from German raw materials. This company also supplied the chlorine gas which was the raw material used

by the only considerable American manufacturer of liquid chlorine. In the same way the great Frankfurt chemical works known as the Deutsche Gold und Silber Scheide Anstalt had, through its American subsidiaries, the Roessler & Hasslacher Chemical Company, the Niagara Electrochemical Company, and the Perth Amboy Chemical Works, established the only large American production of cyanides and the largest American production of formaldehyde and wood distillation products. The importance of these industries will be recognized when it is remembered that cyanides are indispensable to the mining and electroplating industries, while formaldehyde is the basis of the only new and important chemical industry of American origin, the manufacture of synthetic resin products such as Bakelite, Condensite, and Redmanol.

In medicinals very little real American manufacture existed. A few of the coal-tar pharmaceutical products were produced by two American houses in St. Louis, the Mallinckrodt Chemical Works and the Monsanto Chemical Works. By far the most important factor in this field, however, was the New York house of Merck & Co., which was a branch of the world-famous firm of E. Merck of Darmstadt, and has accordingly as such been taken over. The enormous dispensing and distributing business of such firms as Parke, Davis & Co., Lilly & Co., and Powers-Weightman-Rosengarten Co., successful and efficient as it was beyond comparison with similar businesses in any other country, seems to have involved very little real manufacture, and the materials used were largely imported. There seems to have been but little, if any, German interest in this branch of the industry, except among small brokers and dealers.

From all the foregoing it will be seen that the all-important portion of the chemical industry, the branch in which the work of the Alien Property Custodian would necessarily be most arduous and in which its results might be most beneficial, was the dye industry. The vital character of that industry was due not to its financial importance, since the consumption of dyes in the United States at the time of the outbreak of the war did not exceed \$25,000,000 a year in cost to the consuming industries, nor to the fact that these dyes were absolute essentials to industries producing perhaps \$2,500,000,000 of goods annually, but most of all to the fact that the technical skill and equipment provided by a successful dye industry furnished the means, and almost the sole means, to which every nation must look for advances in the application of chemical science to practical undertakings. No other industry offers a livelihood to any such large numbers of highly-trained scientific chemists nor any such incentive to continuous and extended research.

As has been stated, the opening of the year 1914 found nine-tenths of the dyes used in our industries supplied by German houses and the great bulk of these by the largest six German houses. At this time each of these six giants was represented in this country by a subsidiary American corporation. The agent of Bayer was Bayer & Co., Inc., a New York corporation, while in the Synthetic Patents Co., Inc., another subsidiary, was vested the ownership of the 1,200 American patents taken out by the parent house. This New York company also owned other subsidiaries, including the Hudson River Aniline Works, through which it had established its Albany factory. Berlin was represented by the Berlin Aniline Works, also a New York corporation. Kalle & Company were operating through a third New York corporation, also called Kalle & Company. In these three cases all of the stock of the American house was admittedly owned outright by the parent organization. All three were accordingly taken over at the outset. The great Badische Company acted through the Badische Company of New York, the stock of which appeared on the books to be owned by Messrs. Adolph Kuttroff, Carl Pickhardt, and their chief employees. Leopold Casella & Company were represented by the Casella Company, also a New York corporation, the stock of which appeared to be owned by its president, Mr.

William J. Matheson, and its vice president, Mr. Shaw. Hoechst operated through a New York company known as Farbwerke Hoechst, of which the stock stood in the name of its president, Mr. Herman A. Metz. Of these gentlemen, Messrs. Kuttroff and Pickhardt were Germans by birth and Americans by naturalization. Messrs. Matheson and Shaw, American by birth and tradition, and Mr. Metz, American by birth. An extensive investigation was instituted by my bureau of investigation under the direction of Mr. Francis P. Garvan, and as the result of a long-continued and strenuous effort it was at last shown that the ostensible ownership of the stock of these three branches was not genuine but that each remained in fact owned by its German progenitor. As will hereinafter appear in the detailed accounts of these proceedings, each of these three companies has also been taken over.

The outbreak of the war cut off the importation of dyes from Germany. There immediately sprang up a number of American companies, mostly small, organized to embark in the manufacturing business. By strenuous efforts these companies contrived to avert the threatened dye famine which the curtailment of the German supply apparently rendered inevitable. Commencing with those dyes which were easiest to produce, and gradually extending to a limited number of the more essential and well known of the non-patented colors, the production increased until at the time when I took office the requirements of the textile trade were being met and a considerable export business had sprung up. The quality of dyes produced was, except in the matter of standardization, comparable with the German dyes of similar character, but the fast alizarin and anthracene colors were not being produced nor was synthetic indigo, the consumption of which is larger than that of any other dye. The largest of the existing producers, that is to say, Schoellkopf Aniline & Chemical Works, W. Beckers Aniline Company, and the Standard Aniline Company, of Wappingers Falls, have been combined with the aniline oil works of the Benzol Products Company and with the appropriate portions of the business of the General Chemical Company, the Semet-Solvay Company, and the Barrett Company into a single large corporation known as the National Aniline & Chemical Company. This combination has since produced considerably more than half of the dyes consumed in America. During the same period the du Pont Company had begun to construct an enormous plant at Deepwater, Del., established an immense laboratory employing approximately 200 chemists, and had bought the plant of the United Piece Dye Works in which the latter company had succeeded in producing a number of the most valuable dyes applicable to silk. Among other important concerns the Dow Chemical Company, Messrs. Ault & Wiborg, the Sherwin-Williams Company, and the Newport Chemical Works were preparing for the production of colors on a large scale, while many other companies were turning out appreciable quantities. The prices of course rose enormously and the results for a time were correspondingly profitable.

In the meantime the German agencies had been making every effort to retain their organization and their customers. They had on hand, in 1914, a considerable stock of German materials. One or two of the companies, notably Bayer & Co., Inc., sold out at once at a colossal profit. The others, apparently determined to retain their customers and their German connection at whatever cost, peddled out what they had in limited quantities, allowing each customer only a small quantity per month. These concerns made their sales at slight advances in price, hoping by this treatment to retain their customers' good will until the resumption of imports could be brought about. This process was assisted by the two voyages of the submarine *Deutschland*, each of which brought to the representatives of the six great houses a supply of the most essential dyes. Bayer & Co., Inc., increased its production somewhat, as did Mr. Metz (the American agent of Hoechst) in his Consolidated Color &

Chemical plant, while the Cassella Company organized a new subsidiary known as the Century Color Company to commence manufacture under the familiar C. C. C. trade-mark under which it had sold the goods of its parent German house.

At the time when I took my office, therefore, the American dye industry was active and profitable and in almost undisturbed possession of the field; but it required only the slightest investigation to show that the new-born industry's hold on life was of the most insecure description. The supply of crudes had been so expanded by the needs of the explosive industry and the consequent increase in the number of by-product coke plants and recovery installations in gas works that our supply of raw materials was unsurpassed. We were, however, producing only a few of the essential intermediates. We had a plentiful lack of even such technical knowledge as was required to produce dyes in the laboratory to say nothing of the vastly greater amount of similar knowledge required to translate laboratory into commercial production. In the case of all the faster dyes Germany's patents had prevented every attempt at American production, and while the Trading-with-the-Enemy Act authorized issuance of licenses under these patents, the terms were such that no licensee could hope to continue the manufacture in competition with the Germans after the war. In the meantime the representatives of the great German houses were holding their organizations together and keeping their trade as best they could by doling out their remaining stocks and by selling under their own names American products, sometimes mixed with their own German goods. These representatives were waiting for the end of hostilities and were ready at a moment's notice to re-embark in the importing business and assist their German parent houses to destroy the new American industry. It was, therefore, one of the most vital tasks before me to ascertain every trace of German ownership in the new industry and particularly in the American representatives of the German trust. Unless the Germans could be deprived of the benefit of these branch houses, their re-entrance into the field would be all too easy.

This proved to be a hard task. Every variety of camouflage had been resorted to by the Germans to conceal their interests. A favorite method in this, as in other industries, was, of course, that of a fictitious transfer of stock. In a few cases such transfers were carried out after the severance of relations and before the declaration of war. In these cases the character of the transaction was fairly obvious and our course correspondingly simple. In other cases, however—and this was true of two of the three representatives of the great German houses which were ostensibly American-owned—the apparent transfer took place at a period before the war was thought of, at least by anyone outside of Germany. In these cases the transfer was the result of an attack made by persons ostensibly interested in the textile business upon the representatives of the German houses under the Sherman law.

Up to about 1910 all the great German houses shipped their goods to their American representatives on a pure consignment basis. The compensation of the American representative was wholly by way of commission. The American company in these cases was a mere selling agency or branch. In 1912 a group of Philadelphia lawyers brought about the prosecution of an officer of Bayer & Co., Inc. (or its predecessor, Farbenfabriken of Elberfeld, another New York corporation), for some of the corrupt practices in the way of bribing buyers, which, as has been stated, had become universal among the German houses. In the course of this prosecution the lawyers in question became familiar with the general history of the German industry and at once realized that it might be made a subject of an attack under the Sherman law, on the theory that each of the German companies was, through its agent, actually doing business in this country and that the two great cartels were conspiracies in restraint of trade. Acting on this theory, suits were commenced to triple damages against most of the American representatives.

The institution of these suits, which were subsequently settled, resulted, in at least two cases, in a transfer by the Germans of their stock in the American company to the officers of that company. In the case of Badische Company, the stock of which was already in the names of the American representatives, it was only necessary to change the basis of the business from consignment to sale. This was done in all the cases, so that the German house might appear not to be doing business in this country through its representative, but to be merely selling to an apparently independent American corporation. There was on the surface no apparent reason why these transfers should not have been genuine. Each German house really controlled the situation with reference to its agent because it could instantly ruin its agent's business by withdrawing supplies. Accordingly, for a considerable period these houses escaped more than mere general suspicion, and it was not until the Bureau of Investigation of my department had acquired considerable familiarity with German methods of camouflage that the true situation could be disclosed.

This investigation, of course, ran parallel with the similar investigations of several other departments of the Government and the Bureau of Investigation received valuable aid from the offices of Military Intelligence, Naval Intelligence, and War Trade Intelligence, as well as from the Department of Justice and from the British, French, and other allied authorities. All these bodies worked in close cooperation and their mutual assistance was of inestimable value. Information derived from these sources demonstrated that the chemical industry was a natural center for espionage and that this had been true long before we entered the war—indeed, before the war began. The relation between the German government and the great German chemical houses was so close that representatives of the industry were naturally almost direct representatives of the government, and their work in this country gave them unequalled opportunities for examining our industries from within. Customers of the German import houses were constantly in need of expert advice in regard to the processes in which their goods were used. The advising expert supplied by the German houses naturally saw everything there was to see, and what he learned was seldom concealed from his government.

After the war began the industry became a center not only of espionage, but of propaganda and of direct governmental activity. The number of striking instances of this development is so great that only a few can be detailed, but these appear sufficiently striking. Among the early examples unearthed by the Bureau of Investigation was that of the by-product coke plant established by the Lehigh Coke Company. The latter was a corporation organized by a syndicate represented by the Deutsche Bank. At the time the war broke out it had been in operation for a number of years and was promising considerable success. It had not, however, gone extensively into the manufacture of coal tar and its derivatives. In 1915, however, it established a considerable plant for these purposes. Every ounce of toluol and benzol which was produced was sold under contracts binding the purchaser not to use or permit the use of the product for the manufacture of explosives or for the benefit of the Allies. An examination of the correspondence between Hugo Schmidt, the agent of the Deutsche Bank in this country, and the bank, shows that the entire undertaking represented by this by-product plant was a direct effort by the German government to prevent the making of these valuable materials for explosive manufacture in the United States, or rather, to prevent their use for the benefit of Germany's enemies. The undertaking was decided on because the Deutsche Bank had ascertained that the Bethlehem Steel Company, which had a contract with the Lehigh Coke Company for the latter's coke and gas, had practically determined to build such a plant for its own purposes, but that this decision might be changed if forestalled by the erection of a plant by the Lehigh Coke Com-

pany. This actually occurred, with the result that large supplies of these invaluable coal-tar products were kept out of the munition industry, while the demand for them from other industries was prevented from having its natural effect in bringing into existence American plants which would have been free to supply the Allies. This condition continued until just before we entered the war, when the Deutsche Bank, doubtless better informed than most as to the probabilities, sold out the Lehigh Coke Company to a nominee of the H. Koppers Company, which in turn immediately resold to the Bethlehem Steel Company.

A still more striking instance, uncovered by the Bureau of Investigation under the direction of Mr. Garvan, with important aid from the Department of Justice and the Secret Service, was that of the organization known as "The Chemical Exchange Association." The purpose, and for a time the effect, of this enterprise was to corner the supply in the United States of phenol, an essential of the explosive industry, and to prevent its use for the manufacture of high explosives (picric acid and trinitrotoluol, or TNT). This undertaking was apparently initiated by Dr. Albert, the financial adviser of the German government in this country, in direct collaboration with von Bernstorff. Dr. Albert carried out the scheme through Dr. Hugo Schweitzer, the chemist and leading spirit of Bayer & Co. Inc., the American agent of Bayer of Leverkusen. The outbreak of the war had instantly stopped the importation of phenol, which was not manufactured to any extent in this country. Mr. Thomas A. Edison, who required large supplies of phenol for the manufacture of his phonograph records, which were made of a synthetic resin of which phenol and formaldehyde were the chief ingredients, immediately set to work to solve the difficulties involved in the manufacture of this substance. By the most strenuous work the problem was solved in his laboratories in a few weeks, and he commenced the manufacture of very considerable quantities, producing a large surplus beyond his own requirements. This surplus would normally have supplied the means for the manufacture of fairly large quantities of the most valuable explosives. To prevent this, Dr. Schweitzer, on June 22, 1915, entered into a contract with the American Oil & Supply Company, which was the selling agency of the Edison works, for practically the entire surplus of phenol available for sale. As security for the faithful performance of this contract, Dr. Schweitzer put up \$100,000 in cash, which was furnished to him by Dr. Albert, and also a \$25,000 surety company bond. A week later Dr. Schweitzer made a contract with the Heyden Chemical Works (a mere branch of the German house of Chemische Fabrik von Heyden, of Radebeul), of which George Simon, a German subject, was the manager, by which the entire supply of phenol thus purchased was to be taken by the Heyden company and converted into salicylic acid and other harmless medicinal and flavoring products. The arrangement was that the Heyden works were to return to Schweitzer one pound of salicylic acid for each pound of phenol and keep the surplus of the converted product. This involved a very large profit for both parties. In the meantime, to avoid doing business under his own name, Schweitzer registered as a trade name the "Chemical Exchange Association," which was described as a copartnership consisting of himself and Richard Kny. Kny was the father-in-law of George Simon of the Heyden Chemical Company, and was the ostensible proprietor of the Kny-Scheerer Company, one of the most important manufacturers of surgical instruments in this country. This company, like the Heyden Chemical Works, was a purely German-owned concern, and both have since been taken over by me.

The net result of all this was a profit to the Chemical Exchange Association of \$816,000, which was apparently, equally divided between Schweitzer and Kny. Schweitzer's share of the profits seems to have gone straight to the German government, but for some unexplained reason Kny appears to have

been allowed to keep his. The attempt to prevent the use in explosive manufacture of American phenol was completely successful for a time. The success of the venture was celebrated in the latter part of 1916 by a dinner given by Schweitzer and Kny at the Hotel Astor in honor of Dr. Albert. Among other guests were George Simon, F. A. Borgemeister, Norvin R. Lindheim, and Capt. Wolf von Igell, of the German Embassy—a typical gathering of the most active German propagandists in the country.

Less striking examples of the same sort of thing might be cited by the score. An interesting instance is the case of Dr. Isaacs Strauss, organizer and president of the Chromos Chemical Company. Dr. Strauss arrived in this country in September 1914, apparently with a direct mandate from the German government for propaganda among the Jews. He proceeded to establish a periodical known as the *American Jewish Chronicle*. Funds to the amount of \$85,000 were supplied for his activities by Dr. Albert, and \$15,000 by von Bernstorff, and his chemical company, profiting by the enormous war demand and prices, rapidly began to supply further sinews of war. Shortly after the entry of the United States into the war his conduct attracted the attention of the military authorities, and the ensuing investigation led to his internment, whereupon his Chromos Chemical Company and the *American Jewish Chronicle* were taken over by me.

At the time when I took office, it, of course, became the duty of all companies in which any alien enemies held stock to report such ownership. About half of those American chemical enterprises which are now known to be German-owned complied more or less promptly with this requirement. The rest mostly relying upon pretended transfers by which the stock had ostensibly been put in the hands of American citizens, paid no attention to the act until the activities of the Bureau of Investigation had disclosed the true facts. In some cases, however, the camouflage which concealed the true ownership was of a much subtler and more effective description. In the case of more than one of the companies which promptly reported themselves as entirely German owned, measures had been taken to transfer to companies which were presumably beyond the reach of the Trading-with-the-Enemy Act, the essential value of the German property and business.

The most conspicuous instance of this method was Bayer & Co., Inc. This company at an early date reported all its stock as held by one of the officers, Mr. Seebohm, for three trustees who in turn held for the benefit of the German parent house. It was, on the whole, the most important of all the German branches. Besides representing, as sales agent, one of the three equal giant concerns at the head of the German industry, it was the only German branch which had established any considerable manufacture in this country. Through the purchase of the stock of the Hudson River Aniline Works, it had acquired and greatly expanded a considerable plant near Albany, N. Y., in which it produced a few of the simpler coal-tar colors and considerable quantities of pharmaceuticals, especially the most valuable single product of the German house—the drug known throughout the world by its trade name of Aspirin. This was a patented coal-tar product on which enormous profits had been made. Practically the entire management of this company was in the hands of German subjects. The leading spirit, Dr. Hugo Schweitzer, was, as has been stated, among the most ardent propagandists and German agents in the country. The Albany plant represented the expenditure of many hundred thousand dollars, and the enterprise was exceedingly flourishing.

To conceal the profits for the purpose of taxation another company was organized, known as Synthetic Patents Co., Inc., all the stock of which was also held by the German concern, to which were conveyed all the American patents of the German house, approximately 1,200 in number, and all the real estate, including the plant. By contracts between Bayer &

Co., Inc., and Synthetic Patents Co., Inc., almost all of the profits of the former were diverted to the latter in the form of rentals and royalties. The investigation also covered a number of less legitimate evasions of the tax laws, and resulted in the recovery of a large sum by the Treasury.

The militant German character of the men in control of this company was so obvious that the ease with which they surrendered its stock was a matter of some surprise. The explanation was not unearthed until the very thorough examination of the company's affairs by the Bureau of Investigation had proceeded to great lengths. It was then ascertained that on the entrance of the United States into the war the men in control of the company had foreseen the danger of sequestration of the property. In casting about for a means of meeting this emergency they hit upon a small company which had recently been organized in Connecticut to manufacture dyes. This was the Williams & Crowell Company, established by two gentlemen who had some knowledge but little capital. They had succeeded in producing two or three valuable sulfur colors, notably one highly suitable for khaki, of which enormous quantities were obviously going to be required. The situation of these gentlemen was such that, although their company had been able to produce profits out of all proportion to its capitalization, they were not unwilling to sell, and accordingly the idea was conceived of buying this company with a view to the gradual transfer to it of such of the facilities of Bayer & Co., Inc., as could be turned over. The plan was laid before the counsel of the company, Mr. Charles J. Hardy, of New York, who was the chief adviser of most of the German houses in this line of business. He appears to have advised that the company itself could not safely make the purchase owing to the danger of its being taken over by the Government, and that for the same reason the stock of the Williams & Crowell Company should not be bought by the Bayer directors themselves, since they were alien enemies. At his suggestion a new corporation, known as Williams & Crowell Color Co., Inc., was organized in New York and the stock taken in the names of American citizens. Williams & Crowell Company was at this time making profits at the rate of \$50,000 a month and, with the aid of the scientific and business knowledge which could be supplied by the Bayer staff, was in a fair way to immediate and immense success. Indeed, by this simple method, it would have been possible under our very noses to drain the life blood out of Bayer & Company and to transfuse it into the new organization, which the Alien Property Custodian apparently could not touch.

The purchase of Williams & Crowell Co., however, required a substantial sum in cash, approximately \$100,000, and it was at last possible to prove that the \$100,000 thus paid was money of Bayer & Co., Inc., and, therefore, of the German parent house.

This was ascertained only after the Bureau of Investigation had discovered that the treasury of Bayer & Co., Inc., was one of the great sources from which German propaganda funds in this country were derived. The parent German house had enormous business connections all over the world. It supplied immense quantities of its products to the east, especially to China. After the outbreak of the war in 1915, payments for these goods could not be transmitted directly to Germany. As many of the goods had been sold on long credit, very large sums still remained payable to the German house many months after deliveries had ceased. The eastern debtors of the German house were, therefore, directed to make their payments to Mr. Seebohm, of Bayer & Co., Inc., of New York. These funds, amounting to millions, were accordingly received by him and disposed of without being put through the books of Bayer & Co., Inc. What became of most of them cannot now be ascertained, as all of such records as may have been kept were promptly destroyed. It was possible, however, to demonstrate that part of the payment for the Williams & Crowell stock came

from this source. I, accordingly, insisted that the stock be turned over to Bayer & Co., Inc. This was done, and the Williams & Crowell Company thus formed a part of the assets of Bayer & Co., Inc., at the time of the sale of the latter.

Among other interesting facts in regard to Bayer & Co., Inc., disclosed by the investigation was the great care exercised by the parent house to restrain the manufacture of dyes by its American subsidiary. The purpose apparently was to limit this manufacture absolutely to colors in which genuine American manufacture was already well established. The German house was very glad to increase in this manner the competition with which the American infant industry had to struggle, but it was determined that American manufacture in other lines should not be commenced, even under its own control. When the cessation of imports after 1914 threatened a dye famine in this country, Bayer & Co., Inc., commenced to manufacture a few new colors, or rather, colors which were new to the American industry. No sooner did this reach the ears of the German house than the most peremptory letters were written, absolutely forbidding any further extension of the business in this line. The enormous profits possible from such manufacture had no weight with the Germans when compared with the risk that such manufacture might aid the development of a real American industry.

The stock of Bayer & Co., Inc., and of Synthetic Patents Company was sold by me at public auction, the successful bidder being the Sterling Products Company, a West Virginia corporation dealing in proprietary medicines. This company had previously agreed to dispose of the dye plant and patents, in case it secured the property to Grasselli Chemical Company, one of the largest makers of heavy chemicals in the country. The price paid was \$5,310,000, plus back taxes and other obligations of many hundred thousands more. Both purchasing companies appear, on careful investigation, to be thoroughly American.

Two other of the American branches of the six great German dye companies were also taken over at the outset. These were the Berlin Aniline Works and Kalle & Company. These companies were, however, little more than shells, each consisting almost solely of a selling organization without plant or other valuable fixed capital. In the case of the Berlin Aniline Works, there was an attempt to duplicate on a small scale the Williams & Crowell episode, but the resources available were insufficient. Neither of these companies accordingly had anything of great value to sell, and it has, therefore, been deemed the wiser course to liquidate them. The patents of the German concerns were in each case held in its own name and not transferred to the American branch.

Having taken over these three of the six American representatives of the German giants, my activities in this direction seemed to have been brought to a halt. The other three did not report any German ownership and on a preliminary investigation seemed to be American owned. A very careful examination of all available materials, however, sufficed to raise sufficient doubt in each case to force the company in question to offer to submit its entire books and records to our inspection, and to provide an audit at its own expense. An immensely thorough investigation was thus made possible, and in each case it has resulted in a demonstration that the stock of the branch was actually, in part at least, German owned.

In its relation to the American industry, the most important of these companies was the Cassella Color Company. This concern, the agent of Leopold Cassella & Co., G. m. b. H., was managed by W. J. Matheson and Robert A. Shaw. Both of these gentlemen are Americans by birth and tradition, but both of them had been for many years wholly or chiefly engaged in the business of marketing the products of the Cassella works. The stock stood on the books of the company in their name, and appeared to have been purchased for actual cash at par in 1913.

The transcendent importance of this company was due to two facts: First, that it had apparently been absorbed by the National Aniline & Chemical Co., Inc., which up to the present has been by far the largest American manufacturer of dyes; and, secondly, that the headship of the new all-inclusive German cartel, including all the great companies, is vested in Mr. Carl von Weinberg, who was for many years president of Leopold Cassella & Company, and closely associated with Messrs. Matheson and Shaw. The importance of these facts was emphasized when the former Cassella organization became the selling department of the National Aniline & Chemical Company, and when Mr. Matheson assumed its presidency. A storm of rumor immediately arose, and it was suggested to me from every side that the National Company was at least in part German-owned. The facts, however, were found to be as follows: Prior to 1913 the majority of the stock of the Cassella Company of New York was owned by the German house. In that year antitrust suits above referred to convinced all parties interested that it was unsafe to allow the New York agency to continue even in part to be owned by a member of the German trust. Accordingly, the remaining stock was transferred to Messrs. Matheson and Shaw and paid for in cash. An option was, however, reserved. This was reduced to writing so far as it conferred upon the German house the right to take the stock at the book value on the death of either Matheson or Shaw. It was, however, orally agreed that the stock might be taken on the same basis at any time. In the meantime the contract between the German and American companies was so framed that the profits of the company continued to be divided as before, 57 per cent going to the German house and 43 per cent to the American house. The sale, therefore, made substantially no difference in the relative rights of the parties. Messrs. Matheson and Shaw gained nothing which they did not already have in the way of theoretical control of the American house. The German company retained complete practical control of the American house because it could at any moment, by withdrawing supplies, render the American business worthless. The American patents owned by the German house had been assigned to the American company. In most cases, however, reassignments had been executed, but not recorded, so that the real, though not the ostensible, ownership of the patents was in fact still vested in the Germans. The correspondence shows an understanding, the legal effect of which seems to be to continue the German ownership to the extent of 57 per cent in the American company, and I have accordingly demanded and taken over 57 per cent of the stock.

When the dye famine began in 1914, Messrs. Matheson and Shaw determined to commence manufacturing, and for that purpose organized the Century Colors Corporation, this name being selected in order to retain the C. C. C. trade-mark of the Cassella goods. This company was organized with a capital of only \$500, and Messrs. Matheson and Shaw took all the stock. The operations of the company were financed to a considerable extent out of the funds of Cassella Company of New York.

In August 1917, Messrs. Matheson and Shaw, desiring to dissociate themselves from the Cassella name, caused the Century Colors Corporation to purchase from the Cassella Company all its tangible assets. On the same date the capital stock was increased from \$500 to \$200,000, Messrs. Matheson and Shaw paying in the difference. The tangible assets represented everything owned by the Cassella corporation except its patents, good will, and the contract with Leopold Cassella, G. m. b. H., for the sale and purchase of the German products. On September 11, 1917, Messrs. Matheson and Shaw sold to the National Aniline & Chemical Co., Inc., all of the stock of the Century Colors Corporation. Under this contract, Messrs. Matheson and Shaw agreed to subscribe for \$200,000 worth of the National Company's stock and to place their own services at the disposal

of the National, in return for which the National Company agreed to give them 4,000 full paid shares of preferred stock and 40,000 shares of common stock, having no par value. It was also agreed that the existence of the Century Colors Corporation should be continued for at least one year. At this time, in explaining the failure to convey the Cassella Company's intangible assets, Messrs. Matheson and Shaw stated in a letter to the National Company that they did not feel at liberty to dispose of the Cassella Company's intangible assets without first consulting the German house.

After this sale to the National, the personnel taken over from the Cassella and Century Colors Companies rapidly became increasingly important in the National organization. When Mr. Matheson assumed the presidency, the Century staff became to all intents and purposes the National's sales department. All this undoubtedly gave to the new organization a color which afforded considerable justification to the rumors of German ownership. Accordingly, the correspondence was examined with the utmost care. This correspondence, including, as it does, many of the letters which passed between Messrs. Shaw and Matheson themselves at a time when neither could have imagined that their transactions would be under investigation, shows that at the time of the sale to the National, both desired not to sacrifice their German connection, and that neither believed with any great confidence in the success of the American manufacturing industry; though they may have believed that the formation of the National Company offered an opportunity for success in America not theretofore available.

In October 1917, the Cassella Color Company, in spite of the feeling previously expressed by Messrs. Matheson and Shaw that they could not properly transfer any of its intangible assets without consulting the German house, transferred to the National Company a number of important patents. This was done without regard to the existence of the unrecorded reassignments to the German house. This transfer appeared to be invalid, and these patents, together with all other patents known to be the property of the German house, have accordingly been demanded and are vested in the Alien Property Custodian.

At the present time there appears to be no German ownership in the stock of the National Aniline & Chemical Co., Inc. The great majority of the stock is held by the following: Schoellkopf Aniline & Chemical Works (or its stockholders, chiefly members of the Schoellkopf family); General Chemical Company; Barrett & Company; Smet-Solvay Company; W. Beckers Aniline Works; W. J. Matheson; Eugene Meyer, Jr.

A complete working majority of the stock has been placed in the voting trust of which the trustees are as follows: Wm. H. Nichols, president of the General Chemical Company; H. S. Handy, of the Smet-Solvay Company; Wm. H. Childs, president of the Barrett Company; W. J. Matheson; Eugene Meyer, Jr.

A contract has been entered into which will result in the gradual elimination by purchase of the Beckers interest, which has been thought desirable because of Dr. Beckers' German origin. The Cassella Color Company of New York has been partially liquidated and its stock has been reduced from \$200,000 to \$500. The taking over of 57 per cent of this stock will at least permit the elimination of the Cassella name.

The American branch of the great Hoechst Company had for many years been conducted by Mr. Herman A. Metz. Prior to 1912, the New York corporation was known as H. A. Metz, Inc., and a majority of its stock was always owned by the parent house. In that year the German company took over all but 10 shares of the minority stock which had previously stood in the name of Mr. Metz, leaving him the record owner of these ten, the only shares not held by them. At the same time the name of the New York corporation was changed to Farbwerke-Hoechst, so that the value of the good will might be firmly fixed

in the German name. At about this time the antitrust proceedings above referred to were commenced against these companies also. Mr. Metz settled for \$40,000 the suit commenced against his company, and proceeded to make strong representations to the German house to the effect that the stock ought to be owned by him so that it could be asserted that the German house was no longer doing business in America. A prolonged negotiation ensued, the Germans being very reluctant to make any change. At last in the summer of 1913 it was arranged that the 1,990 shares held by the German concern should be transferred on the books to Mr. Metz; that in return he should execute a demand promissory note without interest for the sum of \$597,000; that the note should be delivered to the German company and the stock, together with a suitable transfer properly executed, should be deposited to the sole order of the German concern in a Montreal bank, as security for the note.

At this time and for many years previous the American company had been operating under a contract by which the German house appointed it its sole American sales agent and agreed to furnish it with goods, in return for which the profits were to be divided according to an arbitrary scale, irrespective of stock ownership. Under this arrangement the Germans were to have one-half the profits of the color business and 75 per cent of the profits of the pharmaceutical business, which, owing to the development of salvarsan and novocaine, had become of great importance. In return, and as a check on possible overcharges by the German house, Mr. Metz was to receive a percentage of their profits on the sales to the American company. An irrevocable power of attorney was given to Mr. Metz to vote the stock owned by the German company in the New York house and an option was reserved to the German company to purchase the stock in the event of Mr. Metz's death or retirement.

This contract was continued unaltered after the stock transaction of 1913, and under it the profits were divided as long as it was possible to remit moneys to Germany. There was also an oral understanding between the parties that the note should not be payable except out of the stock or its proceeds, and that it could not be demanded as long as Mr. Metz should remain president of the company. It will thus be seen that the whole stock dealing produced no change whatever upon the rights of the parties. After it, as before, the share in the profits of each party remained the same; power to secure and pass title to the certificates remained as before in the hands of the German company alone; the voting power remained as before in Mr. Metz's hands; in fact none of the incident of ownership was in any way affected by the transaction.

At the outset, Mr. Metz filed reports stating the existence of the note and the fact that certain stock was deposited as security for the same, but it was not until the ascertainment of the entire history of the transaction that the proof could be obtained that the transfer was not and was not intended to be of any effect. At last, however, the investigation thoroughly demonstrated this, and the stock has accordingly been taken over by me.

During the course of the year 1916, Mr. Metz, finding that he could no longer secure from Germany supplies of pharmaceuticals, especially salvarsan and novocaine, which formed the most profitable part of his business, determined to enter upon their manufacture in this country. Correspondence with the German house proving unsatisfactory, he sent his brother, Dr. G. P. Metz, to Germany to secure the necessary permission. This permission was refused, but the latter came home with a sufficient knowledge to permit the commencement of the work. A new company was organized under the name of H. A. Metz Laboratories, Inc., a New York corporation, and this company commenced the manufacture of these two invaluable medicinals, which has been continued since our entrance into the war under license from the Federal Trade Commission.

* The agency of the largest of all the German houses, the great Badische Company of Ludwigshafen, presents, perhaps, the most striking example of the German methods of camouflage as applied to stock ownership. For many years this company has been represented in this country by Mr. Adolph Kuttroff, who was born in Germany, but came to this country at a very early age, and was naturalized in 1867. In a succession of partnerships and incorporations with various members of the Pickhardt family this gentleman has always conducted the business of the Badische in the United States. In 1906, shortly after the formation of the first German dyestuff cartels, when the parent houses of Bayer and Badische became members of the same body, an attempt was made to combine their agencies in this country. A company called the Continental Color & Chemical Company was organized in New York and took over the Badische business of Kuttroff and Pickhardt, and the Bayer business of the Bayer Company's New York subsidiary, then known as Farbenfabriken of Elberfeld. At the end of the year, dissensions led to the dissolution of this company and the Badische agency was then taken over by the Badische Company of New York, a New York corporation. The stock of this company appeared to be entirely owned by Messrs. Kuttroff and Pickhardt, and on its books continued so down to its dissolution in 1917, except for small quantities of stock issued from time to time to the principal subsidiary officers of the company. All this stock, however, was held subject to an option permitting the German company to acquire it at par, and there was an oral understanding that no dividends exceeding 6 per cent should be paid. The balance of the profits, which were considerable, was distributed according to an arbitrary scale arranged by Mr. Kuttroff from time to time among the chief officers of the company. The company was dissolved in 1917 and a new corporation organized under the name of Kuttroff and Pickhardt, Inc., which ostensibly took over only the physical stock in trade of the old company and its officers. The stock of this new company is held substantially in the same proportions by the same persons who held the stock of the Badische Company of New York.

It will thus be seen that the ostensible stock ownership of this agency remained unchanged from 1909 until after our entrance into the war. It had thus been so arranged that no change was necessary in order to avoid the Sherman-law suits, nor in order to escape the attentions of the Alien Property Custodian on casual examination of the books. Indeed, the true facts were only ascertained after a most elaborate analysis of the books by highly skilled accountants, and of the available correspondence and intercepted cables by trained lawyers. Suspicion of the company was generally prevalent, but the first definite evidence was derived from correspondence obtained by the British authorities, which demonstrated that the New York company had been in the habit of asking for the decision of the German house on even such intimate questions of domestic policy as the increase or decrease of minor salaries of the staff. This correspondence indicated a degree of control far beyond that which was attributable to the mere power to stop supplies. It was then ascertained by the accountants that the original \$25,000 paid into the treasury of the company for the first issue of \$25,000 of stock came out of the moneys of the German house in the Continental Company at the time of the liquidation of the latter concern. An intricate analysis also showed that at a time when the original capital stock of the New York Badische Company was decreased the sums paid out went not to the ostensible stockholders but to the German house. Finally it appeared that on three separate classes of transaction very large sums out of the earnings of the New York house were transmitted to the German house when there was no possible obligation to do so, and that this was done by the personal direction of Mr. Kuttroff without consultation with the directors or stockholders. For example: During the years 1915 and

1916 the sum of \$701,944.34 was credited on the books of the German house and subsequently remitted under the head of indanthrene royalties. The company had been selling for the German house for years its high-grade indanthrene dyes which it received from the German house at fixed prices which did not include the sums described as royalties. As the goods were manufactured in Germany and nothing was done to them here, no royalty, properly speaking, could possibly be due. If any was payable, it must have been merely as an enhancement of the price. There was no understanding between the companies to any such effect.

Obviously, then, if the companies had been really independent, the president of the New York concern would never have dared to deprive his own stockholders of any such sums without legal obligation and without even consulting them beforehand. In like manner, in 1914, the sum of \$477,100 was credited and remitted ostensibly as a return of advances made years before by the German house for expenses of the New York concern. Here, again, there was no previous understanding or present authorization requiring or permitting anything of the kind. At the time the alleged advances were made by the German house the New York company was operating merely as an agency on commission. There was no conceivable reason why a part of the agency's expenses should not have been met by the principal in the usual way. Yet again, without consulting anyone, Mr. Kuttroff caused these large sums to be taken out of the hands of the ostensible stockholders and put in those of the real owners of the company. Finally, in the case of the goods received by the submarine Deutschland, the same process was carried on. These goods when originally received were entered on the books like all other shipments of the German house on a sales basis; that is to say, they were treated as the property of the New York house, and the German house was credited with the price, approximately \$800,000. Settlements with the customhouse appear to have been made on this basis. Some months afterward a profit of about \$400,000 had been realized. The book entries were then reversed so as to bring the transaction back to a commission basis in which the German house would be entitled to all these profits except a commission. This change was made by Mr. Kuttroff without the authority of the stockholders or directors, and accordingly a sum of nearly \$400,000 was made available for a remittance to Germany, and was so remitted. These and kindred transactions have so clearly demonstrated that the German company was the real owner of the stock of the American Badische Company that a demand which is to be issued forthwith will be immediately complied with. This demand, owing to the fact that the company has been dissolved, will result in the taking over of only the assets of the company, which, however, are considerable; but these will include certain profits realized, since the dissolution, by the new corporation of Kuttroff and Pichardt, Inc.

From the foregoing it will be seen that the American agent companies bearing the names of each of the six great German dye companies have been taken over. This, it is to be hoped, may interpose some difficulties in the way of any attempt on the part of the latter to re-establish themselves in this country.

The situation presented by the agencies of the German dye companies of the second rank has been less satisfactory. The great Griesheim Elektron Company was represented in this country by two concerns, Geisenheimer & Company, a partnership between American citizens now dissolved, and A. Klipstein, a corporation of which all the stock was held by two unrelated Klipstein families, all citizens. No trace of real German ownership could be discovered, after the most prolonged and laborious investigation both here and abroad, by all the departments interested, in either of these companies, though the business of both had been largely derived from German sources throughout their existence. The house of Weiler-ter-Meer was represented in

this country by the Geigy-ter-Meer Co., now the Geigy Co., in which, prior to the beginning of 1917, the German house owned 20 per cent of the stock. This stock was, however, transferred before our entrance into the war to the Swiss house of J. R. Geigy & Company, a firm in good standing with the allied governments. It has been impossible to ascertain whether this transfer was in any respect for the benefit of the German house, but in any case the great majority of the stock of this company is in Swiss and not in German hands.

Among the chemical companies in which German interests existed outside of the dyestuff business, by far the most important was the Roessler & Hasslach Chemical Company. This was a branch of the great Frankfurt gold and silver refining company known as the Deutsche Gold und Silber Scheide-Anstalt vormals Roessler, and was organized by Messrs. Roessler and Hasslach, two old Scheide-Anstalt employees, who came to this country to introduce the goods of the parent house. From the first, the German concern and its officers and employees owned about three-fourths of the stock of the American house. The latter prospered enormously and built up a very large business. Besides selling the products of the Scheide-Anstalt consisting chiefly of cyanide of sodium and cyanide of potassium, it built up a very large jobbing business. In 1895 the Niagara Electrochemical Company was founded to manufacture metallic sodium by means of the electric power available in Niagara Falls. The sodium thus produced was used for the manufacture of cyanide of sodium in this country, a business which immediately became exceedingly profitable. The stock of this company was divided so that one-third of it went to the Scheide-Anstalt, one-third to Roessler & Hasslach, and one-third to English interests. This company had a capitalization of \$100,000, made fabulous profits, and for the five years before our entrance into the war averaged over 900 per cent in dividends annually.

Meanwhile the Perth Amboy Chemical Works had been established with a capital of \$400,000 to manufacture formaldehyde and wood distillation products; 1,960 of the 4,000 shares of this company were held by the Roessler & Hasslach Company, a similar amount by another outside German corporation, the Holzverkohlungs Industrie, A. G., and a casting vote was left in the remaining 80 shares with Roessler & Hasslach. In the summer of 1916 the officers of the Roessler & Hasslach Chemical Company began to ask the authorities of their parent house to transfer to them more of the stock. The first request was made in a letter which contained a distinct intimation that this change in holdings need not be permanent. In subsequent letters they insisted, as reasons for the proposed sale, that the political situation was very acute; that German-owned property in this country might be sequestered, and that if any of their goods were to be imported and were to get by the British they would have to be able to say that the company which did the importing was not German owned. This proposition met no response. On the contrary, the Scheide-Anstalt officers replied that they did not understand what Messrs. Roessler & Hasslach wanted; that what they proposed must either be a real or a pretended sale; that if a pretended sale was what was suggested the idea was dangerous; and that if a real sale was meant a price would have to be charged which Messrs. Roessler & Hasslach would, under no circumstances, be willing to pay. They then suggested that a confidential man should be sent over to explain just what was wanted. The letters of Mr. Hasslach had, however, left no doubt on this score, as they had asked in the simplest possible language for a sale of the stock and had requested the Scheide-Anstalt to name their price.

In general the letters outlined the proposition as clearly as it could be stated, and the Scheide-Anstalt people cannot have avoided fully understanding just what was wanted, except on the supposition that the letters didn't mean what they said and that the real proposition was one which it was dangerous to put

on paper. Their refusal, at all events, even to name a price, was unequivocal. They said in substance, "rather than part with 'the best cow in the barn,' we ought to take every risk of the political situation and trust to fighting our rights in free America." Notwithstanding this discouraging statement, Messrs. Roessler & Hasslachner did send over a confidential man as was suggested. This emissary, Mr. Oscar R. Seitz, a New York lawyer of Swiss descent, with some German connections, reached Frankfurt on February 1. He brought no letters of introduction, power of attorney, or means of identification. The Scheide-Anstalt people did not know for certain that a confidential man was coming, or that if so, it was to be Mr. Seitz. Yet, he says that after a few brief interviews in which he offered no argument, other than those which had already been stated in the letters from Mr. Hasslachner to his German intimates, the Scheide-Anstalt people agreed to sell to the American representatives the following stock: 3,800 shares of Roessler & Hasslachner, at 200; 140 shares Niagara Electrochemical Company, at 400; 80 shares Perth Amboy Chemical Works, at 200. No counter offer was apparently made, and there seems to be no hesitation about the price, nor was there any suggestion of the purchase of the balance of the German holdings. A wireless was then, on February 6, 1917, sent to the New York office and, upon this wireless, the stocks were transferred on the books of the companies and the necessary \$860,000 was remitted to the German house. The stocks thus sold carried with them control of all three of the companies. The price paid represented a book value approximately twice as great, and the average annual dividends for the preceding five years on the three blocks of stock combined figured out at over 39 per cent on the purchase price. As regards the Niagara stock, the book value was nearly four times the purchase price, while the average dividends for five years figure out an annual return of 225 per cent on the purchase price.

These facts, and a host of additional circumstances likewise pointing inevitably to the conclusion that this sale was not genuine, were brought out in a prolonged proceeding conducted by my representative before the attorney general of the State of New York, who had the power to subpoena witnesses. In the meantime the 47 per cent of the stock of the Roessler & Hasslachner Chemical Company, which was admittedly still German owned, had already been taken over. I thereupon determined, by virtue of the authority conferred upon me by the Trading-with-the-Enemy Act and by the presidential proclamations thereunder, that the stock ostensibly transferred in February 1917, was in fact still German owned; and accordingly I thereupon issued demands for it. This proceeding will result in the Americanization of the most important German-owned chemical companies outside of the dye industry.

Next to Roessler & Hasslachner in importance among companies of the same class is the Heyden Chemical Works; this was the subsidiary of the Chemische Fabrik von Heyden, of Radebeul, Germany, and manufactures salicylic acid and its derivatives, formaldehyde, saccharin, the medicines usually known by their proprietary names aspirin and urotropin, benzoate of soda, and many other valuable products. Of late years it has become enormously successful. Prior to the year 1917, all the stock was owned by the German company, and in addition the American concern was tied by a contract with its parent house under which all the earnings of the American concern over 8 per cent went to the German house in payment for processes and information. When my investigation commenced, all of the stock except three shares stood in the name of T. Ellett Hodgskin, a New York lawyer, who had for some time represented the firm. After considerable examination it was ascertained that this stock, which had been transferred just before our entrance into the war, had been paid at par with a sum of \$149,000, borrowed by Mr. Hodgskin for the purpose from

Richard Kny, father-in-law of George Simon, a German subject and the manager of the company, under an agreement contained in a letter from Mr. Hodgskin to the effect that he would thereafter retransfer it at cost. Richard Kny, it will be remembered, was the partner of Schweitzer in the Chemical Exchange Association, and he was also the ostensible owner of the Kny-Scheerer Chemical Company, which also turned out to be a purely German-owned concern and has been taken over as such. Thorough investigation resulted in the practical admission that this transfer was mere camouflage, and accordingly the stock has been demanded and taken over. Mr. Hodgskin is now under indictment for his participation in similar proceedings in respect to another company. This stock and other rights of the German house in the American company have been sold at public auction to the Monsanto Chemical Works for \$605,000 plus taxes and profits of 1917 and 1918, but the sale has not yet been confirmed by the sales committee.

An almost exactly similar situation was disclosed by the investigation of Bauer Chemical Company, a much smaller concern manufacturing pharmaceuticals, especially the widely advertised Sanatogen and Formamint. In this company also the stock, which was really the property of the Berlin house of Bauer & Company, appeared by a fictitious transaction to have passed into the hands of Mr. Hodgskin. The fictitious character of the transaction in this company also has been admitted, and the stock has been taken over.

Another method of concealment was disclosed in the investigation of American Pyrophor Co., Inc. This company was organized in December 1917, by Charles Ganz, former agent of the Treibacher Chemische Werke, of Treibacher, Austria, and to it Ganz transferred, without authority, the entire business of the Treibacher company in this country, a business consisting of the manufacture of pyrophor, an alloy of iron and cerium, which, when struck or scratched, produces fire and is used for cigar lighters, etc. Here, after investigation, the unauthorized character of the transfer was so clearly shown that it was admitted, and upon demand the stock of the company was turned over. In this, as in many other like cases, it was impossible to determine whether the ostensible new owner of the business meant to keep it for the alien enemies or to steal it for himself.

In pharmaceuticals, the most important concern in the world was that of E. Merck, of Darmstadt. This was represented in this country by Merck & Company, a New York corporation which had an enormous and very profitable business in all kinds of medicinal preparations. The stock of this company appeared on the books to be owned exclusively by George Merck, a member of the family which owns the house of E. Merck, of Darmstadt. Investigation, however, showed that the profits of this company had always been remitted to the German house in a manner utterly inconsistent with the apparent stock ownership, and it now stands admitted that the stock was paid for with money of the German house and belongs to the latter. Mr. George Merck insists that he is the real owner of one-fifth of this stock by virtue of the fact that he owns 20 per cent interest in E. Merck, of Darmstadt. I am of the opinion, however, that indirect ownership of this kind cannot be recognized under the Trading-with-the-Enemy Act, and I have, therefore, determined that the whole of this stock is enemy owned and it has accordingly been taken over.

In addition to the above, I have taken over all or part of the stock of the following less important companies engaged in various lines of chemical activity: Charles Helmut & Co., Inc.; International Ultramarine Works; G. Seigle & Company; Williamsburgh Chemical Company; New Brunswick Chemical Company; Fahlberg Saccharine Company; Philipp Bauer & Co., Inc.; Amid-Duron Company; Haarmann-de Laire-Schaefer Company; Jarecki Chemical Works; Riedel & Co., Inc.; Rohm

& Haas; Somerset Chemical Company; Tropon Works; Gerstendorfer Brothers; German Kali Works; F. Ad Richter Company. The liquidation of the German interests in these companies is proceeding in due course.

The amendment of November 4 to the Trading-with-the-Enemy Act presented for the first time an opportunity for what appears to me to be the most important piece of constructive work which has been possible in my department. Until the enactment of this amendment it had not been possible to take over German patents. These patents, as has been already indicated, formed a colossal obstacle to the development of the American dyestuff industry. Evidently they had not been taken out with any intention of manufacturing in this country or from any fear of American manufacture, which the Germans apparently thought could not be successfully carried on under conditions prevailing in this country in regard to costs and to the supply of technicians and skilled labor. Upon consideration, however it seemed that these patents offered a possible solution for the problem, hitherto unsolvable, of protecting the new American dye industry against German competition after the war. If they were not taken out in order to prevent American competition they must have been obtained as a weapon against competing imports. If they were sufficient to stop importation of competing Swiss, French, and English dyes, they would presumably serve, in American hands, to stop the importation of German dyes. This was particularly probable in the case of the product patents, since most of the coal-tar dyestuffs are definite chemical combinations to which a product patent is entirely applicable.

The idea was accordingly conceived that if the German chemical patents could be placed in the hands of any American institution strong enough to protect them, a real obstacle might be opposed to German importation after the war, and at the same time the American industry might be freed from the prohibition enforced by the patents against the manufacture of the most valuable dyestuffs. Accordingly, these considerations were laid before various associations of chemical manufacturers, notably the Dye Institute and the American Manufacturing Chemists Association. The suggestion was met with an instantaneous and enthusiastic approval, and as a result a corporation has been organized to be known as the Chemical Foundation, Inc., in which practically every important American manufacturer will be a stockholder, the purpose of which is to acquire by purchase these German patents and to hold them as a trustee for American industry, "for the Americanization of such institutions as may be affected thereby, for the exclusion or elimination of alien interests hostile or detrimental to the said industries, and for the advancement of chemical and allied science and industry in the United States." The voting stock is to be placed in a voting trust of which the trustees are to be the five gentlemen who for months have been acting as the sales committee which passes upon sales made by my department, that is to say, George L. Ingraham (former presiding justice of the appellate division, first department, New York Supreme Court); Otto T. Bannard (president, New York Trust Company); Cleveland H. Dodge; Benjamin H. Griswold (senior partner of Brown Brothers, Bankers, Philadelphia); Ralph Stone (president, Detroit Trust Company); and the charter is so framed that under the patents nonexclusive licenses only can be granted on equal terms to all proper applicants, and must be granted to the United States free of cost. The company is capitalized at \$500,000, of which \$400,000 is to be 6 per cent cumulative preferred stock and \$100,000 common stock also limited to 6 per cent dividends. The first president of the Chemical Foundation, Inc., will be Francis P. Garvan, of the New York bar, to whose clear vision and indefatigable industry I am chiefly indebted in the working out of this plan. By Executive Order obtained

under the provisions of the act, I have sold to this company for the sum of \$250,000 approximately 4,500 patents, the remaining \$250,000 has been provided for working capital so that the company may be able to commence immediately and prosecute with the utmost vigor infringement proceedings whenever the first German attempt shall hereafter be made to import into this country. The charter of the corporation provides that surplus income is to be used for the retirement of the preferred stock and thereafter for the advancement of chemical and allied science and industry. The price thus paid was necessarily determined somewhat arbitrarily; the great majority of the patents were presumably valueless. The value of the remainder was entirely problematical and impossible to estimate. Substantially the entire industry having combined for the purpose of this purchase, it would have been impossible on public sale to find as a bidder any legitimate manufacturer. No other bidder could, therefore, have been found on public sale except some speculative individual who might have bought them for purposes practically amounting to commercial blackmail. The combination was not objectionable to public policy since it was so organized that any genuine American, whether a stockholder of the company or not, could secure the benefits of the patents on fair and equal terms.

It is submitted that the organization of this institution constitutes the most important step that has been taken for the protection of the new industry. Tariff protection has proved utterly unavailing in the past. The German industry as hitherto organized, and still more as now organized, has had so much to gain by extending its foreign trade and by destroying the industry in other countries that it would undoubtedly give away its goods in this country for nothing in order to recover the American market. The Chemical Foundation, however, should prove a power sufficient to discourage in a most effective manner any German attempts in this direction. If, as their newspapers boast, the Germans have during the war worked out entirely new dyes superior to their past productions, the protection afforded by it will be invaluable. It has been the uniform experience of the industry that the introduction of new classes of dyestuffs follows only several years after the patenting of the original inventions on which their manufacture depends. Accordingly, the later dyes of to-day depend largely upon the patents of three or four years ago. The patents transferred to the Chemical Foundation include many German patents of 1917 and even of 1918, and also many applications still pending. These patents undoubtedly include the results of the research upon which must be based the manufacture of any new dyes which the Germans are now able to produce and market. Accordingly, at the very least, the institution will be able to protect the American industry for a considerable period, and this should be all it needs. It appears to be the universal view of the more competent manufacturers in this country that given five years of freedom from German competition, the American industry can hold its own. Probably only a measure such as the embargo which appears to have been imposed by the British and French against all foreign dye importations can furnish this protection to the degree necessary to insure the safety of the American industry; but short of such an embargo, the Chemical Foundation would seem to furnish all the aid that possibly can be given.

At the same time the new institution promises an incalculable benefit not only to the dye and chemical industries but to the whole American manufacturing world. The opportunities which it can offer and the rewards which it can hold out to competent research scientists should far exceed those of any institution unconnected with industry, and it may well, therefore, form the nucleus of the greatest research organization in the country.

FOREIGN INDUSTRIAL NEWS

By A. McMILLAN, 24 Westend Park St., Glasgow, Scotland

FERRUGINOUS KAOLIN

A paper on the purification of ferruginous kaolin by J. Milbauer and F. Skutie appeared in the *Chemiker Zeitung* for October 30, 1918. They found that calcination was necessary to get rid of the iron, and that it was best carried out at 700° C., the material being mixed with sawdust as reducing agent and the air being excluded. The calcined kaolin is then dissolved in sulfuric acid of 50° Bé., when the iron passes into solution as ferrous sulfate and remains in the mother liquor, while crystals of alum and aluminum sulfate are deposited. These are not free from iron and have to be further purified. Some companies redissolve the alum and aluminum sulfate in hot sulfuric acid, but this is a difficult process and only to be recommended for working on a large scale. The simplest way is to precipitate the iron in the ferric state by yellow prussiate of potash after having added infusorial earth to the solution to facilitate filtration. By this means 99 per cent of the iron is removed. Reduction of ferric to ferrous iron and crystallization in an indifferent atmosphere also gave good results. Treatment of the raw material with sulfurous anhydride or gases from roasting furnaces or with producer gas, extraction with hydrochloric acid, and further treatment of the alum with various chemicals did not answer so well.

SOLUTION FOR WATERPROOFING DRAWINGS

Drawings to be used in damp localities, mines, etc., may have to be waterproofed. For this purpose, J. S. Carpenter recommends in the *Engineering News Record* of September 20, 1918, a solution of pure gum rubber, as bought in drug stores, in benzene. He puts a piece of rubber about 4 in. square in 1/2 pt. of benzene contained in a large jar. The rubber swells to 3 or 4 times its bulk and is ready for use in 24 hrs. The solution is then poured into more benzene to yield a thin liquid that will spread under a brush. With this liquid the drawing is coated on both sides. A thicker solution of the same substance is utilized as an adhesive to stick parts of large drawings together; the rubber is said to be preferable to starch paste because the joints of the paper do not crimp out of shape and alignment when made with rubber. If the parts have to be separated again, a rather stiff paste should be taken. The same solution may also be used for cleaning dirty drawings. The solution is poured on the drawing, the benzene solution mopped off, and the remaining film of rubber is rolled up and used as eraser. Rubber bands will not answer in place of gum rubber and benzene is more suitable than formaldehyde.

FERROCHROME

Ferrochrome, says *Mining World*, 95 (1918), 481, is an essential in the production of certain classes of steel. Alloyed with steel, it acts as a toughener and is used as chrome-steel for armor-piercing shells, in armor plate, for the wearing parts of aeroplane engines, and gears in motor vehicles. For peace purposes it will be largely employed for such various purposes as motor parts, stainless cutlery, and rustless steel. Before the war, the United Kingdom production was practically negligible. There is now established at Newcastle-on-Tyne a plant sufficient to meet requirements for many years to come. Previously England imported supplies from Norway, where it was produced by hydroelectric power. At Newcastle the power is obtained from the waste gases from coke ovens and the industry will be unique in this respect, that it will be able to compete successfully with the cheap water power of Scandinavia.

BRITISH TURBINES FOR BELGIAN CONGO

Two turbo-alternator sets and condensing plants have been ordered from Messrs. Dick, Kerr & Co., Limited, for the Union Minière de Haut Katanga, a large producer of copper in the Belgian Congo. The turbines, of the Willaus-Zoëly type, will work on steam at 145 lbs. per sq. in., exhausting into a vacuum of 28 in. (barometer at 30 in.), and each of the condensers, with 10,000 ft. of cooling surface, is designed to deal with 66,000 lbs. of steam an hour. The Siemens alternators to which the turbines will be coupled are designed for a normal output of 5,000 kw. at 0.9 power factor (5,560 k. v. a.) when supplying three-phase current at 50 cycles and 6,600 volts, and will be capable of carrying an overload of 25 per cent for 2 hrs. or of 50 per cent momentarily. They will each be provided with a direct-coupled, 110-volt exciter of the overhung type, and will work in conjunction with an automatic voltage regulator. The ventilating air for them will be passed through dry-air filters of the Premier Cooler Company's make.

KRAUSE METHOD OF DRYING EGGS

A German contemporary, the *Lokal Anzeiger*, recently gave an account of the Krause method of drying eggs and foodstuffs, the patent rights of which were acquired last year by the German Imperial Office for food fats and entrusted to the Imperial Drying Company for exploitation. The process was first applied to milk, but has been found suitable for all kinds of fluid foods, e. g., whey, fruit juice, blood, and especially eggs. The advantages of the method are (1) the products can be kept for long periods, (2) they can be transported cheaply, owing to the concentrated form, (3) they undergo no chemical change. The liquid is vaporized, after which the solid particles sink to the bottom in the form of a fine powder. This process takes place within a cylindrical iron container, 5 meters in diameter, in which rotates a metal plate driven by a steam turbine. The liquid flows onto the plate from above and owing to the rapid rotation is flung outwards in the form of vapor. Artificially cleaned and moderately warmed air is passed continuously through the container and this brings about immediate drying of the food substance in the air. In this manner the finest milk, whey, egg, and other powders are obtained which are soluble in water without any further process. This process, as applied to egg drying, was demonstrated on May 14, last, at the Central Milk Office, Berlin. At the present time there is a similar establishment at Bucharest and also in Roumania, where 140,000 eggs are dried per day.

PIGMENTS FOR PRINTING INKS

At a recent meeting of the Oil and Color Chemists Association, London, a paper on "Pigments for Printing Inks" was read by Mr. T. M. Tyson. The author stated that of the two classes of printing inks the pigments used for those employed for lithographic work should be insoluble in water, free from acid, of good solidity, moderate transparency, and of not too high specific gravity, while, for letter-press inks, the pigments should be brilliant and opaque. In general, printing-ink pigments should consist of dyes struck on alumina, blanc fixe, any abrasive material such as barytes being quite inadmissible. The strength of the pigment permits of an impression being secured with minimum layer. Certain apparent faulty properties of some pigments such as instability to acid or alkali, water solubility, etc., are often advantageous for use in inks destined for printing checks, etc.

FUSES FOR HIGH-VOLT CIRCUITS

A useful summary of the various steps that have led to the developments of reliable fuses for circuits up to 2,500 volts is given by Mr. R. C. Cole in a recent issue of the *Electrical World*. The design of an enclosed fuse for such circuits involves careful attention to a number of details. Considerable importance is attached to the choice of a metal, the vapor of which will not support arcing. The filling material must also be able to stand high temperatures without fusing or otherwise disintegrating. In early forms of fuses there was an insufficient amount of filling material to condense the metallic vapor before the melting temperature was attained. Thus the circuit might be broken and yet a conducting film might remain between the severed ends of the metal strip. A certain volume ratio between metal and filling material is needed and, by dividing the metal into a number of strips, the quenching of the arc has been greatly facilitated. Finally, a double filling material was used, a substance specially well adapted to quench the arc being placed in contact with the metal and a combination of calcium carbonate and calcium sulfate at either end. New fluxes have also been developed to prevent corrosion of strips in soldering and a special low melting point alloy has been used for connecting the strips to the terminals. Enclosed fuses for the protection of 2,500-volt circuits have been on the market since 1900, but the continual development of generators of increasing capacity and the conveyance of larger amounts of power, have made new demands on the design of such fuses.

GERMAN TRADE

It has often been stated, says *Mining World*, 95 (1918), 491, that if the Germans had been allowed for another two decades to continue their policy of peaceful penetration they would have conquered the world by other means than force of arms. Even in regard to the mining industry, what they had accomplished was remarkable. They were in possession of the tungsten industry and had a marked superiority in the earlier stages of the war in all things pertaining to electrical work. This has been changed and the British are now able to produce all the high-speed steel necessary for their own industries and are even able to export at reasonable prices to the Allies. British manufacturers can now deal with all the British production of ore and can, if necessary, convert the whole of the world's output into tungsten metal or ferrotungsten. Australian supplies of zinc ore are almost unlimited, and these were under German control. Her smelting plants have been trebled. The production of spelter should ultimately reach 140,000 tons per annum as compared with 32,000 tons before the war, and thousands of tons of potash which were going to waste every year are now gradually being brought to use. Strange as it may seem, Britain was actually dependent on Germany and Austria for many things necessary to win the war.

INDIGO

To make liquid indigo, says *Engineer*, the indigo plant, after being cut and gathered, is first placed in casks, specially made with plugged holes in the side, which are filled with water. After soaking for a few days, lime is added and, in about one week's time, the stem and branches of the plant are removed. Each day the contents of the cask, after being well stirred and beaten, are allowed to settle and, on the following morning, before the process is repeated, some of the plugs are removed, allowing the water above the sediment which has collected during the night to escape. Gradually, the water is thus eliminated and liquid indigo is found at the bottom of the casks. These casks vary in size, some of them being as large as 12 ft. deep by 10 ft. in diameter and are made of thick pine boards held together by bamboo hoops.

SORGHUM AS A COLORING MATERIAL

The French technical press has lately published an interesting communication made to the Academy of Sciences by Mr. Piedalu. It deals with the utilization of sorghum as a coloring matter. The glumes or husks of sweet sorghum and those of sorghum with black seed, hitherto of no use at all, are found to yield a gum with very fine shades of color ranging from pink to bright red, salmon, scarlet, pearl-gray, dark gray, dark brown, and khaki—all colors which, being sun- and soap-proof, are highly suitable for dyeing wool, silk, feathers, and vegetable fibers. The discovery of this new dyeing material, it is stated, is one of great importance and steps are being taken to work it out on a large scale.

ELECTRIC SALT PRODUCTION

According to the *Times Engineering Supplement*, London, a new industry is being inaugurated in Norway for the production of salt by the electrical evaporation of sea water. Each kw.-year is calculated to produce 10 tons of salt, besides concentrated brine, which can be worked up for by-products. The intention is to produce all the different kinds of salt consumed in Norway, where the consumption is at present about 300,000 tons a year; this corresponds to about 30,000 kw. annually, apart from the energy required for the by-products such as potash, magnesia, and bromine. It is proposed to erect the first factory at Osteröen, near Bergen, with an initial output of 60,000–70,000 tons a year, to be increased later to 200,000 tons. This factory is expected to start work towards the end of this year, and a second factory at Glomfjorden will, according to present plans, be completed in the course of 1920. The plant has not yet been ordered, pending the result of the working at two preliminary factories, but it has been said that the problem is practically solved.

SHIPBUILDING

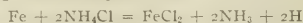
In some of the countries not hitherto associated with shipbuilding, says the *Glasgow Herald Supplement* for December 28, 1918, there have recently been indications to encourage the industry. A motor cargo vessel of 500 tons capacity was launched in the autumn at a new yard at Buenos Aires for trade between the Argentine and North America. It is proposed that ultimately vessels of 2,000 tons dead weight will be built at this yard. The Lloyd Nacional Shipping Company of Rio Janeiro is also to begin the building of wooden vessels for motor propulsion, while it is reported that the Vickers Company is to build at La Plata, in the Argentine, ten steamers of 10,000 tons each and four of 7,500 tons each. At Llanco, in Southern Chile, two new shipbuilding plants are being laid out for the building of wooden ships of 3,000 tons or over, while at Havana, Cuba, a company has been formed for the construction of ocean-going cargo vessels of from 8,000 to 10,000 tons.

USES OF MAGNESIUM

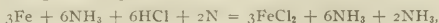
Since the outbreak of war many new uses have been found for the metal magnesium. In combination with aluminum and other metals, it produces an alloy with a specific gravity about one-half that of aluminum, which is largely used for aeroplane parts. On the other hand, if the weight has only to approach that of aluminum, a considerable admixture of heavy material is possible. An alloy containing only 10.30 per cent magnesium is stated to have great strength. In a recent issue of *Chemical and Metallurgical Engineering*, the formulas of some compositions containing magnesium and aluminum recommended for use in automobile and aeroplane construction are given. Reference is also made to a recent patent claiming that 92 per cent magnesium and 8 per cent aluminum gives an alloy of specific gravity 1.75 with a strength equal to that of gun metal.

NEW AMMONIA SYNTHESIS

The particulars which H. Hampel and R. Steinan give in the *Chemiker Zeitung* of December 1918, of their new ammonia process are meager and the inventors do not explain their apparatus, the construction of which they admit offered great difficulties although they do not work at high temperatures or pressures. They point out that both the hydrogen and nitrogen should be used in the atomic, not the molecular, state. The hydrogen is generated and used in the nascent condition; whether or how they dissociate their nitrogen is not stated. They start from ammonium chloride which is heated in presence of iron filings and decomposes thus:



and this hydrogen is the hydrogen utilized. When the reaction takes place in presence of nitrogen, the hydrogen is bound according to the equation



and this reaction gives 2 molecules of ammonia more than the ammonia started with. This constitutes the yield of the method. The 6 moles of ammonia are passed into the solution of the iron chloride to precipitate the iron as hydrate while the ammonium chloride is recovered and the ferric hydroxide is reduced by water gas. There may be something in the method suggested, says *Engineering*, 107 (1919), 143, although vapors of ammonium chloride are corrosive and unpleasant to deal with apart from other reasons. Hampel and Steinan, therefore, have tried to work with solutions instead of vapors. They claim with their apparatus to have obtained an ammonia of from 94 to 99 per cent, 23 per cent of which would be obtained from nitrogen while the bulk is wanted in the continuous process. But it remains true that, if the hydrogen is split off from some ammonium chloride in the first instance, there does not seem to be really any gain.

LIGHTING MACHINE TOOLS

The use of white paint has been found very effective in assisting the local lighting which is often employed for machine tools in addition to the overhead lighting system of the shop. In one case, where a machine room was lighted by an overhead system to an average intensity of about 2 ft. candles, the massive vertical slotters installed in it were finished with a very dark paint, and the lighting of the tables in the region where the cutter operated was insufficient to enable the cutter to be set accurately to the pencil markings on the rough castings that were to be machined. As a remedy the machines were each provided with a lamp on a drop cord, and their surfaces facing the table were painted white. By this expedient the shadows from the lamp were softened very materially through the reflection from the white painted surfaces and the illumination on the table was increased by about 75 per cent.

GERMAN SUBSTITUTE MATERIAL

The German *Pfaelzische Post* says that the war has brought to light the most diverse substitute materials. A really good and useful material to take the place of the missing jute is today the so-called "textilit." Textilit will remain after the war and be considered one of the raw materials of the textile industry. It is a mixed product, the result of a paper thread and a fiber thread being twisted together. It contains a very small percentage of long fiber, but yet has proved itself a full substitute for linen and jute weaving and sewing yarns and webs of all sorts. Bags can also be made of it. The uninitiated cannot distinguish the new products from the former linen or jute fabrics. Through the admixture of fiber material, there has resulted a decidedly greater firmness than was the case with pure paper fabrics. About twenty-three of the largest factories in this orchard of industry are now making textilit.

TEXTILE COLORS IN RUSSIA

In the year 1913, says the *Z. anorg. Chem.*, September 27, 1918, the Russian textile industry consumed about 20 million puds (320,000 tons) of cotton, for which the following quantities (in puds) of dyes were used: Vegetable colors, 37,052; sulfur colors, 110,694; mordanted colors, 34,572; hydrosulfite colors, 31,154; lac colors, 15,447; discharge colors, 15,864; alizarin colors, 27,235; total, 340,640 puds, or 5,500 tons. For 3,655,247 puds of woolen materials, 113,800 puds of dyes were used, and for the silken goods (213,873 puds) 22,672 puds. Wool and wool dyes are now in most demand. Before the war, the dyes were imported chiefly from Germany and also from Switzerland, Holland, and England, in the order named. It would seem that a good market could be opened up here.

ELECTRIC WELDING

Four leaflets containing with electric arc welding have been issued by the Equipment and Engineering Co., Norfolk St., London. One of them describes switchboards, resistances, and other accessories used with welding apparatus; the second gives details of various grades of metallic electrodes with instructions for their use; and the third draws the attention of tramway engineers to the advantages of electric welding in repair work. The fourth leaflet contains an account of the E. and E. magnetic system of arc welding which is designed to avoid the waste of energy involved by the resistance generally inserted in the circuit. The method employed is to drive the generator by means of a Daysohms automatic magnetic clutch. With this device there are no circuit breakers to open or fuses to blow; the operator may lay his electric holder down on his work, and the short circuit thus caused will merely make the speed of the generator drop to a low value, the current not rising. The clutch is controlled from a control box which the operator keeps by his side during the process of welding. By turning a handle on the cover of this box he can set the current to any one of a number of predetermined values.

UTILIZATION OF SEAWEED

As has been recently noted in *THIS JOURNAL*, XI (1919), 58, alcohol may be obtained from seaweed in addition to potash. Mr. Kayser, working at the Pasteur Institute, Paris, and using *Laminaria digitata*, the common seaweed tangle, professes to have obtained on an average of no less than 6 qts. of alcohol from each 100 lbs. of seaweed and was of the opinion that the yield could be increased by using higher pressures during the manufacture. The plants were first submitted to a process of evaporation and reduced to 10 per cent. They were then placed in water containing 3 to 6 per cent of sulfuric acid at about 60° C. After being neutralized to 1 per cent of acidity, the sugary liquid with nitrogenous material added in some cases was sprinkled with brewers' yeast. Fermentation quickly followed, especially where nitrogenous material was added. The alcohol was recovered from the fermented liquid in the usual way and the residue was available for the extraction of potash.

JAPANESE STEEL

Figures prepared by the Yokohama Chamber of Commerce show a large increase in both the production and the consumption of steel in Japan during the war. In 1913 the production was 254,000 metric tons and the imports 543,000 tons, while the domestic consumption was 765,000 tons, 33,000 tons being exported. In 1917, when the production rose to 529,000 tons and the imports to 675,000 tons, the consumption was 1,182,000 tons, 22,000 tons being exported. The imports in 1915 fell to 243,000 tons (the lowest figure recorded since 1904) owing to the diminution of supplies from Europe; but, in the following years, they increased greatly owing to imports from America.

SCIENTIFIC SOCIETIES

SPRING MEETING AMERICAN CHEMICAL SOCIETY BUFFALO, N. Y., APRIL 7 TO 11, 1919

The Spring Meeting of the AMERICAN CHEMICAL SOCIETY will be held with the Western New York Section in Buffalo, April 7 to 11, inclusive. There is every prospect that the meeting will be one of the largest ever held by the AMERICAN CHEMICAL SOCIETY as unusual interest has developed in problems of reconstruction, in the future utilization of war-time products, in heretofore secret information on chemistry warfare that can now be released, in the development of a comprehensive compendia of the literature of chemistry, and in many other problems which the Buffalo Meeting will consider. A large number of chemists who have already signified their intention to be present assures also an unusual opportunity for meeting and discussing chemical problems with chemists who have been closely in touch with the nation's affairs.

Also, the Western New York Section is making arrangements for interesting excursions to industrial plants of importance. Note carefully some of the important plants to be visited as outlined in this preliminary announcement.

The Society and hotel headquarters will be at the Statler Hotel, where registration will take place beginning at 3 P.M., Monday, April 7. Information Bureau will be located at the hotel and competent guides placed at all railroad stations.

CHAIRMAN OF LOCAL COMMITTEES

Executive and Program—C. G. Derick
Finance—J. F. Schoellkopf
Registration and Information—E. K. Strachan
Arrangements for Meetings—D. H. Childs
Excursions and Exhibits—W. H. Watkins
Niagara Falls Excursion—A. M. Williamson
Hotels—John A. Miller
Smoker—F. A. Lidbury
Banquet—Walter Wallace
Niagara Falls Exhibit—F. S. Low
Publicity—H. G. Saunders
Invitation—D. W. Sowers
Entertainment of Ladies—Mrs. J. F. Schoellkopf, Jr.
Clubs—D. C. Howard

GENERAL PROGRAM

MONDAY, APRIL 7

4:00 P.M.—Council Meeting at the University Club, Delaware Avenue and Allen Street. Dinner for the Council as guests of the Western New York Section at 6:30 P.M.

TUESDAY, APRIL 8

9:30 A.M.—General Meeting, Hotel Statler. "The Future of American Chemical Industry," by Wm. H. Nichols, President, American Chemical Society.

(One other general address to be announced.)

2:30 P.M.—General Symposium on the "Chemistry and Technology of Mustard Gas." Wilder D. Bancroft, *Chairman*. Numerous interesting papers are offered. These will take up the whole of the afternoon of Tuesday and may continue on Wednesday morning in the Biological, Physical and Inorganic, and Organic Divisions.

8:15 P.M.—Smoker, Hotel Statler.

WEDNESDAY, APRIL 9

Divisional Meetings—9:30 A.M. to 1 P.M. and 2:30 to 5:30 P.M., at Technical High School.

1:15 P.M.—Buffet luncheon at Technical High School.

6:00 P.M.—Dinner to Council at Canisius College.

8:30 P.M.—At Hutchinson High School—Public Address, "A Chemical Story," by Edgar F. Smith, Provost of the University of Pennsylvania.

THURSDAY, APRIL 10

9:30 A.M. to 1 P.M.—Divisional Meetings.

1:15 P.M.—Buffet luncheon at Technical High School.

1:30 P.M.—Excursion. National Aniline & Chemical Co., Buffalo Foundry & Machine Co., and tour of the city.

7:00 P.M.—Banquet. The capacity of the hall requires that only 400 tickets be issued. Dinner will be served at small tables aggregating from 6 to 8. The local committees will arrange to make reservation for parties on application at the registration desk.

EXCURSIONS

Excursions are being arranged for Friday, April 11, to include the works of Pratt and Lambert, paint and varnish makers; Spencer Kellogg Sons and Company, linseed oil crushers; the Lackawanna Steel Company; the Larkin Company; and the Municipal Laboratories and Water Purification Works.

Alternative to these an all-day excursion to Niagara Falls is planned, including visit to power plant, luncheon at the Chamber of Commerce, pictures and exhibits of Niagara Falls products, drive along the Gorge, and visit to the Canadian side and Victoria Park.

DIVISIONAL PROGRAMS

The usual meetings will be held by all the Divisions, except the Fertilizer Division, and by the Rubber Chemistry Section, with the following special program:

THE DIVISION OF INDUSTRIAL CHEMISTS AND CHEMICAL ENGINEERS will make a special effort on papers on the probable future of those chemicals which have been abnormally stimulated during the war and on the library of the industrial laboratory.

THE PHARMACEUTICAL DIVISION announces a symposium on "The Possibilities in Drug Research."

THE RUBBER CHEMISTRY SECTION will apply for permission to organize at this meeting as a Division.

ENTERTAINMENT OF LADIES

A committee is preparing an interesting program for the pleasure of the visiting ladies. Details will be found in the final program.

PAPERS FOR THE MEETING

THE DIVISION OF INDUSTRIAL CHEMISTS AND CHEMICAL ENGINEERS have voted that the titles of all papers shall be sent to the Secretary of the Division, which title must be accompanied by an abstract, even if short; that any title sent without an abstract shall not be printed in the program; and that the time limit for the presentation shall be 5 minutes, unless special arrangements are made with the Secretary of the Division.

By vote of the Council no papers may be presented at the meeting, titles for which are not printed on the final program.

"By Title" should be placed on the announcement of any paper where the author is to be absent, so that members may understand in advance that the paper will not be read.

ADDRESSES OF DIVISIONAL SECRETARIES

Agricultural and Food Chemistry: T. J. Bryan, 4100 Filmore St., Chicago, Ill.

Biological Chemistry: R. A. Gortner, University of Minnesota, University Farm, St. Paul, Minn.

Fertilizer Chemistry: H. C. Moore, Armour Fertilizer Works, Atlanta, Ga. (Will not meet.)

Industrial Chemists and Chemical Engineers: H. E. Howe, 30 Charles River Road, Cambridge, Mass.

Organic Chemistry: Harry L. Fisher, Columbia University, New York City.

Pharmaceutical Chemistry: Geo. D. Beal, University of Illinois, Urbana, Ill.

Physical and Inorganic Chemistry: W. A. Patrick, The Terraces, Mt. Washington, Md.

Water, Sewage and Sanitation Chemistry: W. W. Skinner, Bureau of Chemistry, Washington, D. C.

Section of Rubber Chemistry: W. H. Smith, Bureau of Standards, Washington, D. C.

ABSTRACTS OF PAPERS

In order that the meeting may receive due and correct notice in the public press, every member presenting a paper is requested to send an abstract to the Secretary, Box 505, Washington, D. C. The amount of publicity given to the meeting

and to the individual papers will entirely depend upon the degree to which members cooperate in observing this request. A copy of the abstract should be retained by the member and handed to the secretary of the special division before which the paper is to be presented in Buffalo. Short abstracts will be printed in *Science*.

HOTELS

The following list of Buffalo hotels, with rates, is for your information. Write direct to the hotel to secure your reservation. Hotel headquarters will be at the Statler Hotel.

NAME	Rooms with Bath		Rooms without Bath	
	Double	Single	Double	Single
Broezel.....	\$4.00 up	\$2.50 up	\$2.50 up	\$1.50 up
Genesee.....	.....	.....	.....	1.50 up
Iroquois.....	4.50 up	2.50 up	3.00 up	2.00 up
Lafayette.....	4.50 up	3.00 up	3.50 up	2.00 up
Lenox.....	4.00 up	2.50 up	.....	.....
Markeen.....	3.50 up	2.00 up	2.75 up	1.50 up
McLeod's.....	3.00 up	1.50 up	2.00 up	1.00 up
Men's.....	.....	.....	.....	0.75 up
Statler.....	4.50 up	3.00 up	3.50 up	2.00 up
Touraine.....	3.00 up	2.00 up	.....	.....

FINAL PROGRAM

The final program will be sent to all members signifying their intention of attending the meeting, to the secretaries of sections, to the Council, to members of the Western New York Section, and to all members making special request therefor to the Secretary's office.

SPECIAL MEETING OF THE ADVISORY COMMITTEE
AMERICAN CHEMICAL SOCIETY

The Advisory Committee of the AMERICAN CHEMICAL SOCIETY met at the residence of Dr. Wm. H. Nichols, 420 Park Avenue, New York City, at 4:30 o'clock, February 28, 1919.

Among the many matters of special interest presented to the Committee was a communication received from the National Research Council asking the appointment of nine representatives of the AMERICAN CHEMICAL SOCIETY on its Chemistry Section.

The Committee on behalf of the Council voted to accept the invitation of the National Research Council and the responsibilities involved.

The following nine subdivisions were adopted as a basis of appointment:

- | | |
|--|----------------------------------|
| 1—Organic (Industrial, Dyes, Explosives, etc.) | 5—Mineral and Inorganic |
| 2—General Organic | 6—Biological (Food, Agriculture) |
| 3—Colloid and Photographic | 7—Physical and Theoretical |
| 4—General Industrial | 8—Analytical |
| | 9—Pharmaceutical |

The men selected to represent the Society were as follows:

C. L. Alsberg	J. M. Francis	John Johnston
W. D. Bancroft	E. C. Franklin	Julius Stieglitz
C. G. Derick	W. F. Hillebrand	J. E. Teeple

A communication to President Nichols from the Editor of *Chemical Abstracts* regarding proposals being made for further cooperation with foreign journals in abstract matters was considered. It was voted by the Advisory Committee that in their opinion, this matter was clearly within the province of the Editor of *Chemical Abstracts* and that he was authorized to take such action or no action as he saw fit so long as he retained the control of *Chemical Abstracts* and did not involve the Society in unauthorized expenditure.

An invitation from the National Foreign Trade Council to appoint delegates to the 6th National Foreign Trade Convention at Chicago, April 24 to 26, 1919, was accepted, and Messrs. T. A. Grasselli, Wm. Hoskins, L. V. Redman, and T. B. Wagner were appointed.

A communication from L. H. Baekeland was presented regarding a proposal received from the Société de Chimie Industrielle as to a federation of chemical societies in Paris and a request from the Society to meet in Paris this coming April, especially inviting the President of the Society to be present. The President stated that it was impossible for him to go and it was decided that certain members of our Society now in France be invited to attend the meeting, if held, for the purpose of information only and to report back to the Council.

AMERICAN ELECTROCHEMICAL SOCIETY

The American Electrochemical Society will meet in Rumford Hall, Chemists' Club, New York City, April 3 to 5, 1919.

The annual business meeting and election of officers will take place Thursday morning, April 3, and will be followed by a technical session for the discussion of papers. The afternoon will be devoted to the same purpose. In the evening there will be an illustrated lecture by W. S. Landis on "The Oxidation of Ammonia to Nitric Acid." Friday, April 4, will be devoted to the symposium on "Released Information."

On Saturday, April 5, there will be an all-day trip to Perth Amboy and vicinity, the following plants being accessible to visitors: American Smelting and Refining Co., Roessler and Hasslacher Chemical Co., United Lead Co., and Raritan Copper Works.

PROGRAM OF PAPERS

- Notes on Electrostatic Precipitation. H. D. BRALEY.
A Process for Electrically Refining Nickel. G. A. GUESS.
Principles of Inductive Heating with High Frequency Currents. E. F. NORTHROP.
Uranium. GUSTAVE GIN.
Remarkable Pitting of Electroplating. O. P. WATTS.
Electroplating on Iron from Copper Sulfate Solution. O. P. WATTS.
Nelson Electrolytic Chlorine Cell. C. F. CARRIER.
Electrolytic Silver and Gold Refining at Perth Amboy. G. G. GRISWOLD.
Improving the Quality of Gray Iron by the Electric Furnace. G. K. ELLIOTT.
The Electric Furnace in the Steel Foundry. W. E. MOORE.
Power Production for Electrochemical Purposes. C. S. COOK.

Symposium on Released Information

- Edgewood Arsenal. W. H. WALKER.
An Electrolytic Process for the Production of Sodium Permanganate from Ferromanganese. R. E. WILSON and W. G. HORSCH.
Silicon Tetrachloride. O. HUTCHINS.
The Role Played by Silicon and Titanium Tetrachlorides during the Past War. G. A. RICHTER.
Portable Electric Filter for Smoke and Bacteria. A. B. LAMB.
The Preparation of Fluorine. W. L. ARGO, F. C. MATHERS, B. HUMISTON and C. O. ANDERSON.
Lead Plating of Shell Interiors and Boosters. A. G. REEVE.
Electric Furnace Manufacture of Silicomanganese. B. C. KLUGH.
Electric Furnaces Used in the Production of Essential War Materials. T. F. BAILY.
Chemical War Secrets and Releasing Manufacturers' Reports. E. GUDEMAN.

CALENDAR OF MEETINGS

American Electrochemical Society—Thirty-fifth General Meeting, Rumford Hall, Chemists' Club, New York City, April 3 to 5, 1919.

American Chemical Society—Spring Meeting, Hotel Statler, Buffalo, N. Y., April 7 to 11, 1919.

National Foreign Trade Council—Sixth National Foreign Trade Convention, Congress Hotel, Chicago, Ill., April 24 to 26, 1919.

NOTES AND CORRESPONDENCE

13,000 MEMBERS!

AMERICAN CHEMICAL SOCIETY

This is the Secretary's ambition for 1919. With your help it can be done. Please remember, however, that I need your help, that I will appreciate it, and that I expect you to send me an application blank with the name at the top of some chemist who has decided to join the AMERICAN CHEMICAL SOCIETY, and with your name at the bottom recommending his election. A chemist who is not a member of the AMERICAN CHEMICAL SOCIETY must feel lonesome; others realize, if he does not, that he is not doing his part toward the advancement of the profession upon which his own welfare depends.

CHARLES L. PARSONS, *Secretary*

THE INDUSTRIAL FELLOWSHIPS OF THE MELLON INSTITUTE

The Industrial Fellowship System, formulated by the late Dr. Robert Kennedy Duncan in 1906,¹ and primarily placed in experimental operation at the University of Kansas in January 1907,² was inaugurated at the University of Pittsburgh in September 1911.³ In March 1913, Messrs. Andrew William Mellon and Richard Beatty Mellon, bankers of Pittsburgh, established it on a permanent basis at that institution. Thus while the Mellon Institute of Industrial Research, the home of this successful system of practical coöperation between science and industry, is an integral part of the University of Pittsburgh and operates in close sympathetic accord with it, it possesses an endowment of its own and is under its own management.

According to this system of research, an industrialist, a company, or an association of manufacturers having a problem or group of problems requiring investigation may become the donor of an Industrial Fellowship by contributing to the Mellon Institute a definite amount of money, for a period of not less than one year. This foundation sum must be adequate for the purchase of all necessary special apparatus or other equipment as well as to furnish the annual stipend of the research man or men selected to work on the particular problem, the solution of which is of interest to the donor. The Institute houses the investigatory work, furnishes it with the use of its permanent equipment, affords library and consultative facilities, gives careful direction to the progress of the research, and provides an atmosphere which is conducive to productive inquiry. All results obtained during the course of the Industrial Fellowship belong exclusively to the donor. The main object of the Institute is to supply for competent investigators every incentive and the most favorable opportunities for fruitful research in the physical sciences and technology, and to make science subservient to the practical needs of industry. It is not, in any sense of the word, of a commercial nature, being entirely independent and deriving no financial profit from any investigation conducted under its auspices. This system constitutes a tried method of combatting pseudo-research in industry, for the cost factor is reduced to a minimum: if by the Mellon Institute, which is national in its activities, has been able to demonstrate to American manufacturers that industrial research, properly carried out, is profitable to them.⁴

THE GROWTH OF THE INDUSTRIAL FELLOWSHIP SYSTEM¹

Each succeeding year it has been our privilege to report progressive growth in both the number of Industrial Fellowships in operation and the amounts subscribed for their support. This makes evident the confidence which industrialists have in the Mellon Institute and the genuine value to industry of the Industrial Fellowship System.

The following table presents the number of Industrial Fellowships which have been founded in the Institute from March to March of each year, 1911 to 1919; the number of Industrial Fellows (research chemists and engineers) who have been employed thereon; and the total amounts of money contributed for their maintenance by the Industrial Fellowship donors (industrialists and associations of manufacturers).

MARCH TO MARCH	Number of Fellowships	Number of Fellows	Amounts Contributed
1911-1912.....	11	24	\$ 39,700
1912-1913.....	16	30	54,300
1913-1914.....	21	37	78,400
1914-1915.....	21	32	61,200
1915-1916.....	36	63	126,800
1916-1917.....	42	65	149,100
1917-1918.....	42	64	172,000
1918-1919.....	47	77	238,245

The total amount of money contributed by industrial firms to the Institute for the 8 years ending March 1, 1919, was \$919,745. During the 8 years, the Institute itself expended over \$330,000 in taking care of overhead expenses—salaries of members of permanent staff and office force, maintenance of building, apparatus, etc.—in connection with the operation of the Industrial Fellowships. Besides this amount, the building and permanent equipment of the Institute, which make it the most complete and modern industrial experiment station in the country, represent an investment of about \$350,000.²

As indicated in previous reports, when the Industrial Fellowship System passed out of its experimental stage—when the Mellon Institute took possession of its permanent home in February 1915—23 fellowships were in operation,³ while on March 1, 1918, there were 42 fellowships.⁴ It was mentioned in the report for 1916,⁵ when 36 fellowships were in operation, that the growth of the Institute had about reached the stage where it would become necessary to decline further industrial investigations temporarily, since our laboratories were almost filled up to capacity. Notwithstanding that fact, the impetus imparted to the investigational activity in American chemical manufacturing, the direct result of the appreciation of urgent action in industrial research, induced us to arrange for the acceptance of 6 new fellowships during the Institute year, March 1, 1916, to March 1, 1917,⁶ and 5 other fellowships during the past Institute year. At the present time (March 1, 1919) there are 47 fellowships⁷ and 5 additional ones have recently been arranged for, to begin just as soon as the necessary laboratory space can be provided.

TYPES OF INDUSTRIAL FELLOWSHIPS

The Industrial Fellowships are of two general types, *vis.*, Individual and Multiple. An Individual Fellowship utilizes the

¹ For previous reports on the status of the system of coöperation between science and industry in operation at the Mellon Institute, see Duncan, *Science*, N. S., **39** (1914), 672; Bacon, *Ibid.*, **43** (1916), 453; *Ibid.*, **45** (1917), 399; and Weidlein, *Ibid.*, **47** (1918), 447; see also *THIS JOURNAL*, **10** (1918), 401.

² For a detailed description of the home of the Mellon Institute, see Hamor, *THIS JOURNAL*, **7** (1915), 333.

³ On the status of the Industrial Fellowship System in 1915, see Bacon, *Ibid.*, **34**; and *J. Soc. Chem. Ind.*, **35** (1916), No. 1.

⁴ See Weidlein, *Loc. cit.*

⁵ Bacon, *Science*, N. S., **43** (1916), 453.

⁶ Bacon, *Ibid.*, **45** (1917), 399.

⁷ See appended list.

¹ *North American Review*, May 1907; "The Chemistry of Commerce," **1907**, 241; and "Some Chemical Problems of To-day," **1911**, 224; see also *J. Soc. Chem. Ind.*, **38** (1909), 684.

² Duncan, *THIS JOURNAL*, **3** (1911), 177; *J. Frank. Inst.*, **1913**, 43; *Harper's Mag.*, **126** (1913), 385; and Bacon, *THIS JOURNAL*, **7** (1915), 343.

³ Bacon, *J. Frank. Inst.*, **1914**, 623; and *THIS JOURNAL*, **7** (1915), 343.

⁴ For demonstrations of the value of research, see Hamor, *Sci. Mon.*, **1** (1915), 86; *Ibid.*, **6** (1918), 324; and Bacon, *Sci. Am.*, Mar. 17, **1917**, 281.

services of one research man, directly responsible to the Administration, while a Multiple Fellowship has the intensive work of one or more investigators under the supervision of a Senior Fellow, who, in turn, is under the direction of the administrative staff.

There are now (March 1, 1919) 35 Individual and twelve Multiple Fellowships. Of these two types, the following have been founded by associations:

No.	Names	Company-Members in Associations
151.....	Leather belting	40
152.....	Refractories	84
153.....	Canning	71
158.....	Leather soling	60
167.....	Magnesia	4
171.....	Asbestos	10
173.....	Fiber	20
185.....	Insecticides	9
189.....	Laundry	2500

Industrial Fellowships established by associations of manufacturers not only enable the Institute to be of direct service to groups of industrial concerns instead of to individual companies, but their successful operation also gives rise to more stable relations of cooperation among the company-members of these associations by the induction of the reciprocal exchange of experience and research results.

Several of the Multiple Fellowships now in operation (Nos. 160, 169, and 190) have been effectively at work since the foundation of the Institute, while most of the Individual Fellowships have been promoted continuously for the past 3 years. The larger Multiple Fellowships (especially Nos. 152, 169, 183, 184, and 190) are so well established and so distinctive in their fields of inquiry that they are not uncommonly regarded as independent organizations, and several of them have, in fact, been mistaken for the Mellon Institute as a whole. These misapprehensions are the result of the existing favorable relations of the Fellowships to the Institute, which, when the donors so desire, secure to them a degree of autonomy which could hardly be surpassed under other conditions. The liberties of action, thus designedly and freely conceded wherever possible, have done much to ensure the constantly successful conduct of the Industrial Fellowships. It is of interest to note here that the incumbents of the larger Industrial Fellowships are recognized generally as experts in the specific branches of technology in which they are carrying out investigations.

THE INDUSTRIAL FELLOWSHIP AGREEMENT

Each fellowship which is accepted by the Institute is the subject of a definite agreement between the industrialist, company, or association of manufacturers concerned and the Institute. The following is the form of agreement now in use by the Institute:¹

AGREEMENT FOR.....INDUSTRIAL FELLOWSHIP No.....This Agreement made and entered into this.....day of.....19....., between Mellon Institute of the University of Pittsburgh, of the City of Pittsburgh, Pennsylvania, hereinafter called the "Institute," and.....of....., hereinafter called the ("Company") ("Association") ("Exchange") ("Donor"),

WITNESSETH: That for the purpose of promoting the increase of useful knowledge, the parties hereto agree as follows:

1—The Company shall pay to the Institute (annually) in advance for a period of.....year(s), beginning on.....19....., (the date on which work is commenced), the sum of.....dollars (\$.....), for the foundation of an Industrial Fellowship to be known as.....INDUSTRIAL FELLOWSHIP No.....the exclusive purpose of which is.....

2—The Institute shall accept the sums so to be furnished by the Company and shall devote them to the furtherance of the problems of this Fellowship; and to this end all money received from the Company under this Agreement shall be paid over

by the Institute in monthly installments to the holder of this Fellowship, in such amount as may be agreed upon by the Institute and the Fellow concerned, and expended for such apparatus, chemicals, and other supplies related to this research as the Director of the Institute may deem necessary for its efficient operation, and for traveling expenses related to the elucidation of the problems concerned. The Fellow shall be provided, at the expense of the Institute, with a separate laboratory, with the advice and direction of the administrative officers of the Institute, and with the general facilities of the Institute. The Company, on its part, shall cooperate with the Institute in this research by providing the Director thereof and the Fellow of this Fellowship with its sympathy and with whatever knowledge of the subjects of research it may possess, and, on approval of the Company, with its factory facilities for large-scale experimentation.

3—The holder of the Fellowship provided hereunder shall be appointed by the Committee of Management of the Institute upon the nomination of the Director in accordance with the terms of his formal letter of application to and as approved by the Director, and he shall give his whole time and attention to the object of the Fellowship, with the exception, if the Director so elect, of three hours a week which he shall give to instructional work in the University of Pittsburgh. The Fellow shall work under the advice and direction of the Director and shall, from time to time, through the Director, forward to the Company reports of the progress of his work. During the existence of the Fellowship provided hereunder the Company shall have the right, through and with the acquiescence of the Director, to employ and take into its regular service the Fellow of this Fellowship, upon terms to be agreed upon between the Fellow and the Company.

4—The Institute, at the expiration of this Fellowship, shall return to the Company any money paid to it by the Company in case any thereof shall remain unexpended for the purpose of this Fellowship; or if a new Fellowship then be established in the Institute by the Company any unexpended money of this Fellowship may be transferred to the account of the new Fellowship.

5—Any and all discoveries made by the Fellow during the term of this Fellowship, as well as all information obtained by him germane to the subjects of his investigation, shall become the property of the Company, subject to the terms and provisions of this Agreement, and the Fellow making such discovery or obtaining such information shall promptly and without demand make revelation of all such information and discoveries. Such revelations shall be made to the duly designated representatives of the Company directly, or through the Director, as the Director may determine.

6—The Fellow of this Fellowship making a discovery or invention germane to the subjects of his investigation shall, at any time, at the option and expense of the Company, apply for letters patent, and shall upon demand assign such letters patent and any and all rights to such invention to the Company under the conditions of this Agreement. In case the Company desires to keep secret such discovery or invention, or for any reason desires that letters patent shall not be applied for, the Fellow shall not at any time apply for patent or patents in his own name and shall not disclose such discovery or invention to others except as herein provided.

7—The Company shall, in addition to the sum paid to the Institute as foundation for the Fellowship, pay to the Fellow a maximum cash bonus of.....dollars (\$.....) or any part thereof which in the opinion of the Board of Arbitration (hereinafter provided for) is deserved by the Fellow of this Fellowship, and the amount of this payment and the time or times of payment shall be decided by the Board of Arbitration upon application of either of the parties hereto.

8—In the event of any difference of opinion between the parties hereto as to the interpretation of this Agreement, or the rights of the respective parties to this Agreement, the matters in issue shall be referred to a Board of Arbitration, which Board shall consist of a representative of the Institute and a representative of the Company and a third person whom these two shall select. The decision of this Board shall be obtained without recourse to the courts and when rendered shall be binding upon the parties hereto.

9—During the term of this Fellowship, the holder thereof may publish such results of his investigation as do not, in the opinion of the Company, injure its interests. On or before.....19....., the holder thereof shall have completed a comprehensive monograph on the subjects of his research. The subject matter of such monograph shall not contain specific information of the process or methods of the Company, but it

¹ This form has replaced the one described in THIS JOURNAL, 7 (1915),

INDUSTRIAL FELLOWSHIPS IN OPERATION AT THE MELLON INSTITUTE ON MARCH 1, 1919

No.	NAMES OF INDUSTRIAL FELLOWSHIPS	INDUSTRIAL FELLOWS, NAMES, AND DEGREES	FOUNDATION SUMS AND DATES OF EXPIRATION
117	Window Glass	Fellow to be appointed	\$3,000 a year. Bonus, \$2,000
127	Collar	H. D. Clayton (B.A., Ohio State University)	\$2,800 a year. June 14, 1919
129	Illuminating Glass	A. H. Stewart (B.A., Washington and Jefferson College)	\$2,100 a year. October 1, 1919
145	Soup	Fellow to be appointed	\$2,000 a year.
150	Enameling	R. D. Cooke (M.S., University of Wisconsin)	\$2,600 a year. April 1, 1919
151	Leather Belting	P. G. McVetty (M.E., Cornell University), Senior Fellow	\$4,900 a year. April 1, 1919
152	Refractories	R. A. Edson (B.A., Clark College) R. M. Howe (M.S., University of Pittsburgh), Senior Fellow B. M. Burchfield (B.A., Southwestern College) E. N. Jessop (B.S., University of Pittsburgh) S. N. Phelps, Assistant	\$7,000 a year. May 1, 1919
153	Canning	M. R. Daughton (B.A., University of Nebraska); 2nd Fellow to be appointed	\$6,000 a year. May 1, 1919
154	Paper	Howard Curtis (B.A., Washington and Jefferson College)	\$2,175 a year. June 1, 1919
155	Protected Metals	J. H. Young (Ph.D., Ohio State University)	\$3,000 a year. June 1, 1919
156	Physiological Research	K. K. Jones (M.S., Kansas State Agricultural College)	\$4,000 a year. August 1, 1919
157	Dental Products	C. C. Vogt (Ph.D., Ohio State University)	\$2,000 a year. July 1, 1919. Bonus, royalty on sales
158	Leather Soling	C. B. Carter (Ph.D., University of North Carolina)	\$3,500 a year. June 1, 1919
159	Copper	L. H. Perkins (B.S., New Hampshire College) R. E. Sayre (M.S., University of Wisconsin)	\$5,400 a year. July 1, 1919
160	Oil	W. F. Faragher (Ph.D., University of Kansas), Senior Fellow W. A. Gruse (Ph.D., University of Wisconsin)	\$10,000 a year. September 1, 1919. Bonus, \$10,000
161	Glass	R. R. Shively (Ph.D., University of Pittsburgh)	\$2,000 a year. September 1, 1919
162	Gas	J. B. Garner (Ph.D., University of Chicago), Senior Fellow H. B. Heyn (B.S., University of Wisconsin)	\$7,500 a year. September 15, 1919
163	Aluminum	E. O. Rhodes (M.S., University of Kansas), Senior Fellow R. D. Trusler (B.S., Syracuse University)	\$6,500 a year. September 15, 1919
164	Alloy	E. O. Harder (Ph.D., University of Illinois)	\$3,500 a year. October 1, 1919
165	Coffee	C. W. Trigg (B.S., University of Pittsburgh)	\$2,250 a year. October 1, 1919. Bonus, 2 per cent of gross profits
166	Food Container	F. W. Stockton (B.A., University of Kansas)	\$5,000 a year. October 16, 1919
167	Magnesia	M. S. Mason (M.S., University of Illinois) R. H. Heilmann, Assistant (University of Pittsburgh)	\$6,000 a year. January 1, 1920
168	Yeast	Ruth Glasgow (M.S., University of Illinois), Senior Fellow Grace Glasgow (M.S., University of Illinois) G. S. Bratton (B.S., University of Tennessee) F. M. Hildebrandt (Ph.D., Johns Hopkins University) W. H. Randall, Assistant (George Washington University)	\$15,000 a year. November 1, 1919
169	Copper	G. A. Bragg (B.S., University of Kansas), Senior Fellow J. W. Schwab (B.S., University of Kansas) F. P. Rupert (Ph.D., Massachusetts Institute of Technology)	\$6,000 a year. November 1, 1919
170	Household Utilities	E. R. Edson (B.A., Clark College) A. F. Shupp (Ph.D., University of Pittsburgh)	\$5,000 a year. November 1, 1919
171	Asbestos	M. G. Babcock (M.S., Iowa State College)	\$3,500 a year. November 1, 1919
172	Silicate	J. D. Malcolmson (B.S., University of Kansas)	\$2,500 a year. December 1, 1919
173	Fiber	R. K. Brodie (M.S., University of Chicago)	\$3,000 a year. November 1, 1919
174	Glycerin	Nelvin DeGroot (B.Ch.E., Ohio State University) J. V. Faragher (Ph.D., Massachusetts Institute of Technology)	\$5,000 a year. November 15, 1919
175	Light Metals	P. G. Davidson (Ph.D., Columbia University)	\$4,000 a year. December 1, 1919
176	Fuel	Fellow to be appointed	\$5,000 a year. January 1, 1920
177	Toilet Articles	H. E. Peck (B.S., Clarkson Memorial College of Technology)	\$3,500 a year. January 1, 1920
178	Silverware	L. M. Liddle (Ph.D., Yale University), Senior Fellow	\$2,500 a year. December 11, 1919
179	Organic Solvents	H. W. Greider (M.S., University of Kansas)	\$5,600 a year. January 1, 1920
180	Keratin	B. A. Stagner (Ph.D., University of Chicago)	\$4,000 a year. January 1, 1920. Bonus, \$5,000
181	Synthetic Resins	Senior Fellow to be appointed A. E. Coke (B.S., University of Chicago)	\$5,000 a year. December 23, 1921
182	By-Products Recovery	Walther Riddle (Ph.D., University of Heidelberg) H. E. Gill, Assistant (University of Pittsburgh)	\$3,000 a year. January 1, 1920
183-A	Organic Synthesis	G. O. Curme, Jr. (Ph.D., University of Chicago), Senior Fellow H. R. Curme (Ph.D., University of Pittsburgh) J. N. Compton (M.S., Columbia University) C. O. Young (Ph.D., University of Pittsburgh)	\$32,400 a year. January 1, 1920
183-B	Organic Synthesis	E. W. Reid (M.S., University of Pittsburgh) H. A. Morton (Ph.D., University of Pittsburgh), Senior Fellow	
184	Coke	C. J. Herby (B.S., Pennsylvania State College) F. W. Sperr, Jr. (B.A., Ohio State University), Advisory Senior Fellow O. O. Malleis (M.S., University of Kansas) L. R. Office (B.S., Ohio State University) H. S. Davis (Ph.D., Harvard University)	\$7,020 a year. January 1, 1920
185	Insecticides	O. F. Hedenburg (Ph.D., University of Chicago)	\$3,500 a year. January 1, 1920
186	Fertilizer	H. H. Meyers (B.S., University of Pennsylvania)	\$4,000 a year. January 5, 1920. Bonus, \$5,000
187	Glue	R. H. Bogue (M.S., Massachusetts Agricultural College)	\$2,500 a year. January 5, 1920
188	Distillation	David Drogin (M.S., University of Pittsburgh)	\$3,000 a year. January 18, 1920
189	Laundry	H. G. Ellidge (M.S., University of Pittsburgh) Alice L. Wakefield, Assistant (B.S., Margaret Morrison)	\$5,000 a year. February 15, 1920
190	Bread	H. A. Kohman (Ph.D., University of Kansas), Senior Fellow Roy Irvin (M.S., University of Kansas)	\$10,000 a year. March 1, 1921. Bonus, \$10,000
191	Fruit Beverages	R. J. Cross (B.A., Leland Stanford, Jr., University) H. A. Noyes (M.S., Massachusetts Agricultural College)	\$3,000 a year. March 1, 1920

shall be confined to a statement of new discoveries of scientific fact obtained by this Fellowship. A copy of this monograph shall be forwarded to the Company and a copy shall be signed and placed in the archives of the Institute until the expiration of three years from the time hereinafter provided for the termination of this Fellowship, when the Institute shall be at liberty to publish it for the use and benefit of the public. Such monograph when published shall not contain data or information in regard to the cost of manufacture by any process revealed in such monograph.

In the event that in the opinion of the Company such publication at such time will unduly injure its interests, it shall have the privilege of appealing at any time for an extension of time of such publication to the Board of Arbitration provided for herein which, after considering the appeal, shall, if in its opinion such publication will unduly injure the Company's interests, extend the time of publication to a time when in the Board's opinion publication will not unduly injure the interests of the Company.

10—The Fellowship provided under this Agreement shall terminate the day of 19.....

IN WITNESS WHEREOF, the parties hereto have caused their names to be subscribed the day and year above mentioned by their duly authorized officers.

WITNESSED:

MELLON INSTITUTE OF UNIVERSITY OF PITTSBURGH

Director

ADMINISTRATION

The Director and Assistant Director Hamor were absent on leave throughout 1918, having had charge of the technical activities of the European Division of the Chemical Warfare Service.¹ During this period, Associate Director Weidlein served as Acting Director and distinguished himself by noteworthy accomplishments for the Government as well as for the Mellon Institute. Richly endowed with all the qualities which

¹ For a résumé of this work, see THIS JOURNAL, 11 (1919), 13.

make for success in research administration, Mr. Weidlein not only directed the Institute's work with a self-sacrificing skill which inspired the admiration of the donors and his associates, but he also found time to serve as chemical expert for the War Industries Board, in which positional capacity his attainments elicited the highest official commendation. With the patriotic concurrence of the donors of certain of the Industrial Fellowships, Mr. Weidlein was also enabled to direct at the Institute a number of investigations of pressing importance to the War Department.

Intimately associated with Mr. Weidlein during this trying period of intensive research effort were Assistant Directors Tillotson and Pratt, both of whom actively and constantly participated in establishing the conspicuous success of the researches conducted for the Government and for our industrialists. The present status of the Industrial Fellowships alone bears testimony to the high executive ability of these three men and their sincere devotion to the system and the Institute.

During the year the administration was strengthened by the appointment of Mr. Harry S. Coleman to an Assistant Directorship. Mr. Coleman is a mechanical engineer possessing splendid training and industrial experience, which peculiarly qualify him to assume supervision of certain of the Institute's inquiries in the domain of mechanical technology. A constantly increasing number of investigations are coming to the Institute from that field, and three of the Industrial Fellowships now in operation largely involve experimental engineering work.

The Administration of the Mellon Institute is now constituted as follows:

RAYMOND F. BACON, Sc.D.	WILLIAM A. HAMOR, M.A.
Director	Assistant Director
EDWARD R. WEIDLEIN, M.A.	DAVID S. PRATT, Ph.D.
Associate Director	Assistant Director
E. WARD TILLOTSON, Jr., Ph.D.	HARRY S. COLEMAN, B.S.
Assistant Director	Assistant Director
PITTSBURGH, PA. March 1, 1919	R. F. BACON

BUREAU OF STANDARDS' SAMPLES

NOTICE OF CHANGE IN METHOD OF DISTRIBUTION EFFECTIVE
APRIL 1, 1919

The Bureau of Standards reports that it is making strenuous efforts to renew its depleted stock of standard samples. The very great increase in the demand for these samples from regular sources and extra calls from the inspection sections of the War and Navy Departments together with the inability to get increased appropriations for this work have made it very difficult to keep the supply adequate. The demands of the military branches of the Government have made it impossible to procure the material for the renewal of some of the samples and have made it very difficult to procure the machinery for the preparation of the iron and steel samples. It may not be realized generally that the preparation of a sample consumes about three-fourths of the time required for the entire work upon it.

The present method of distribution has been known for some time to be cumbersome. New ordering and shipping regulations have therefore been adopted and ordered published on two additional pages, 5 and 6, of the Supplement to Circular 25, "Standard Samples—General Information." This new supplement can be obtained on request from the Bureau of Standards, Washington, D. C.

As adopted, these regulations provide for the ordering of standard samples by number and name from the list printed on the first page of the above-mentioned supplement just as at present. From this time forward all samples for points in the United States or its possessions will be shipped by parcel post, C. O. D. Those for points in Canada, Mexico, and other foreign countries will be shipped by express, C. O. D. The

regulations of the Department of Commerce require that the payments for these samples be in the hands of government agents before delivery can be made. By using the parcel post exclusively the Bureau hopes to make it possible for customers to send in their orders and pay for them through their own post office when delivery is made. They hope in this way to make prompter shipments and avoid the necessity for refunds when samples ordered are out of stock. The 10 per cent quantity discount on 4 or more samples ordered at one time has been discontinued.

The Bureau has on hand at present a fairly adequate stock of the following:

SAMPLE No.	NAME	CONSTITUENTS DETERMINED OR INTENDED USE	Weight of Sample Grams	Fee per Sample with Certificate
1	Argillaceous limestone	Complete analysis	100	\$1.00
2	Zinc ore D	Zinc	100	1.00
3	Iron B	C, Si, Ti, P, S, Mn	150	2.00
4	Iron C	C, Si, Ti, P, S, Mn, Cu	150	2.00
5	Iron E	C, Si, Ti, P, S, Mn, Cu, Cr, Ni, V	150	2.00
88	Steel, Bessemer, 0.1 C	C, Si, P, S, Mn	150	2.00
98	Steel, Bessemer, 0.2 C	C, Si, P, S, Mn	150	2.00
118	Steel, B. O. H., 0.2 C	C, Si, P, S, Mn	150	2.00
128	Steel, B. O. H., 0.4 C	C, Si, P, S, Mn	150	2.00
158	Steel, B. O. H., 0.1 C	C, Si, P, S, Mn	150	2.00
168	Steel, B. O. H., 1.0 C	C, Si, P, S, Mn	150	2.00
17	Sucrose	Calorimetric value and saccharimetric value	60	2.00
20a	Steel, A. O. H., 0.4 C	C, Si, P, S, Mn, Cu, Cr, V, Ni	150	2.00
21a	Steel, A. O. H., 0.6 C	C, Si, P, S, Mn, Cu, Cr, V, Ni	150	2.00
22a	Steel, Bessemer, 0.6 C	C, Si, P, S, Mn	150	2.00
24	Steel, vanadium, 0.15 V	C, Si, P, S, Mn, V (Ni, Cr, Cu, Mo)	150	2.50
26	Crescent iron ore	Al ₂ O ₃ , CaO, MgO	100	1.50
27a	Sibley iron ore	SiO ₂ , P, Fe	150	2.00
28	Norrie iron ore	Mn (low)	100	1.50
29	Magnetite iron ore (titaneous)	Full analysis	150	2.00
33	Steel, nickel	C, Si, P, S, Mn, Ni (Co, Cr, Cu, W, Mo)	150	2.50
34	Steel, A. O. H., 0.8 C	C, Si, P, S, Mn (Cu, Cr, Mo)	150	2.00
35	Steel, A. O. H., 1.0 C	C, Si, P, S, Mn (Cu, Cr)	150	2.00
37	Brass, sheet	Cu, Zn, Sn, Pb, Fe, Ni	150	3.00
38	Naphthalene	Calorimetric value	50	2.00
40	Sodium oxalate	Oxidimetric value	75	1.25
41	Dextrose	Reduction value	170	2.00
42	Tin	Melting point	340	3.00
43	Zinc	Melting point	350	2.00
44	Aluminum	Melting point	200	2.00
46	Cement (normal)	Testing sieves	160	0.25
47	Cement (extra fine)	Testing sieves	160	0.25

There are at present in course of preparation samples No. 6c Iron D; 13b B. O. H. Steel, 0.6 C; 14b B. O. H. Steel, 0.8 C; 23a Bessemer Steel, 0.8 C; 25a Manganese ore; 30a Chrome-Vanadium Steel; 31a Chrome-Tungsten Steel; 32a Chrome-Nickel Steel; and 37a Sheet Brass. Of these it is hoped to have Nos. 30a and 37a ready for distribution by April 1, 1919. Nos. 6c and 25a should be ready by June 1, 1919, and the others will follow as rapidly as facilities will permit.

FRASCH SULFUR MINING PROCESS DECISION

According to the *Oil, Paint, and Drug Reporter* for March 10, 1919, vast deposits of sulfur in the United States are opened up to all who would bring them to the surface, under a decision just handed down by Circuit Judges Buffington and Woolly, and District Judge Thompson, in the United States Circuit Court, sitting at Philadelphia. The suit was instituted by the Union Sulfur Company, of Louisiana, against the Freeport-Texas Company upon allegation of infringement of certain basic patents standing in the name of Herman Frasch, deceased, and taken over by the Union Company. This company alleged the Freeport-Texas Company was infringing upon its rights.

The case appealed from the District Court of Delaware sets a precedent in the history of sulfur mining.

In briefest terms the decision of the court, which reverses the lower tribunal, is that the so-called Frasch patents cover methods and processes not of basic patentability, and that no control of certain mining methods is given by them. Sulfur deposits are, therefore, opened up and the studies and experiences which Frasch made and had are now available to the world.

The opinion of the court is contained in a decision covering 52 typewritten pages. The outstanding dictum is that affirmation of the finding of the lower court would have the effect of retarding sulfur mining for more than a score of years, save by those who are in control of what are known as the Frasch patents. The court's decision was written by Judge Buffington, the other judges concurring.

SULFUR MINING METHODS

In his opinion the court enters learnedly and entertainingly on the history and methods of sulfur mining in England, Italy, particularly Sicily, and elsewhere, and then comes down to operations in the United States. Taking up the Louisiana sulfur mining activities, he says that a deposit was found in that State in 1869 at a depth of 400 to 500 feet below the surface, and incident to drilling for oil. Though vast sums of money were spent in securing the highest engineering skill and equipment, all efforts to mine successfully the Louisiana sulfur deposits failed for a period of 25 years. The richness of the beds and the futile efforts to make them available, it is then set forth, attracted the attention of Frasch, who had experimented in the sulfurous oil mining in Pennsylvania. It is admitted that Frasch did pioneer work along the lines involved in the suit, but it is contended that his method of drilling and the use of either heat or chemical liquefaction were not perfected by himself, that workmen and engineers carried on his experiments, and that finally, by a process of evolution, a method was perfected which is now commercially profitable, but which the court holds is not controlled by certain patents which Frasch secured, and which are the subject matter for the litigation thus decided.

The court says that in the Louisiana district the early drilling methods disclosed quicksand and water; that the drill further showed that after passing these there existed a vein of cap rock overlying the sulfur, and upon which caisson shafts could be rested, so that the sulfur could safely be mined through the shaft carried from the caisson through the cap rock. Drilling, however, revealed the presence of water strongly impregnated with sulfurous gas, and this proved a serious obstacle and contributed to the abandonment of the shafting operations, although it did show the intimate proximity of sulfur and water to each other. The principal difficulty in shafting arose from the quicksand because, when the shaft reached a certain depth, the quicksand forced its way up from the bottom of the inside of the rings and precluded further effort. The sulfurous gases killed several workmen.

DISSOLVED SULFUR UNDER GROUND

It, therefore, became Frasch's idea to abandon shafting operations and to drill and pump out oil which was impregnated with sulfur; also to drill a small sized hole into the sulfur beds, force down hot water, and then pump the liquefied sulfur to the surface. However, the plan, when submitted to companies in England and Italy familiar with sulfur mining, was pronounced impractical, even impossible. But Frasch in several experiments with sulfurous oil wells had successfully devised means of utilizing hydrochloric acid in increasing the oil flow. By plugging the well after the acid was poured down, pressure of carbonic acid gas generated, forced passage-ways through seams in the limestone and thus opened channels for oil supply.

Frasch's patent for processes of drilling were two, the court says, first, use of hot water to liquefy sulfur; second, liquefaction by chemicals. The water process was patented October 20, 1891; patent No. 461,429. The first trial of Frasch's patent proved practical, for sulfur was liquefied under ground and brought to the surface, the result of four or five hours' pumping being 500 barrels of sulfur. But corrosion of pump rods from sulfur checked operations. Aluminum parts were decided upon and later other improvements on the patents were made.

THREE PATENTS INVOLVED

Three patents were involved in the suit in the light of previous processes which apply to both porous and non-porous sulfur, and the court, therefore, addressed itself to the question whether they involved Frasch's inventions. The court holds, however, that the patents granted in 1905 and which were subsequent to the original patent, which expired in 1908, if sustained, would have conferred a monopoly of sulfur mining for 31 years. The court proceeds with the discussion of patents issued and modifying the first granted. It points out that "these subsequent patents were in the nature of a consistent series of delays which, while perhaps legal and involving nothing censurable, yet would have the effect if validated by court, and if enforced, of shutting out the public from the fields of underground sulfur liquefaction for 31 years." The court, therefore, takes the position that it behooves it, before being led to a decision with such grave consequences to the sulfur industry, to take care from being led to a decision "which, instead of fulfilling the constitutional purposes of promoting the progress of science and useful arts, in reality blocks the path of progress." The court proceeds to discuss the various subsequent and modifying patents as mechanical improvements were made and methods perfected and adds: "As to the several combinations in claims which embrace delivery of hot water at different levels, we are of opinion they do not involve patentability and also lack inventive substance." The patent granted in 1911, for instance, covers a perforated lining which distributes the outgoing hot water over a wider zone and by its many scattered holes prevents clogging where surrounding substances cave in as liquefaction proceeds. The court holds in this instance that the use of perforated pipes for such general purposes is too manifestly such a mere mechanical expedient that it cannot find any inventive act in using such a strainer and accordingly it holds such claims void. Similarly several other claims are decreed invalid and, therefore, the court dismisses the bill.

THE TRAINING OF THE CHEMIST

Editor of the Journal of Industrial and Engineering Chemistry:

Since the publication of the former article on this topic [THIS JOURNAL, 11 (1919), 166] correspondence with the chairman of the committee of the Society on the Relation of Industries and Universities and with the chief chemists of some 35 leading commercial organizations justifies the following propositions:

1—It is urged that the above-named committee propose to the Society at large that it place itself on record as favoring either the extension of the school year from 9 to 11 months, or the extension of the course from 4 to 5 years, or both.

2—It is strongly urged that the above-named committee appoint one man in each section of the Society to act as a sub-committee in that section, to consult with the industries that may be located within convenient reach of the educational institutions of the section, to persuade the managers of the industries and the authorities of the schools to enter into an arrangement by which chemistry students may get actual industrial experience during their years of training, and to make report of what has been done to the central committee for presentation at the Fall Meeting of the Society.

It is believed these recommendations are well grounded. They are based on opinions expressed within the last month by some prominent and well-known commercial organizations, whose experience and position in the industrial world entitle their judgment to wide publication and to the careful consideration of all who are trying to train chemists. Representatives of these companies were asked to state what defects they had found in the young men in their organization, other than deficiencies in the personal qualities not likely to be affected by education, such as character, ability to get on with men, personal magne-

tism, mediocre or low brain power, etc. A questionnaire is a nuisance, generally speaking. That the men and companies, addressed in this case considered the matter of some importance, is indicated by the fact that out of 125 concerns appealed to for information 35 were heard from directly, and a half dozen more indirectly, a rather large percentage of returns for this method of getting at facts.

The men making the replies and the companies represented are as follows:

L. C. Jones, National Aniline and Chemical Company
E. C. Uhlig, Brooklyn Union Gas Company
J. B. Barnett, General Chemical Company
W. C. Carnell, Rohm and Haas Company
C. Geltharp, Pittsburgh Plate Glass Company
C. R. Hazen, Milton-Hersey Company, Canada
G. W. Thompson, National Lead Company
J. M. Francis, Parke, Davis and Company
G. M. Berry, Halcomb Steel Company
W. R. Whitney, General Electric Company
W. B. Brown, Victor Chemical Works
J. R. Powell, Armour Soap Works
G. K. Elliott, The Lunkenheimer Company
W. C. Geer, B. F. Goodrich Company
F. F. D. Crusier, The Diamond Match Company
Paul Rudnick, Armour and Company
F. C. Atkinson, American Hominie Company
Carleton Ellis, Ellis-Foster Company
The Naugatuck Chemical Company
A. N. Clark, Owosso Sugar Company
E. J. Gutsche, Detroit Copper and Brass Rolling Mills
E. H. Raquet, New Hampshire and H. R. Railroad Company
W. K. Robbins, Amoskeag Manufacturing Company
J. H. Kemster, Universal Portland Cement Company
A. M. Knight, Deere and Company
H. T. McAllister, Ludlum Steel Company
C. M. Prentiss, C. M. and St. P. Railway
Karl F. Stahl, General Chemical Company of Pennsylvania
L. B. Robinson, Robinson Laboratory of Cincinnati
W. B. Price, Scovill Manufacturing Company
Maximilian Toch, Toch Brothers of New York City
A. D. Smith, The Milliken Company
C. W. Bedford, Goodyear Tire Company
A. V. H. Mory, Sears, Roebuck and Company

The training defects noted by these employers of chemists fall quite naturally into three classes:

I—There are those which can be corrected within the limit of time now given to the training, namely 36 months, by all of us who are engaged in this work. Possibly we, and not the students nor the conditions, are responsible for them. They are given in the following list:

(a) The young graduate cannot evaluate measurements. This is stated in various ways in more than two-thirds of the replies, but whatever the form of statement, reduced to its lowest terms it means that the young chemist does not understand that a rapid qualitative reaction may have a greater value in some circumstances than a more accurate and painstaking analysis. One of the replies states the case clearly in these words: "The young graduate lacks accuracy where it is required and tries to be too accurate where it is not required."

(b) Ability to represent experimental data graphically is lacking.

(c) There is carelessness in handling apparatus, especially sensitive instruments.

(d) Notes are inadequate, insufficient, and unenlightening—sometimes even untrustworthy.

(e) The young graduate is contented to get only the data asked for and seldom goes beyond that point.

(f) There is a deficiency in mathematical accuracy. More stoichiometry should be given.

(g) The foundation in theory is often poorly laid.

(h) The young graduate lacks concentration, is either indifferent or lazy.

If only one man, or ten men, out of the thirty-five had stated that he had found these defects, one might conclude that they did not represent a general condition. The fact is that most of the employers have found deficiencies along these lines. An-

other important fact is that every teacher recognizes them as faults all too common in students. To correct them is clearly our responsibility, and the correction is also clearly within the range of the possibilities of the training course as now given. Every teacher can see ways in which they can be removed. If a student persists in retaining such defects as these through a four years' course, should he not be advised to seek a career in some other line than chemistry? Why can't we all get together at the April meeting of the Society, teachers in secondary schools and colleges and universities, and at an informal conference where everybody can talk, thresh out the whole subject with the purpose of securing united effort in eradicating such defects as these, or in persuading those who do not respond to the operation to enter some other profession?

All these defects should respond to the training that can be given in the usual period of 36 months.

II—The second class into which fall many of the replies consists of those defects that can be corrected by the extension of the time of training, either from 9 months to 11 months for the year, or from 4 years to 5 or 6, or, what is better in the opinion of the author, a combination of both. In this class come such defects as the following:

(a) A student learns nothing from unsuccessful experiments.

(b) The English is defective. This appears in more than three-fourths of the replies. Only one employer states that he is not concerned with the quality of English as exemplified in the reports of work done. A great majority of employing chemists deplore the inability of the young men either to express themselves clearly in spoken English or to present an easily readable written report.

(c) There is a decided lack of independence and initiative. The young graduate requires too much assistance, or as another expresses it, "He is a good machine."

(d) The students should have more "brain exercise, and schemes to get them on the alert should constantly be tried."

(e) The young graduate does not do sufficient reading on the side. He is more eager to take directions through his ear than through his eye.

(f) The usual course gives too much analytical work and too little constructive work.

(g) The lack of imagination is emphasized by over half of the replies. One chemist asks, "Can't there be a course in chemical imagination?"

Every teacher of young chemists knows that the pressure due to the crowding in the present chemistry courses causes an effort to get over a considerable amount of ground and there is little chance for getting at what lies underneath. The result is that the graduate has accumulated breadth of information rather than depth of mental power. It is obvious that if students are to learn the value of mistakes they must be given time to make mistakes and corrections. If the student is to develop independence he must be given time to flounder. If his course is to result in greater brain power, if he is to be less mechanical, if he is to have a chemical imagination as a result of his training, if he is to develop initiative, if he is to do constructive work, opportunity, even though limited in scope, must be given him to try a few things which for him are new although for the teacher and the science they may not be. It takes more time and is a good deal harder work, for the young undergraduate as well as for the experienced worker, to think out an idea and to express it ("to get it across" is the modern way of saying it) than to do what some teacher or some director or some book states shall be done. The more frequently the hands and body make a given motion, the more easily and quickly it can be made. The same principle applies to the use of the brain, but it takes more time to develop a "brain motion" than it does a "body motion."

The first of these two classes of defects is within easy control of those of us who are training chemists, and their correction

can be accomplished within the present time limits of the course. The second class is also within easy control if sufficient time can be given in which to do the necessary work. The third class of replies is entirely outside the control of the teachers and to a large extent of the institutions with which they are connected.

III—The third class consists mainly of one thing. Almost 95 per cent of the replies received stated that the student does not know how to apply practically what he has learned during his course. In this respect the student of chemistry is not equipped, generally speaking, as well as his brother student in engineering and in agriculture. The chemistry students have not had the opportunity during the course that other technical students get of coming in close contact with the practical side of their work. He does not know what is expected of him in a plant. He has very little idea that the business world is concerned with profits. Chemistry is to the student the means of getting a job rather than either a real part of him or an essential part of a commercial process.

Every practical working chemist knows that educational institutions can give only to a very limited extent practice in actual chemical processes that are commercial. Some of the larger universities and certain trade schools have technical or industrial laboratories in which such processes as filtration, distillation, drying, etc., are done on an industrial scale. One of the employers wrote that "the graduates of trade schools are better equipped practically than those who have come from a more elaborate course." This criticism of a lack of an acquaintance with the practical application of chemical processes is well taken. Every teacher realizes the deficiency and deplores it all the more because he knows that he is quite unable to correct it. Most laboratories in our educational institutions cannot equip themselves with what might be called industrial chemical apparatus, and even if they could it is to be questioned whether the result of the use of such apparatus in a school laboratory would give the practical ideas which employers want. All the work done in an educational institution must of necessity have the "educational flavor." If industrial processes are to take on a "commercial flavor" for the undergraduate, the work can be best done in the industrial plants themselves. The success of the coöperative courses at Cincinnati and Akron is conclusive evidence of this.

It is apparent that both the manufacturing chemists and those who are engaged in training chemists are agreed that there is this lack of practical knowledge in the undergraduate. The teachers know that the lack can best be supplied by the industries themselves. If that part of the training is to fall within the four or five or six years of the preliminary course, and that is where many of us believe it should come, the industries and the educational institutions must work together, each giving that part of the training that it can give best.

A few of the replies received to the inquiry fall outside of these three classes. They are not on that account less important, but it is probable that they apply with equal force to students in all courses as well as those in chemistry. The educational institutions must carry the responsibility for them. If the graduate is more concerned with what he gets than what he gives, if he lacks interest in the work he is doing, if he gives little attention to the "why" and "how" of the process in which he is engaged, if he overrates his commercial value and ability, those who have trained him are largely responsible. Such defects can be and ought to be removed even in a much shorter period than the four years now given to the training of young men.

As one reads over the above classification of the defects of young chemists as seen by their employers, the wisdom of the proposed recommendations in the opening paragraphs of this article and the necessity of changes in the courses in chemistry are apparent. It is worth while both from the point of view

of chemical industry and of chemical education that these changes be undertaken at once.

UNION COLLEGE
SCHENECTADY, N. Y.
March 4, 1919

EDWARD ELLERY

AN INSTITUTE FOR COÖPERATIVE RESEARCH AS AN AID TO THE AMERICAN DRUG INDUSTRY

Editor of the Journal of Industrial and Engineering Chemistry:

In responding to an invitation to express an opinion regarding the proposed national institute for drug research the writer is glad to avail himself of such an opportunity for recording his hearty commendation of the project. The subject of research is one so broad in its applications as to cover practically every field of human endeavor, and no nation can be expected to develop its resources or take any part in the general extension of knowledge if the spirit of research is dormant. The stirring events of recent years, and the altered conditions which have thus been effected in the world at large, have demonstrated most clearly and forcefully the great part which chemical science is destined to take in human affairs, and in this connection it is desirable to consider its importance in the useful arts rather than in the destructive forces of war.

The views of many of those who are actively engaged in scientific work, as well as others who are leaders in industrial pursuits, have already been expressed, and there would seem to be but little more to be said regarding both the utility and the actual need of an institute for drug research. There is, however, one phase of such a project in which the writer is more especially interested to which sufficient consideration does not seem as yet to have been given. This relates to the more extended investigation of the products of the vegetable kingdom, a subject which may be comprehended under the title of phytochemistry. In glancing over the communications that have already been published it does not seem quite clear what particular fields of research are to be included in the plan for a national institute, but the impression is received that pharmacology or chemotherapy and the synthetic production of organic medicinal chemicals would be accorded the most prominent place. In connection with one of the proposed plans of work to be undertaken it has indeed been suggested by an esteemed scientist that "in time there might even be a division for the prosecution of pharmaceutical chemical research." Very divergent views appear to be held with regard to the meaning of pharmaceutical chemistry, and when the scope and functions of the proposed national institute become more clearly defined it will doubtless be considered whether it would most appropriately be denoted as an institute for drug research. According to common usage, especially in European countries, the word "drug" is employed to designate all crude vegetable substances, and a distinction is also made between technical drugs and those used for medicinal purposes, although in a few instances a natural product may be included in both classes.

While it cannot be doubted that all of the lines of research thus far proposed would be productive of great and lasting benefit, it seems to the writer that a valuable opportunity for promoting the usefulness of the institute would be lost if due consideration were not given to the chemical and pharmacological investigation of our native plants as well as the vegetable products from other lands. It is possible that researches of this character might be considered to pertain to the domain of pharmaceutical chemistry, and, therefore, to be of subordinate interest or at least not requiring immediate attention. Those who have devoted themselves to such studies will, however, readily recognize and appreciate the fact that a field of the most fruitful investigation still remains largely unexplored, for among the vast number of plants in our own country or its insular possessions there are comparatively few whose constituents are known,

and it may safely be assumed that among them there are many that would be found to have valuable medicinal properties. It was, for example, recently observed by the writer that a plant which is very abundant in the southern states contains a large proportion of an alkaloid, the composition and properties of which are still undetermined, and many others of a similar or equally interesting character could certainly be found. Numerous plants, especially in the western flora, contain aromatic substances, but the composition and possible utilization of these substances, either in medicine or the arts, still remains to be ascertained. Such subjects, whether they be considered to pertain to pharmaceutical or biological chemistry or any other branch of chemical science, require for their elucidation the highest chemical training and skill, and an especially broad knowledge of the character and behavior of all classes of organic compounds. A considerable staff of experienced investigators could, therefore, be most usefully employed in such lines of work, since results would be achieved which would often be of lasting benefit to mankind.

The details of organization and policy to be pursued by the national institute which it is proposed to establish having already been entrusted to a capable committee, the writer, in concluding these brief remarks, can only express the hope that their labors may be attended with the most abundant success.

PHYTOCHEMICAL LABORATORY
BUREAU OF CHEMISTRY
WASHINGTON, D. C.
March 10, 1919

FREDERICK B. POWER

CHEMICAL RESEARCH IN THE VARIOUS COUNTRIES OF THE WORLD

In normal times the amount of chemical research in the various countries can be gauged with considerable accuracy by the number of abstracts published in *Chemical Abstracts* of papers produced by citizens of the different nations. In the abnormal times brought about by the great world war such figures reflect the situation with less accuracy because of the chemical research on war subjects not published and because, as it happens, it has been possible to cover the current German and Austrian chemical literature with only a fair degree of completeness. This literature has been covered pretty well, however, so that the figures, though a few per cent low as regards Germany and Austria, tell a story that is really not far from the truth and one that is of a good deal of significance.

COUNTRIES	Number of Abstracts			Per cent of Total		
	1913	1917	1918	1913	1917	1918
United States.....	3940	4602	4136	21.1	43.9	45.4
Great Britain.....	2741	1560	1531(b)	14.7	14.9	16.8
France.....	2481	794	841	13.3	7.6	9.2
Germany.....	6339	2065	1258	34.9	19.7	13.8
Austria.....	539	112	95	2.9	1.1	1.0
Italy.....	905	305	286	4.9	2.9	3.1
Russia.....	474	264	67	2.5	2.5	0.7
Holland.....	328	276	326	1.8	2.6	3.6
Norway.....	15	19	22	0.08	0.18	0.24
Sweden.....	110	64	36	0.58	0.62	0.40
Switzerland.....	226	114	129	1.21	1.08	1.42
Belgium.....	185	7	2	0.99	0.06	0.02
Japan.....	71(a)	166	254	0.38	1.58	2.78
Spain.....	34	26	17	0.18	0.24	0.19
Denmark.....	41	20	17	0.21	0.19	0.19
Argentina.....	Not counted	Not counted	49	—	—	0.54
Other Countries.....	52	89	42	0.27	0.84	0.46
TOTAL.....	18,681	10,483	9,108			

(a) The Japanese chemical literature was not covered completely previous to 1918.

(b) Of these 147 appeared in Canadian publications.

The figures for 1918 in the accompanying table are new. Those for 1913, the last year not affected by the war, and for 1917, have already been published and discussed,¹ but are furnished again for ready comparison. It will be noted that the number of chemical papers published in the United States in

1918 is smaller by a bit less than five hundred than in 1917, but that the per cent of the total is up a little. It is interesting to speculate on the margin by which the United States will maintain its lead.

E. J. CRANE

OHIO STATE UNIVERSITY
COLUMBUS, OHIO
February 4, 1919

BACK TO THE COLLEGES AND UNIVERSITIES

Editor of the Journal of Industrial and Engineering Chemistry:

Your editorial in the February issue of the *Journal of Industrial and Engineering Chemistry* entitled "Back to the Colleges and Universities" agrees so completely with my own views that I appreciate the opportunity to lend emphasis to the good advice you are giving to our young men. Even before the war there was a very serious shortage of highly trained chemists in the United States and now, since the industries and the rapid expansion of research institutes and laboratories have absorbed such men much faster than they have been supplied, the shortage is a source of very grave concern to such as look ahead in considering the welfare of our country in the industries, in educational fields, and in other branches of research. Our young men should understand that there is for the moment an ample supply, indeed an excess, of the half-finished product, the college graduate, with which the country has in large measure contented itself in the past and that what our country needs most emphatically, if it is to stand any chance of competition with European industry and science, is an ample supply of the finished product, the university Ph.D., or the equivalent of the graduate technical school. Broad training and mastery of the resources in research, in organic, inorganic, and physical chemistry, is represented by the graduate degree and this it is that lends its vital value to the degree. What patient would care to lend himself knowingly to treatment by a physician who had completed only half of the highly developed training which is now required for the M.D. degree in order to make the physician of to-day familiar with all the resources of modern medicine? In the same way our research laboratories and industries have realized to their own great advantage the value of the completely trained chemist. For that reason my own advice to able young men returning from service has been to return to their studies to complete their training—for their own good and for the good of the country. Men showing no decided promise in chemistry are advised to drop the science and turn to some field better qualified to bring out the best that is in them.

This advice tallies, I believe, exactly with your own views.

UNIVERSITY OF CHICAGO
CHICAGO, ILLINOIS
February 17, 1919

JULIUS STIEGLITZ

TEACHING FELLOWSHIPS IN CHEMISTRY AT THROOP COLLEGE OF TECHNOLOGY

Upon the recommendation of its Director of Chemical Research, Throop College of Technology has established six Teaching Fellowships in Chemistry carrying an annual stipend of \$750 each, in addition to free tuition.

The primary object of these fellowships is to give to a group of well-qualified men a training in chemical research which will prepare them for the many important positions in scientific and industrial research laboratories and in the development departments of American chemical industries.

The Fellows will devote not more than twelve hours a week to instruction work of a character that will afford them useful experience. The remainder of their time will be available for research and advanced study leading to the higher degrees.

¹ THIS JOURNAL, 10 (1918), 236.

The Fellowships are open to men who have taken thorough undergraduate courses in chemistry and physics (and preferably also courses in mathematics through the calculus), and who have already demonstrated their interest and resourcefulness in scientific work. Applicants should have already received, or should expect to receive before September 1919, a bachelor's degree, or better, a master's degree, from a college or university of recognized standing.

The new chemistry building, which was erected in 1917, provides excellent facilities for instruction and research. A permanent annual income of \$10,000 has been provided for the support of chemical research.

Advanced courses in chemistry, varied somewhat in different years, are offered to the Teaching Fellows and other properly qualified students, in the following subjects: Chemistry of the Rarer Elements, Organic Chemistry (Special Topics), Surface and Colloid Chemistry, Radiochemistry and Photochemistry, Kinetic and Electron Theories. In addition, Fellows coming from other institutions have the opportunity of attending two somewhat unique courses offered to junior and senior students at Throop College, namely, the unusually thorough problem course in Physical Chemistry consisting of 150 classroom exercises, and the laboratory course in Special Analytical Methods which familiarizes the student with a large variety of physico-chemical and other special methods of analysis.

Dr. Arthur A. Noyes, Director of Chemical Research at Throop College, in cooperation with the other professors of the chemistry department, will suggest to the Teaching Fellows a variety of problems for research, and will be in close touch with their research work during the portion of the year which he spends at the college.

In physics and mathematics, work of an advanced character is being organized under the supervision of Dr. Robert A. Millikan, Director of Physical Research at Throop College; Dr. Harry Bateman, Professor of Aeronautical Research and Mathematical Physics; and Dr. James H. Ellis, Assistant Professor of Physicochemical Research.

Applications should be sent to Professor Stuart J. Bates, Throop College of Technology, Pasadena, California, so as to reach him not later than April first of each year.

DENATURED ALCOHOL

FORMULA NO. 30 FOR SPECIAL DENATURATION OF ALCOHOL FOR USE BY CHEMICAL AND PHYSICAL LABORATORIES

Treasury Department
Office of Commissioner of Internal Revenue
Washington

To Collectors of Internal Revenue and Others Concerned:

The following formula, designated as No. 30, in Regulations No. 30, revised, for the special denaturation of alcohol to be used exclusively as a reagent for analytical and testing purposes by chemical and physical laboratories, is hereby authorized:

To each 100 gallons of pure 95 per cent ethyl alcohol add 10 gallons of pure methyl alcohol, which methyl alcohol is to have a specific gravity of not more than 0.810 at 60° F.

Alcohol so denatured shall not be redistilled or purified before use, and is not to be recovered for reuse. The use of specially denatured alcohol, Formula No. 30, will not be permitted until the intended use and method of its use is fully and satisfactorily set forth in the application filed.

Laboratories availing themselves of the privilege here granted must duly qualify, keep records, and otherwise comply with the law and regulations, as in the case of manufacturers using specially denatured alcohol. The form of bond will be 582 or 582-A.

Approved: CARTER GLASS
Secretary of the Treasury
February 20, 1919

DANIEL C. ROPER
Commissioner of Internal Revenue

THE NEXT PHARMACOPOEIA

May 1920, only a little more than a year hence, will again witness the assembling in Washington of the delegates to the United States Pharmacopoeial Convention. This fact should stimulate pre-convention activity on the part of those who have had experience with the present revision and are prepared to suggest improvements for a new edition.

It is desirable at this time that pharmacists, physicians, chemists, botanists, biological experts, or any others who use the U. S. P. IX should submit to the chairman of the Revision Committee, either personally or through associations, such helpful information as their experience may have suggested, or which may have come to their attention.

These suggestions will be compiled systematically and circularized to the present Revision Committee, the authors being credited in each instance with the recommendations, and the compilation will be submitted to the 1920 convention for the benefit of the new Committee of Revision.

The Committee of Revision earnestly urges coöperation in the preparation of this report and requests that suggestions be sent in on a special form, using a *separate sheet for each subject*. As many forms as are desired may be obtained from Charles H. LaWall, Chairman of the Committee of Revision of the United States Pharmacopoeia, 39 S. Tenth St., Philadelphia, Pa.

AMMONIACAL SILVER OXIDE SOLUTIONS

In the course of some recent work in this laboratory, circumstances called for the use of an ammoniacal solution of silver oxide.

Several explosions, one of them being serious, resulted from handling this material.

Silver nitride (Ag_3N) and related explosive compounds are well known, but it is commonly asserted that they are only formed by the prolonged action of ammonium hydroxide on silver oxide in the presence of air. Precautions had been accordingly taken to exclude air and also to use only freshly prepared material, yet it was made painfully evident that this did not prevent silver nitride from being formed, nor is there any obvious theoretical reason why access of air should play any part in its formation.

In the circumstances, a warning as to the properties of ammoniacal silver oxide solutions and the ease with which readily and powerfully detonating compounds are generated in them seems not out of place.

ALFRED TINGLE

ANALYTICAL LABORATORY
DEPT. OF CUSTOMS AND INLAND REVENUE
OTTAWA, CANADA, October 25, 1918

CONCERNING MANUFACTURE OF SULFONIC ACIDS

The Department of Agriculture announces that the Color Laboratory of the Bureau of Chemistry, of this Department, has developed, on a laboratory scale, a new process for the manufacture of certain sulfonic acids. This process, as carried out in the laboratories, appears so promising that it is thought that some manufacturers of chemicals and dyestuffs in this country may be able to supply their demands for these and other valuable compounds by this process, provided the process can be reproduced upon a technical scale so as to obtain results commensurate with the laboratory investigations. The process refers particularly to the sulfonation in the vapor phase of benzene, naphthalene, and other hydrocarbons.

With a view to helping the chemical industry of this country, the Department of Agriculture hereby announces that it is ready to assist manufacturers who wish to produce these compounds. The expenses of the technical installation and of the

labor and materials necessary will of necessity be borne by the firm, individual, or corporation wishing to manufacture the products. The chemists of the Color Laboratory will assist with expert advice, etc. The Department reserves the right to publish all the data obtained from the technical experiments.

This offer of assistance will not be held open by the Department for an indefinite period.

EDWARD HART FELLOWSHIP FUND

Alumni and friends of Lafayette College, Easton, Pa., under the leadership of Mr. George P. Adamson, have raised \$10,000 to be known as the Edward Hart Fellowship Fund. It is proposed to use the income of the Fund in fostering graduate research in the field of viscous and plastic flow. Applications are to be made to Professor Eugene C. Bingham, Easton, Pa., prior to April first of each year.

GRADUATE FELLOWSHIPS IN ORGANIC CHEMISTRY MT. HOLYOKE COLLEGE

Two graduate fellowships in organic chemistry, each to the value of \$600, available for the academic years 1919-20 and 1920-21, respectively, have been granted to Mount Holyoke College by the National Aniline and Chemical Company. They were accepted by the college with the understanding that any investigations undertaken by students who are holding them

should be in the field of dye chemistry. Miss Lucina Robinson, who graduated from Smith College in 1917 and who since then has held a position with the General Chemical Company at their Marcus Hooks works, has been appointed to the fellowship for the year 1919-20.

MANUFACTURE OF METHYLDICHLORARSINE—CORRECTION

In the article of the above title [THIS JOURNAL, 11 (1919), 105], the name of H. H. Clapp should have appeared as co-author with Messrs. Uhlinger and Cook, as Mr. Clapp for several months had complete charge of the manufacture and worked out most of the improvements.

March 5, 1919

R. H. UHLINGER

REPORT OF THE PATENT COMMITTEE TO THE NATIONAL RESEARCH COUNCIL—CORRECTION

Editor of the Journal of Industrial and Engineering Chemistry:

Through a regrettable clerical error the name of Mr. Prindle, one of the most active members of the Patent Committee of the National Research Council, was omitted among the signers of the report.

May I request you to correct the omission in your next number?

New York City

March 5, 1919

L. H. BAEKELAND, *Chairman*

WASHINGTON LETTER

By PAUL WOOTON, Union Trust Building, Washington, D. C.

The bills of particular interest to chemists caught in the legislative jam, when the 65th Congress passed out of existence on March 4, 1919, were the general leasing bill, the water power bill, and the potash bill. Many of the other bills which failed affected to a greater or less extent certain purchases of and payments for chemical materials. These were the general deficiency bill, the Army appropriation bill, Navy appropriation bill, agricultural appropriation bill, and the sundry civil bill.

While many comparatively more important bills were failing, the validation of informal contracts bill passed and was promptly signed by the President. Section 5 of that bill carried relief for the producers of war minerals. The section, as printed in this correspondence last month, was from a conference report which afterwards had to be changed, due to pressure from the House of Representatives. On that side of the Capitol there was great opposition to any measure which would place the entire \$50,000,000 of the War Minerals Act at the disposal of the Secretary of the Interior to settle claims. There was also the feeling that the long list of war minerals in the original act should not be included in the relief bill. This led to the modification of Section 5, so as to limit the amount which could be expended for relief to \$8,500,000, and the minerals to be considered to manganese, chrome, pyrites, and tungsten.

Immediately following the signing of the bill, former Senator J. F. Shafroth, of Colorado, was appointed by the Secretary of the Interior to head the War Minerals Relief Mission. Philip M. Moore, of St. Louis, and former Representative M. D. Foster, of Illinois, were appointed to serve with him. The commission will have charge of the payment of the losses incurred in an effort to supply war minerals at the behest of the Government.

Every effort is being made to prevent the filing of claims which are without merit. For this purpose, an extensive questionnaire has been prepared. The thirty-two questions asked therein must be replied to and an affidavit made that the replies are correct. These questions are so pertinent that it will be evident to any one, who is uncertain as to the status of his loss, whether his claim falls within the category prescribed by the law.

The commission is under the direction of Director Manning, of the Bureau of Mines, and has its offices in those of that Bureau.

The high hopes which have been entertained by the American producers of potash were dashed to pieces when the bill provid-

ing for the restriction of potash imports for two years met with objection and was not further considered. Senator Walsh, of Montana, in objecting to the bill, did so on the ground that there was too little time left before the end of the session to give the bill the consideration which, in his opinion, so far-reaching a measure should have.

The potash industry made a splendid showing at the hearings conducted by the Senate Committee on Mines and Mining. The producers went into detail showing the remarkable accomplishments since the German supply was cut off. The industry has reached a point, they declare, where they can see their way clear in a very short time to compete with the imported product. Had the war lasted two years more, it is said, or if Congress would restrict imports for two years, America would have another great industry. The bill will be brought forward again on the reconvening of Congress.

Failing to get the bill through, Senator Henderson, the chairman of the Committee on Mines and Mining, succeeded in securing the signatures of thirty-five senators to a request addressed to the War Trade Board asking that its powers be used to keep out foreign potash. This the War Trade Board declines to do on the ground that it was not intended that the powers be used in giving protection to any industry when no matter of war necessity exists.

Caustic soda to the extent of 97,376,334 pounds was exported from the United States during 1918, according to the figures of the Bureau of Foreign and Domestic Commerce. The largest exports went to Japan. While caustic soda was sent to nearly every country in the world, the principal markets in the order of their importance were as follows: Brazil, Canada, Cuba, Argentina, Philippines, Mexico, Italy, France, and Australia.

During 1918, the United States exported 21,754,728 pounds of glycerin. Italy was by far the heaviest purchaser, taking more than half of the total exports. The extent of our trade in glycerin is shown by the fact that exports were made to fifty-three separate countries. Exports to England were in second place, amounting to 6,575,725 pounds. Other countries which received important shipments were Canada, Chile, Japan, Philippines, British South Africa, Scotland, Mexico, Cuba, China, and Venezuela.

A controversy is in progress between the Secretary of the Navy and Van H. Manning, of the Bureau of Mines, as a result

of the following statement issued by the Navy Department:

During the experimental period of the work on helium gas, the Bureau of Mines, assuming that the plants designed by the organization would be in successful operation, advised that the experimental work on the two commercial plants should be stopped.

The War and Navy Departments, and particularly the naval bureau of steam engineering which was concerned with the production of helium, insisted, on the contrary, upon a continuation of the experimentation at these plants. Their judgment was vindicated within a few weeks when it was shown that helium could be produced in quantity at a reasonable price at both these plants.

Mr. Manning immediately took vigorous issue with the statement and indicated that the Navy now is attempting to secure the credit for the work done by the Bureau of Mines on helium.

Publication of the statement that no American gas shells were fired at the enemy, brought forth from General Sibert the following interesting and complete statement on the handling of American-made gas:

1—In June 1918, the following shipment of gases in bulk was made to the American forces in France to be exchanged for gas shell:

	Tons
Mustard gas.....	15
Chlorpicrin.....	705
Phosgene.....	48

2—Further shipment in bulk overseas was stopped pursuant to a telegram from France dated July 21, 1918, the reason for this being that France had no more extra gas shells to be filled with American gas.

3—There not being gas shells available with suitable boosters and adapters, the gas plants were not operated to capacity. However, sales of some excess gas were made both to England and to France. England was sold 900 tons of chlorpicrin and 368 tons of phosgene. France was sold 300 tons of chlorpicrin and 1408 tons of chlorine, equivalent to 1126 tons of phosgene. Phosgene is 80 per cent chlorine, and France furnished phosgene shell in exchange for this chlorine.

4—In addition to the above, 200 tons of mustard gas were shipped to England for loading shell originally made for Russia. These shell were never loaded, and the gas, or at least a large part of it, was utilized by the English in loading shell.

5—There were, therefore, shipped to Europe 3662 tons of gas, or its equivalent, which gas was largely loaded into shell and used by the United States troops, or those of our Allies, against the enemy.

6—3662 tons of gas would have loaded about 1,600,000 shell, two-thirds of them being 75 mm. and one-third 155 mm., a number which is

thought to be at least equal to the total number of gas shell fired by the American troops in action in France, showing that while American gas was not actually fired in American shell in the war, it was fired against the enemy and that America furnished at least as much as she used.

7—In addition to this, 18,600 Livens drums loaded with phosgene were shipped to France. These contained 279 tons of gas, and some of them at least were fired at the enemy.

8—As soon as shell were available they were loaded with gas and 25,000 shell, 75 mm. caliber, were shipped to France on August 7, 1918. On August 9, another shipment of 50,000 shell of the same caliber was made, after which time shipments were made as fast as shell and boosters were available.

9—The first shipment of shell would have reached France by September 1. They were un assembled. All component parts, however, were shipped.

10—The Ordnance Department decided in June to assemble gas shell in France. The time lost in such assembly is the only reason for these shell and others not reaching the front before the armistice.

In a display of the work of the Division of Classification of Personnel of the War Department one of the placards read as follows:

But 181 chemists and chemical workers occur per 100,000 drafted men. 2916 chemists have been classified and reported by name to the Chemical Warfare Service since May 1918.

Each man's record was investigated and if found satisfactory assignments were made to experimental stations, gas shell plants, ordnance work, gas mask factories, etc.

Fifty-five varieties of chemists are included in the classification of chemists and chemical workers.

Because a complaint and investigation by the Federal Trade Commission into alleged unfair practices of the North American Linseed Products Company brought about forfeiture of the concern's charter to the State of West Virginia, the Commission to-day decided to take no further action, dismissing its case without prejudice.

At the same time, the Commission dismissed a complaint against the United Drug Company, it having appeared that questioned methods of competition employed by the Liggett Company, controlled by the United Drug Company, did not affect the business of competitors. The Commission found that the Liggett concern was not selling goods below cost in its "One Cent Sales." Dismissal was made "without prejudice as to any future cases of a similar character."

INDUSTRIAL NOTES

The following statement is authorized by Mr. Benedict Crowell, Assistant Secretary of War: The United States nitrate plants were built with the greatest urgency to meet imperative military necessities. These immediate military demands were extinguished by the signing of the armistice. The problem now is to endow these plants with the maximum peace-time value, while maintaining and enhancing their war efficiency. This involves new questions in the technique of fertilization, and requires not only constructive but creative work. Following a careful study of the situation, it has been decided to establish forthwith a civilian organization, under the interdepartmental control of the Secretaries of War, Navy, Interior, and Agriculture, to be known as the United States Fixed-Nitrogen Administration, and charged with all of the Government's fixed-nitrogen interests. In due course the nitrate plants and other interests now administered by the Nitrate Division of the Ordnance Department of the Army will be turned over to this new fixed-nitrogen administration. Mr. Arthur Graham Glasgow has been requested to act as first administrator and to be responsible for creating the new organization.

Plans have been adopted by the Island Oil and Transportation Corporation for the construction of a large "topping" plant at Tampico, Mexico, for the extraction of gasoline from the crude product of its wells. The proposed refinery will have a daily capacity of 20,000 bbls. of crude oil.

The American Sanitary Products Company has been incorporated in St. Louis to manufacture and sell chemical sanitary products, with a capital stock of \$25,000. The incorporators are Euphrasia W. Schramm, William C. Schramm, and Henry Wrape.

The American Oil and Refining Co., Dover, Del., has been incorporated with a capital of \$1,000,000, to acquire oil and mineral lands and develop the same.

Between thirty and forty naval stores producers of the South met in New Orleans, February 26, and formally adopted the plan of the organization committee of the producers' association for the formation of the Naval Stores Producers' Export Company. The organization is to be incorporated in Wilmington, Del., with a capital stock of \$3,000,000, divided into 30,000 shares. The meeting was held under the auspices of the Turpentine and Rosin Producers' Association of New Orleans, and was presided over by Carl F. Speh, secretary-manager of the local organization. The proposed company will engage first in rosin export, later possibly engaging also in the turpentine trade. Previous to the war an average of 1,350,000 bbls. of rosin was exported annually for 10 years by the producers acting individually. During the war this average dropped to about 800,000. The producers now propose to combine under the provisions of the Webb-Pomerene act to rebuild and expand their foreign trade by standardization of service and quality.

Interests of enemy aliens in two important drug and pharmaceutical manufacturing companies were sold recently to American citizens by A. Mitchell Palmer, alien property custodian, through his director of sales, Joseph F. Guefy, of 110 West 42nd Street, New York City. These were the Bauer Chemical Company, of 30 Irving Place, New York City, and F. Ad Richter & Co., of 74 Washington Street, New York City.

As a result of a conference held by representatives of the sodium nitrate importers and members of the Sales Office of the War Department, an agreement has been reached whereby Government surplus stocks of sodium nitrate will be disposed of by the same people from whom it was purchased on the basis of market price less actual expense incurred in making sales.

The First National Oil Co., Wilmington, Del., has been incorporated with a capital of \$2,500,000, to acquire oil and natural gas properties and dispose of products from same.

LIST OF APPLICATIONS MADE TO THE FEDERAL TRADE COMMISSION FOR LICENSES UNDER ENEMY-CONTROLLED PATENTS PURSUANT TO THE "TRADING-WITH-THE-ENEMY ACT"

YEAR	PAT. NO.	PATENTEE	ASSIGNEE	PATENT	APPLICANT
1904	757,136	Martin Moest, Höchst-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Oxidizing organic compounds	E. I. du Pont de Nemours & Co., Wilmington, Del.
1905	780,404	Max Bazlen and Hans Labhardt, Ludwigshafen-on-the-Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Process of oxidizing methyl groups in aromatic hydrocarbons	E. I. du Pont de Nemours & Co., Wilmington, Del.
1905	805,890	Otto Schost, Höchst-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Diamidoformyl diphenylamine and process of making same	E. I. du Pont de Nemours & Co., Wilmington, Del.
1912	1,022,019	Hans Bucherer, Biebrich, Germany	Kalle & Company, Aktiengesellschaft, Biebrich, Germany	Amino-oxy-naphthalene sulfonic acid and process of making same	E. I. du Pont de Nemours & Co., Wilmington, Del.
1912	1,023,758	Friedrich Raschig and Max Kohnert, Ludwigshafen-on-the-Rhine, Germany	Friedrich Raschig, Ludwigshafen-on-the-Rhine, Germany	Process for the manufacture of chlorinated phenol esters and of oxybenzyl alcohols, oxybenzaldehydes, and oxybenzoic acids	E. I. du Pont de Nemours & Co., Wilmington, Del.
1914	1,101,111	Arthur Zitscher, Offenbach-on-the-Main, Germany	Chemische Fabrik Griesheim-Elektron, Frankfurt-on-the-Main, Germany	Process of making the arylamides of 2,3-oxy-naphthoic acid	E. I. du Pont de Nemours & Co., Wilmington, Del.
1915	1,128,369	Albrecht Schmidt, Gustav Kronlein, and Ernst Runne, of Höchst-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Carbazol sulfonic acids and process of making same	E. I. du Pont de Nemours & Co., Wilmington, Del.
1915	1,128,370	Albrecht Schmidt and Gustav Kronlein, of Höchst-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Indophenolsulfonic acids and process of making	E. I. du Pont de Nemours & Co., Wilmington, Del.
1916	1,193,566	Felix Kunert, Offenbach-on-the-Main, Germany	Chemische Fabrik Griesheim-Elektron, Frankfurt-on-the-Main, Germany	Compounds for use in the production of dyestuffs	E. I. du Pont de Nemours & Co., Wilmington, Del.
1916	1,207,802	Otto Schmidt, Ludwigshafen-on-the-Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Producing aromatic amines and catalysts therefor	E. I. du Pont de Nemours & Co., Wilmington, Del.
1917	1,220,248	Arthur Luttringhaus, Mannheim, and Wilhelm Koch, Ludwigshafen-on-the-Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Process of producing ketonic compounds	E. I. du Pont de Nemours & Co., Wilmington, Del.
1917	1,237,828	Otto Schmidt, Ludwigshafen-on-the-Rhine, and Hugo Blankenhorn, Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Effecting catalytic hydrogenizations	E. I. du Pont de Nemours & Co., Wilmington, Del.
1903	746,784	Réné Bohn, Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Process of dyeing textile fiber blue	E. I. du Pont de Nemours & Co., Wilmington, Del.
1904	772,237	Paul Jeammaire, Muhlhausen, and René Bohn, Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Printing with indanthrene	E. I. du Pont de Nemours & Co., Wilmington, Del.
1907	840,419	Oscar Bally, Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Process for dyeing textile fiber violet blue	E. I. du Pont de Nemours & Co., Wilmington, Del.
1908	893,384	Arthur Schlegel, Ludwigshafen-on-the-Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Dyeing	E. I. du Pont de Nemours & Co., Wilmington, Del.
1912	1,042,356	August Leopold Laska, Arthur Zitscher, and Felix Kunert, Offenbach-on-the-Main, Germany	Chemische Fabrik Griesheim-Elektron, Frankfurt-on-the-Main, Germany	Disazo dyes and process of making them	E. I. du Pont de Nemours & Co., Wilmington, Del.
1914	1,097,406	Arnold Erlenbach, Dessau, Germany	Actien Gesellschaft für Anilin Fabrikation, Berlin, Germany	Process of destroying insects	E. I. du Pont de Nemours & Co., Wilmington, Del.
1914	1,121,295	Arthur Schlegel, Mannheim, Germany, and Karl Pfister, Philadelphia, Pa.	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Process for producing stable dyes	E. I. du Pont de Nemours & Co., Wilmington, Del.
1915	1,127,027	Felix Kunert and Edwin Acker, Offenbach-on-the-Main, Germany	Chemische Fabrik Griesheim-Elektron, Frankfurt-on-the-Main, Germany	Process of producing dyestuffs on the fiber by means of the one-bath method	E. I. du Pont de Nemours & Co., Wilmington, Del.
1915	1,145,072	August Leopold Laska and Arthur Zitscher, Offenbach-on-the-Main, Germany	Chemische Fabrik Griesheim-Elektron, Frankfurt-on-the-Main, Germany	Azo dyestuffs insoluble in water and process of making them	E. I. du Pont de Nemours & Co., Wilmington, Del.
1916	1,185,943	Arthur Schlegel, Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Process of dyeing yarn	E. I. du Pont de Nemours & Co., Wilmington, Del.
1916	1,197,633	Erwin Hoffa, Höchst-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Process of producing yellow insoluble azo dyes on the fiber	E. I. du Pont de Nemours & Co., Wilmington, Del.
1917	1,232,620	Edmund Stiansy, Headingley, Leeds, England	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Tanning	E. I. du Pont de Nemours & Co., Wilmington, Del.
1904	770,177	Paul Julius Hans Reindel and Fritz Carl Gunther, Ludwigshafen-on-the-Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Azo dye and process of making same	E. I. du Pont de Nemours & Co., Wilmington, Del.
1905	807,422	Karl Etbel, Biebrich, Germany	Kalle and Company, Aktiengesellschaft, Biebrich, Germany	Zinc azonaphthol dye and process of making same	E. I. du Pont de Nemours & Co., Wilmington, Del.
1907	849,690	August Leopold Laska, Offenbach-on-the-Main, Germany	Chemische Fabrik Griesheim-Elektron, Frankfurt-on-the-Main, Germany	Yellow wool-dye	E. I. du Pont de Nemours & Co., Wilmington, Del.
1907	849,739	August Leopold Laska, Offenbach-on-the-Main, Germany	Chemische Fabrik Griesheim-Elektron, Frankfurt-on-the-Main, Germany	Yellow monazo dye and process of making same	E. I. du Pont de Nemours & Co., Wilmington, Del.
1907	860,575	Conrad Schraube and Erhart Schuler, Ludwigshafen-on-the-Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Azo dye	E. I. du Pont de Nemours & Co., Wilmington, Del.
1911	986,287	Wilhelm Herzberg and Oswald Scharfenberg, Schöneberg, Berlin, Germany	Actien Gesellschaft für Anilin Fabrikation, Berlin, Germany	Monazo dye for wool	E. I. du Pont de Nemours & Co., Wilmington, Del.
1912	1,024,308	Hans Bucherer, Biebrich, Germany	Kalle and Company, Aktiengesellschaft, Biebrich, Germany	Manufacture of azo coloring-matters containing a carbazoli derivative	E. I. du Pont de Nemours & Co., Wilmington, Del.

The Color Company of America, Inc., has been incorporated with a capital of \$10,000, to make colors, dyestuffs, and chemicals. The incorporators are W. C. Calmowitz, T. Williams, W. Bradley, 14 Cedar Street, New York.

The Sneed Chemical Laboratories have filed incorporation papers under the laws of Delaware, with a capital of \$150,000. The incorporators are W. F. O'Keefe, George Steigler, J. H. Dowdell, of Wilmington.

The Secretary of the Interior is authorized to lease phosphate lands, of which there are large areas in Florida, Montana, Wyoming, Idaho, and Utah, in areas not to exceed 2,560 acres of land and royalties of not less than 2 per cent of the gross value of the output. These leases are subject to a readjustment of terms and conditions at the end of each 20 years. Claimants are also allowed to acquire a mill site of 40 acres. The law limits to one the number of phosphate leases which may be taken and held, and like the oil bill, forbids interlocking stockholders in excess of the maximum area allowed by law.

The Home Oil Refining Company, which has just been incorporated with a capital stock of \$5,000,000, has taken over the properties of the Home Oil Refining Co., of Yale, Okla.; the O. K. Refining Co., of Niotaze, Kan.; and the W. P. Mason Refining Co., of Fort Worth. It is announced that the company will move the refinery of the O. K. Refining Co., at Niotaze, Kan., to Fort Worth and enlarge its capacity to 5,000 bbls. a day. The acquired holdings also embrace more than 400 tank cars and other equipment. The new company has extensive oil lease holdings in the Central West Texas fields which it plans to develop.

The American Nitro-Phospho Corporation, New York, has been incorporated with a capital of \$50,000, to deal in fertilizer and seeds. Incorporators are J. B. Goldsborough, J. Breuchaud, F. L. Pruyn, 290 Broadway, New York City.

A test of the garbage reduction process employed by the American Food Producing Company, of Los Angeles, will be made at the plant of the Independent Packing Company at St. Louis to demonstrate to municipal officials the process by which the company proposes to dispose of St. Louis garbage collections.

Natal, South Africa, is becoming important in the production of sulfate of ammonia. A monthly production of 250 tons is reported and it is expected that this will be increased to 350 tons by the end of the current year.

According to a chart of importation by quantity recently issued by the United States Department of Commerce, the importation of soy bean oil for 1918 was twenty times that of 1914. The import of copra was nine times that of 1914.

The Western Cotton Oil Co., Haskell, Texas, has been incorporated with a capital stock of \$800,000, by J. C. Duke, D. C. Cogdell, and J. H. Chancellor.

Knowledge of colloidal chemistry continues to lead to important commercial results. The use of colloidal graphite in oil as a lubricant is said to increase the life of aero motors using such lubrication by 200 to 300 per cent. Colloidal coal has been suspended in fuel oil with excellent results and marked advance may be expected in that direction. An entirely novel development is the perfection of a colloidal enamel or baking japan in water, no solvent being used. The article to be coated is first heated, and may then be sprayed, brushed, or dipped, after which it is heated in an electric oven. Small pieces may be baked in the dipping basket without the work sticking since there is no solvent, and there is no tendency for the enamel to run on the work while being heated. The elimination of solvent is not only a saving but primarily a large factor of safety.

The annual report of E. I. du Pont de Nemours & Company, sent to stockholders recently, states that the closing of munitions plants will not jeopardize dividends or the strong financial position of the company. War contracts amounting to \$260,000,000 have been cancelled, and the working force has been cut from 85,838 to 28,000. The company is now pushing the development of its commercial business.

Announcement is made of the organization of the American Pine Pitch Export Company, with a paid up capital of \$1,000,000, having offices in New Orleans. The company will establish its own agencies in the principal countries of Europe, South America, and Africa, and will operate under the provisions of the Webb-Pomeroy law. Eleven companies are included in the organization, representing an annual output of 1,000,000,000 ft. of yellow pine lumber. Officers are W. H. Sullivan, of the Great Southern Lumber Co., Bogalusa, La., president; Charles Green, Laurel, Miss., vice president; W. J. Sowers, New Orleans, secretary.

The Bureau of Mines announces that a strictly American process for producing high-grade caustic potash from American raw materials has been developed in the Burgess Laboratories at Madison, Wisconsin. The raw materials employed are alunite and crude caustic from wood ashes.

The Texas Sulfur Co., Inc., expects to begin soon the erection of a sulfuric acid and fertilizer plant at El Paso, Tex., where about 50 acres of ground have been purchased for a site. The headquarters of the company are at Orange, Tex. A. C. Fleig is president; A. C. McFarlane, vice president; T. M. Dodd, treasurer; H. M. Tippet, secretary. Capital stock is \$500,000. Mr. Fleig will take charge of the construction of the plant.

Former Senator J. F. Shafroth, of Colorado, Philip M. Moore, St. Louis, Mo., and former Representative M. D. Foster, of Illinois, have been appointed by Secretary of the Interior Lane as members of the commission that will have charge of the payment of the losses incurred by mining men in the production of manganese, chrome, pyrites, and tungsten for war purposes. During the war the Interior Department, the Emergency Fleet Corporation, and the War Industries, War Trade, and Shipping Boards insistently urged the mining men to produce these materials to supply the urgent needs of the nation for war purposes. When the armistice came, these mineral producers, as a result of their response to the demands of the Government, had on hand ready for delivery quantities of these materials, for which there was no peace-time market. Congress set aside the sum of \$8,500,000 to meet claims for these losses, which must be filed within three months after the passage of the act. The law states that the claims must have been incurred between April 6, 1917, when the United States went to war, and November 11, 1918, when the armistice was signed. The Secretary of the Interior is charged in the act with taking into consideration and charging to the claimant the market value of the minerals on hand November 12, 1918, and also the salvage or usable value of the machinery that was installed to produce these war minerals.

The Bureau of Mines announces that it is making a preliminary investigation of gas masks with a view to establishing a list of approved devices for use in the mining and allied industries. After the preliminary investigation the Bureau will issue a schedule of tests which apparatus must meet in order to gain the approval of the Bureau of Mines. These investigations will be conducted at the Bureau's Pittsburgh Station by men who have had intimate connection with the development of mine rescue apparatus and gas masks used in warfare.

The O. J. Weeks Company, manufacturing chemists, have leased for a number of years the factory at the corner of Williamson and Grove Streets, Elizabeth, N. J., known as the Ratcliff Chemical Works.

Chemical Exchange of the United States, Inc., Manhattan, making oils, colors, drugs, and chemicals, has been incorporated with a capital of \$50,000, by H. Finkleman, S. Hechtkopf, A. Goldbach, 112 East 81st St., New York City.

The important position of Argentina in the linseed trade was emphasized when the war limited the sources of linseed and increased the demand for linseed oil. Enormous quantities of linseed were required to produce the oil for ship paint, camouflage material, and rainproof equipment. A large part of these needs was met by the crops of the United States and Canada, but a still greater share was supplied from Argentine fields, where the linseed area exceeds that of any other country. The average Argentine linseed (or flax) area of 3,000,000 acres is approached only by that of British India; the United States follows with about 2,000,000 acres, and Canada with 1,000,000 acres, while Uruguay, Japan, and several countries in Europe each cultivate normally from 50,000 to 100,000 acres of flax. In most of the European flax-growing regions the crop is raised for its fiber, while in North and South America, as in India, the seed is the product chiefly desired.

The French government the past year, following the custom of the Allies, has endeavored to create a national chemical industry to meet the monopoly which Germany has controlled throughout the world, and to free the French textile and other trades from a particularly onerous dependency. Before the war France imported from Germany every year 61,000,000 francs' worth of chemical products, consisting largely of artificial dyestuffs, and, moreover, Germany maintained in France seven subsidized laboratories directed by German chemists, so that German products might escape import duties and cost of transportation, and under guise of French firms could take part in bids for government contracts. Products of these seven firms were consumed by four-fifths of the French consumers of chemicals and dyestuffs.

The Federal Trade Commission has ceased the practice of granting licenses for the working of enemy-owned patents. All these patents, and among them many valuable dye patents, have been turned over to the Alien Property Custodian, who now holds them in trust. It is understood that the Alien Property Custodian intends to sell these patents outright in the same manner in which he is dealing with the rest of the alien enemy property placed in his hands.

The Schaefer Alkaloid Works, the Standard Essence Company, and the Thorium Chemical Company have been merged and the consolidation will continue the business of these firms under the name of Maywood Chemical Works, Maywood, N. J.

The Atlantic Chemical Co., Newark, N. J., with a capital of \$1,000,000, has filed a certificate of incorporation with the Secretary of State at Trenton, N. J. The incorporators are L. L. Terhune, W. W. Ames and J. W. Fulkner.

The American Cotton Oil Company has recently established a large research department. This chemical department has its headquarters at the Chicago factory of the N. K. Fairbank Company and is to conduct research work, both pure and applied, for the American Cotton Oil Company, the N. K. Fairbank Company, and the Union Seed and Fertilizer Company. The personnel of this department includes: *Director*, Dr. V. H. Gottschalk; *Senior Chemists* (in charge of divisions), J. C. Ingram, H. C. Holden, and Dr. M. L. Dolt; *Junior Chemists*, K. R. Beach, J. G. Hawthorne, R. S. Bracewell, H. T. White, H. D. Rasmuson, G. R. Jenkins, Miss E. A. Jones, Miss Eloise Parsons, Miss Marietta Eichelberger, W. D. Edwards, Wm. Kahlbaum, and L. W. Babcock.

The Redmanol Chemical Products Company has placed a fellowship at the Mellon Institute of Industrial Research, Pittsburgh, Pa. The fellowship will be in the hands of a senior and junior chemist and will be of three years' duration.

The prospects of a good supply of oil fuel for Egypt are very promising. At the beginning of the war the Anglo-Egyptian Oil-Fields was the only one of the various companies formed to search for oil in Egypt that remained in operation, and down to 1914 the only finds of importance had been at Gensah, where none of the gushers that had been struck had given anything like a permanent yield. But the new field discovered in 1914 at Hurgada has been proved to be of singularly regular formation, and its yield has steadily increased, until, according to recent reports, it now stands at over 15,000 tons of crude oil a month. Meanwhile the Suez refinery has been enlarged, and there is every reason to hope that as much oil will shortly be available for internal consumption as can be dealt with by the company's existing facilities. It is stated that, in consequence, most of the public utility companies in Egypt have now converted their plants to burn petroleum residue.

At the organization meeting of directors of the Air Reduction Company, Inc., New York, N. Y., held on February 19, 1919, the following officers were elected: President, A. S. Blagden; vice-president, A. R. Ludlow; treasurer, C. E. Adams; secretary, M. W. Randall; assistant treasurer, C. L. Snow; assistant secretary, C. C. Emerson.

PERSONAL NOTES

Dr. John Johnston, secretary of the National Research Council, has been appointed professor of chemistry in Yale University.

Mr. C. H. MacDowell, director of the Chemicals Division of the War Industries Board during the war, and previously president of the Armour Fertilizer Company, and Mr. Donald Riley, formerly Lieutenant Commander in the Navy, and in charge of procurement of chemicals and explosives for the Navy during the war, are in Paris acting in an advisory capacity to the American Peace Commission. Mr. MacDowell stated that the work would be on problems of reconstruction, particularly from the raw material side, in the dyes, ferro-alloys, potash, and agricultural chemical industries.

Charles F. Roth, recently discharged from the Chemical Warfare Service, addressed the Southern California Section of the A. C. S. on March 13, on "The Responsibility of the Chemist; and Some Words upon the Coming Chemical Exposition."

Mr. G. S. Meikle, formerly an engineer in the research laboratory of the General Electric Company, and more recently in the Development Division of the Chemical Warfare Service, is now with the G. S. Meikle Co., New York City.

Mr. Arthur W. Elkins, chemical engineer with the General Chemical Co., died on March 1, 1919, at East Orange, N. J.

The Advisory Council for Scientific and Industrial Research of Canada has awarded three fellowships and five studentships this year for investigations in some department of science bearing on industrial processes. W. F. Seyer will continue researches carried on last year in connection with the utilization of the tar sands of Alberta. D. W. Hatcher will pursue investigations at McGill University in connection with the production of hydrogen peroxide and its solutions. O. J. Walker, a graduate of Saskatchewan University, will undertake research work in connection with the vulcanization of rubber. Donald G. McGregor, graduate of Dalhousie College, will study the separation of the products of the distillation of coal in the manufacture of gas. Harold A. Braendie will investigate the elasticity of non-isotropic samples of crude rubber. Eleanor Shanley, a graduate of McGill, has undertaken research on the bacteriology of canned fish.

A captain in the Norwegian navy, Mr. Bull, has invented a new bronze alloy, the so-called M. bronze, which is particularly adapted for bearings, armaments, and machinery parts where a comparatively high hardness is required, and for welding and rolling. In order to satisfy different requirements the bronze is worked out in three qualities: hard (M. H.), medium hard (M. M.), and soft (M. B.). For use where an especially good quality is demanded and for ships' use there can also be produced a finer quality, like mangan bronze. As there have lately been great difficulties in procuring certain expensive metals for the making of common bronze alloys, the Norwegian Department for Industrial Supplies has asked the consumers of such alloys to adopt the new bronze as soon as possible. Several of the government works have used this bronze for a considerable period with good results. As the price is much lower than that of the regular bronze, the new material offers considerable economic advantage.

A company to manufacture dyestuffs has been formed in Sweden with a fully paid up capital of \$3,216,000. The new works will have the services of Birger Rosenquist, who was formerly a representative in Boston of a large German dyestuffs establishment.

The International Nitrogen Company, capital \$4,000,000, has been organized in Cleveland, Ohio. The officers are: President, B. F. Bourne, of the Bourne-Fuller Company; vice president, F. H. Chapin; treasurer, S. C. Ernst. The first factory will be built at Rochester, N. Y.

The New Brunswick Chemical Company plant, which has been in the hands of the Alien Property Custodian since the declaration of war between this country and Germany, has been sold for \$22,650 to Hugo Boblenzer, president and treasurer of the company. The latter owned 755 shares of the concern valued at \$30 a share.

The Norwegian canned goods exporters have been suffering considerably during the war for want of tinplate for cans. There has now been started a mill for rolling tinplate. The production for a start is calculated for 18,000 tons of tinplate per year, but it can be increased to three times this quantity. The imports of tinplate to Norway were 32,000 tons in 1912, 41,000 tons in 1915, and 29,000 tons in 1916.

Major George L. Norris, engaged in aircraft production, has received his honorable discharge from the Army and has returned to his former position as metallurgical engineer with the American Vanadium Co., Pittsburgh. Major Norris was district manager of production, Pittsburgh office, until November 1, when he was transferred to Washington and assigned to duty as chief metallurgist, raw materials department, Bureau of Aircraft Production.

Mr. Edward S. Rothrock, 1st Lieutenant in the 21st Infantry, Camp Kearney, Cal., has recently been appointed chemist for the Ashland Iron & Mining Co., Ashland, Ky.

Mr. C. B. Wiltrout, industrial and technical chemist, is with the Eureka Centrale Sugar Co., Mayaguez, P. R., as superintendent of fabrication for the cane crop of 1919.

Mr. Wm. H. Ross, having received his discharge from the Chemical Warfare Service, has returned to his former position in the Bureau of Soils.

Mr. Raymond E. Kirk has returned to his work as instructor in general and analytical chemistry at Iowa State College, Ames, Ia., after having had leave of absence for the duration of the war to engage in the inspection of powder and explosives for the Ordnance Department, U. S. A.

Arthur D. Little, Inc., announces the following additions to its technical staff: Mr. Robert Woods VanKirk, M. I. T. 1918, chemical engineer; recently engaged in the Development Division of the C. W. S., stationed at Cleveland, Ohio. Mr. John Stevens, M. I. T. 1918, chemical engineering administration; recently served as a private in the Research Division of the C. W. S., engaged upon gas defense work, stationed first at Washington and later in the Little Laboratories. Lt. Earl Place Stevenson, B. S.; Wesleyan College, Middletown, Conn., 1916, instructor in organic chemistry at M. I. T. 1917 and 1918; recently engaged in the Research Division, C. W. S., Washington and Boston. Mr. Eric R. Jette, B. S.; Franklin and Marshall, Lancaster, Pa., 1918, engaged as a civilian in the Pyrotechnic Section of the Research Division, C. W. S., Washington. In addition, the following members of the staff who had left the company's employ for governmental activities have returned to the staff: Mr. Harrison E. Howe, consulting chemist, Ordnance Department, assigned to the Nitrate Division, Army Ordnance, for the purpose of correlating the research being conducted in various laboratories on the fixation of atmospheric nitrogen, which division appointment is still held. As noted in our February issue, Mr. Howe has also been commissioned Major, Ordnance Section, Officers Reserve Corps. Lt. Roy C. Charron, who was first chemist for the division gas officer at Camp Devens, Mass., and later assistant to chief of the emergency laboratory section, Pyrotechnic Division, C. W. S., American University, Washington, D. C. Mr. J. M. Cullen, who was in the U. S. Navy.

Mr. W. J. Winninghoff has returned to his former position with the Cooper Hewitt Electric Company, having been on a temporary leave of absence to do work in the Chemical Warfare Service at Clark University.

Mr. M. G. Spencer, formerly connected with the Midvale Steel Co., and later with the Watertown Arsenal, in the capacity of chief chemist, has joined the staff of the Electric Steel Company of Indiana, Indianapolis, Ind., in charge of metallurgical operation.

Mr. W. H. Aldridge of 14 Wall Street, New York City, has recently accepted the presidency of the Texas Gulf Sulfur Company, now developing a large sulfur deposit at Matagorda, Texas.

Professor William J. Hale, of the department of chemistry of the University of Michigan, has resigned his position there and has accepted a position with the Dow Chemical Company, at Midland, Mich., in which he will devote his entire time to research work.

Dr. Hugh S. Taylor has returned to Princeton University to take up his duties again after service with the British Government in the Munitions Invention Department, where he has been engaged on problems connected with the preparation and purification of hydrogen.

Mr. H. M. Heefner has resigned his position on the chemical staff of the Ault and Wiborg Co., Cincinnati, Ohio, and has accepted a position with the du Pont Company at their Harrison Works, Philadelphia.

Mr. C. H. Stone, formerly manager of the Lansing Fuel and Gas Company, is now in the employ of the Rochester Railway and Light Company, making some special investigations for the vice president, R. M. Searle.

Mr. Everett E. Porter who has been in the chemical service of the Government and located with the Bartlett, Hayward Company, Baltimore, Md., is now research chemist for the Ashland Iron & Mining Co., Ashland, Ky.

Mr. Benjamin B. Schneider, who was formerly a member of the firm of Schneider and Wolfe, engaged in the practice of patent law, and who was prior to that an examiner in the U. S. Patent Office and an assistant chemist in the Department of Agriculture, is now connected with the legal firm of Dyrenforth, Lee, Chritton & Wiles, to continue in patent practice.

Capt. R. L. Kramer, C. W. S., who has been Officer-in-Charge of the men in uniform at the War Laboratory, Johns Hopkins University, has been released from service and has entered as a graduate student in chemistry at Johns Hopkins.

Capt. R. R. Renshaw, C. W. S., who has been directing a corps of research men in the Johns Hopkins University War Laboratory, will remain at the university for special research work in organic chemistry. Capt. Renshaw is professor of chemistry at Iowa State Agricultural College on leave of absence.

Mr. Ernest A. Stoppel, recently employed as aeronautical chemist at the general laboratories of the Bureau of Aircraft Production, Pittsburgh, has accepted a position as assistant chemist with Valentine & Company, varnish makers, of New York City.

Lt. Lloyd Van Doren, C. W. S., who was formerly in General Sibert's office in Washington, has accepted a position as Carnegie assistant under Dr. Frazer, of Johns Hopkins University, and will work for the remainder of the year on osmotic pressure.

J. O. Lewis, superintendent of the petroleum experiment station at Bartlesville, Oklahoma, has just been appointed chief petroleum technologist of the Bureau of Mines, Department of the Interior, in place of Chester Naramore, who has resigned from the government service to join the Union Petroleum Company with headquarters at Philadelphia, Pa.

Mr. W. P. Dykema, petroleum engineer of the Bureau of Mines, has been transferred to the petroleum experiment station at Bartlesville, Okla., as superintendent.

J. H. A. Fink, for many years the export manager of the Mallinckrodt Chemical Works, has severed his connection with that firm and accepted a similar position with J. L. Hopkins & Co., 100 William Street, New York City.

Lt. A. Klipstein, Jr., Infantry, U. S. A., has taken up his former connections with A. Klipstein & Co., New York, having received his discharge from the Army after a service of eighteen months.

Capt. E. H. Kellogg, of the Chemical Warfare Service, U. S. A., recently returned from France, has taken up his duties with the Brown Company, Berlin, Me., as chemical engineer, having obtained his discharge from the Army.

Mr. Alfred H. Clarke, who was formerly instructor in chemistry at the Chicago Heights High School, and who later enlisted in the Chemical Warfare Service, where he served in the Offense Research Section of the Research Division in Washington, has received his discharge and is now teaching at the Lane Technical High School, Chicago, Ill.

Mr. Robert L. Wilson, formerly chief chemist of the Aetna Plant, Aetna Explosives Company, is now manager of the Northwestern Chemical Company.

Mr. E. M. Hayden, who has received his discharge from the Army, where he served in the capacity of 1st Lieutenant, C. W. S., U. S. A., and as Commanding Officer of the Kingsport Plant, Edgewood Arsenal, Kingsport, Tenn., is now chemical engineer for the Connecticut Metal and Chemical Co., New Britain, Conn.

Dr. Frank K. Cameron and Dr. H. S. Gale sailed recently to undertake for the Bureau of Mines an investigation of the European potash situation.

Professor Arthur G. Williams, formerly instructor at Beloit College, has been discharged from the Army in which he served with the rank of Captain, and has accepted a position as assistant professor of chemistry in the Oklahoma Agricultural and Mechanical College, Stillwater, Okla.

Mr. James Richardson Donald, who for the last two years has been in charge of the inspection of explosives for the Imperial Ministry of Munitions, has returned to his old firm, Messrs. J. T. Donald & Co., Chemical Engineers and Consulting Chemists, Montreal and Toronto, Canada.

Mr. Willis Clark, formerly with the Dow Chemical Company, of Midland, Mich., has accepted a position to teach physical chemistry at the Detroit Central Junior College.

Mr. William Hoskins, Jr., who has been in the Army since August 1917, serving first in the 149th Field Artillery at Fort Sheridan, and then later transferred in the Sanitary Corps, in the Division of Food and Nutrition of the Surgeon General's office in Washington, D. C., has been discharged and is now with Mariner & Hoskins, Chicago.

Dr. W. V. Evans, formerly of the Ordnance Department, U. S. A., and later detailed to the Bureau of Mines, Pittsburgh, Pa., to take charge of a unit investigating high explosives, has been discharged from the Army and has returned to his position as assistant professor of chemistry at Northwestern University, Evanston, Ill.

Mr. H. D. Valentine, who was inducted into service in September 1917, and who served in various branches of the U. S. Army, the latest being in the Ordnance Section of the Chemical Warfare Service, has received his discharge and is now teaching in the College of Mechanics and Engineering of the University of Wisconsin, at Madison, Wis.

Mr. R. C. Lyons, who has been chief chemist of Rock Island Arsenal for the past four years, has resigned his position to become chief chemist for the A. O. Smith Corporation, Milwaukee Wis.

Dr. P. W. Bridgman has returned from the naval experimental station at New London, Conn., to his work in the Jefferson Physical Laboratory, Harvard University.

W. P. Putnam, Major of Ordnance, U. S. A., has returned to Detroit to resume his activities as president and general manager of the Detroit Testing Laboratory.

Mr. George A. Richter, who had the rank of Major in the Chemical Warfare Service and who recently received his discharge from the Army, has taken up the work of reorganizing a research force with the Brown Company, Berlin, N. H.

Mr. Seward Snyder, formerly of the Prest-O-Lite Company, but lately with the Ordnance Department, is now with F. C. Atkinson at the American Hominny Company, Indianapolis.

Mr. H. P. Vannah, formerly plant chemist with E. and T. Fairbanks & Co., scale manufacturers of St. Johnsbury, Vt., is now chemist in the research laboratory of the Brown Company, Berlin, N. H.

Mr. B. A. Gish, who severed his connection as chemist of the H. E. Young Co., Inc., of Charlottesville, Va., several months ago, has accepted a position in the division of chemistry of the Virginia State Agricultural Department, his work being that of developing the mineral and agricultural interests of the state.

Dr. I. Dreyfus has recently resigned his position as chief chemist of the Beckers Works of the National Aniline Company. Dr. Dreyfus has been connected with this plant since its infancy and was one of the men who, in connection with Dr. Beckers, helped to develop it to its present efficiency.

Dr. A. L. Walters, lately of the Army Medical Corps, has resumed his old duties as director of the department of experimental medicine, Eli Lilly and Co., Indianapolis.

Mr. Charles Rascher, who was first-class Sergeant in the Chemical Warfare Service, stationed at Lakehurst Proving Grounds, Lakehurst, N. J., is now in the laboratory supply business with A. Daigger & Co., Chicago, Ill.

Mr. John R. Kuebler, of the Research Laboratory, Gas and Flame Division, Chemical Warfare Service, who has been stationed at Washington during the war, will resume his old duties in the chemistry department at the Shortridge High School, Indianapolis.

Mr. Leslie Hellerman, who enlisted in the Ordnance Department, and then later was transferred to the Chemical Warfare Service, has been discharged from the Army and is now registered as a graduate student at the University of Chicago.

Mr. Morris Kharasch, who left his research work at the University of Chicago to enlist in the Chemical Warfare Service, where he was assigned to research work in the chemical laboratory of the Edgewood Arsenal, has been discharged from the service and is now completing his graduate research work at the University of Chicago.

Mr. Nicholas D. Cheronis, who enlisted in the Chemical Warfare Service where he was assigned to work on the development of the so-called "gas fighting suit" in the Protective Clothing Unit, in charge of Professor Arthur E. Hill, of New York University, has been discharged from the Service and is doing graduate work at the University of Chicago.

Mr. F. F. Blicke, 2nd Lieutenant in the Chemical Warfare Service, American University Experiment Station, Washington, D. C., has received his discharge from the Army and has been reappointed research associate at the University of Chicago.

Mr. Isidor Levin, who served as a private in the Offense Laboratory, Development Division, Chemical Warfare Service, until his discharge, has resumed his position as chemist in the laboratory of the Peter Schoenhofen Brewing Company.

Mr. R. Q. Brewster has finished his work for the Ph.D. degree at the University of Chicago and has accepted an instructorship in organic chemistry at the University of Kansas, Lawrence, Kan., where he will take up his duties at once.

Dr. R. D. Mullinix, who has been an instructor in chemistry at Northwestern University, is now research chemist in the International Filter Company, Chicago.

Lieut. R. A. Hall, who has been cited many times for bravery, is now in the hospital at Camp Upton, N. Y., recovering from wounds and injuries received while at the front as Gas Officer.

Mr. Marks Neidle, formerly assistant professor of physical chemistry in the School of Chemistry, University of Pittsburgh, is now chief chemist with the Sterling Varnish Company, Pittsburgh, Pa.

Capt. T. Dale Stewart, formerly instructor in chemistry at the University of Chicago, and recently liaison officer for the research laboratory of the C. W. S. with the A. E. F., is resuming his duties at the University of California as instructor in organic chemistry.

Mr. M. N. Straughn, formerly of the Bureau of Chemistry in Washington, died in Porto Rico on January 9, 1919.

Dr. Thomas McCutcheon, associate professor of chemistry at the University of Pennsylvania, has resumed his work there. Dr. McCutcheon has been in the service of the War Industries Board in England and France.

Miss Aida M. Doyle resigned from the Bureau of Chemistry in February and is now with E. I. du Pont de Nemours & Co., Wilmington, Del.

Dr. F. C. Frary, formerly of the Oldbury Chemical Company of Niagara Falls, who has lately been engaged in war research, first in Washington and later at the Edgewood Arsenal of the Chemical Warfare Service, is organizing a research laboratory for the Aluminum Company of America, at Pittsburgh, Pa.

Mr. J. D. Edwards, associate chemist, and Mr. A. D. Bell, assistant chemist, Bureau of Standards, expect to leave the Bureau in April to take up research at the laboratory recently organized by Dr. F. C. Frary for the Aluminum Company of America, at Pittsburgh, Pa.

Mr. E. H. Grafton, who has been with the Manhattan Rubber Manufacturing Company, Passaic, N. J., has returned to the University of Chicago and is finishing his doctorate work in physical chemistry.

Mr. J. G. Goodwin has resigned from his position in charge of the department of chemistry at Rockford College, Rockford, Ill., and is now a member of the sales force of Schaaf & Company.

Mr. H. V. Cadwell, who was enlisted in the School for Ensigns, U. S. Navy, at Northwestern University, Evanston, has been discharged, and is again a member of the sales force of the Central Scientific Company.

Mr. Harry W. Wolf has recently resigned as general manager of the Rector Chemical Corp., N. J., to take charge of the chemical engineering research laboratories of Dr. Alcan Hirsch, New York City.

Messrs. J. F. Schoellkopf, C. P. Hugo Schoellkopf, and J. F. Schoellkopf, Jr., have withdrawn as directors of the National Aniline & Chemical Co., New York, N. Y.

Mr. E. J. Miller, who served for fifteen months as 1st Lieutenant in the Sanitary Corps, at American University, where he was engaged in gas warfare investigations, has returned to his position as chemist at the Michigan Experiment Station, East Lansing, Mich.

Mr. Stanley E. Kerr, formerly Lieutenant in charge of the chemical service at Walter Reed Hospital, Washington, D. C., sailed recently for Turkey as a member of a party of workers of the American Committee for Relief in the Near East.

Major J. H. Walton, Engineers, Gas Officer with the First Army, has returned to this country and resumed his position in the chemistry department of the University of Wisconsin. Major Walton has recently been promoted to full professor of chemistry.

Mr. C. J. Patterson, formerly chief chemist for the Ismert-Hincke Milling Company, is now chief chemist with the Campbell System, Inc., at Kansas City, Mo.

Mr. L. Christison, who was formerly located at the Kenvil Plant of the Hercules Powder Co., is now research chemist with the Essex Aniline Works, Inc., of South Middleton, Mass.

Mr. E. C. Carlyle has resigned his position as analytical chemist with George H. Morrill & Co., Norwood, Mass., and has become associated with Saarbach Laboratories, Inc., New York.

Mr. A. C. Arend, who was chemist and engineer for the Glass Brick Co., Huntington, W. Va., prior to having served in the Chemical Warfare Service of the U. S. Army at Cleveland, O., from which service he was recently mustered out, has accepted a position as assistant engineer, Division of Structures, Engineering Department, City of Cincinnati, O.

Mr. W. A. Bender has resigned his position as chief, San Francisco Station, U. S. Food and Drug Inspection, and has taken a position as chief chemist with the Douglas Packing Co., Rochester, N. Y.

Mr. H. A. Slippy is now permanently located in Cincinnati as chief asphalt chemist of the Pittsburgh Testing Laboratory, with which company he has been connected for the past three years.

Mr. D. F. Snyder, formerly chemist to the Texas Food and Drug Department, is now with the Calco Chemical Co., Bound Brook, N. J.

Mr. R. E. Strohecker, formerly chemist for the Federal Packing Co., Enosburg Falls, Vt., is at the present time superintendent of the Morristown plant of the Nestlé's Food Co., Inc.

GOVERNMENT PUBLICATIONS

By R. S. McBRIDE, Bureau of Standards, Washington

NOTICE—Publications for which price is indicated can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. Other publications can usually be supplied from the Bureau or Department from which they originate. Commerce Reports are received by all large libraries and may be consulted there, or single numbers can be secured by application to the Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington. The regular subscription rate for these Commerce Reports mailed daily is \$2.50 per year, payable in advance, to the Superintendent of Documents.

CONGRESSIONAL COMMITTEES

Lignite. Two reports have been rendered on Senate Bill 3220, authorizing the Secretary of the Interior to make investigations through the Bureau of Mines of lignite coals and peat to determine the practicability of their utilization as fuel and in the producing of commercial products. These are Senate Document 345, 1 p., dated January 23 and House Report 972, 2 pp., dated January 23. They include no technical details.

SMITHSONIAN INSTITUTION

International Catalogue of Scientific Literature. 5 pp. Report for year ending June 30, 1918.

ASTROPHYSICAL OBSERVATORY

Report on Astrophysical Observatory. 9 pp. For year ending June 30, 1918.

GENERAL SUPPLY COMMITTEE

Government Supplies. Bids on schedules of supplies for the coming fiscal year are being invited, covering drugs, medicines, and chemicals, Class 4 of specifications and proposals, and a supplement to the 1919 Class 5, laboratory apparatus, hospital appliances, surgical instruments, etc.

AIRCRAFT PRODUCTION BUREAU

Wood. Information for inspectors of airplane wood. 72 pp.

FUEL ADMINISTRATION

Boiler Water Treatment. Engineering Bulletin 3. 8 pp. Prepared in cooperation with the Bureau of Mines.

Coal. Engineering Bulletin 5. 8 pp. Based on articles by W. P. Frey, and prepared in cooperation with Bureau of Mines.

Combustion and Flue Gas Analysis. Engineering Bulletin 4. 12 pp. Based on article by J. W. Hays and prepared in cooperation with the Bureau of Mines.

Steam. Engineering Bulletin 6. 14 pp. Prepared in cooperation with Bureau of Mines.

PUBLIC HEALTH REPORTS

Patent Medicines. Disclosure of Ingredients. Vol. 34, p. 164, January 31. A regulation requiring disclosure of the ingredients of proprietary medicines has been held invalid by the New York Court but it is stated to be capable of amendment so as to make it valid.

GEOLOGICAL SURVEY

Peat in 1917. C. O. OSBORN. Mineral Resources of the United States, 1917, Part II. 27 pp. Issued December 19, 1918.

The year 1917 was one of great prosperity for the peat industry of the United States. The quantity of peat produced and sold exceeded the quantity marketed in any preceding year, and, with the exception of the manufacture of peat for use as fuel, all branches of the industry shared in the general prosperity. The most striking development, however, was the

greater use made of peat as a culture medium for nitrifying and other bacteria in the manufacture of bacterial fertilizer.

The quantity of raw peat marketed in the United States in 1917 was 97,363 short tons, a quantity greater by 44,857 tons, or about 85 per cent, than the output in 1916 and by 42,220 tons, or nearly 77 per cent, than the record output of 55,143 tons in 1911.

Nearly all producers of raw peat in the United States refine their entire output, and it was therefore impossible to determine accurately the value of the raw product. However, the average price for all refined products received at the point of consumption was a little more than \$7.29 a ton, and the gross market value was \$709,900, a gain of 26 cents in average price per ton and of \$340,796, or approximately 92 per cent, in gross market value.

The manufacture of fertilizer is the largest and most successful industry based on peat in the United States. All the individuals and companies that produced peat in 1917 also manufactured peat fertilizer or fertilizer filler, the output of which, as reported to the United States Geological Survey, amounted to 92,263 short tons. Compared with the production in 1916 this quantity is greater by 44,157 or almost 92 per cent, and exceeds the record established in 1911 by 40,530 tons, or about 78 per cent.

The average price received for the material in 1917 at the point of consumption was \$7.14 a ton, a gain of 14 cents a ton over the average price received in 1916. These gains in output and price were sufficient to make the total market value of the production in 1917, amounting to \$658,500, exceed the value of the output in 1916 by \$322,496, or nearly 96 per cent.

Of the total quantity of peat fertilizer and fertilizer filler marketed in 1917, 26,850 short tons, or about 29 per cent of the entire output, valued at \$256,000, was bacterized.

The quantity of peat used in compounding stock feed in the United States in 1917 was 5,100 short tons, valued at \$51,400, or an average price of \$10.08 a ton. Compared with 1916, the output in 1917 was greater by 800 tons, or almost 19 per cent, and the value was greater by \$19,150, or about 59 per cent. Three peat producers manufactured stock food in 1917, compared with two in 1916.

Magnesium in 1917. R. W. STONE. Mineral Resources of the United States, 1917, Part I. 5 pp. Issued December 11, 1918.

The production of metallic magnesium is a new industry in the United States, the first output on a commercial scale having been made in 1915. Prior to that year several firms had experimented in the isolation of the metal, but as the demand was small, as the known uses were few, and as a supply could be obtained from Germany, little progress was made toward commercial production. When the European war began not only was the German supply of the metal and of magnesium chloride from which it is extracted cut off but at the same time there arose a large demand. Whereas formerly only a small quantity, perhaps a few thousand pounds, had been used for flashlights in photography, the demand came for large quantities to be used in war materials.

In 1915 the total production of three firms was 87,500 pounds, valued at about \$440,000. In 1916 four firms produced 75,400 pounds of magnesium, valued at \$311,462. This production represented a reduction in 1916 of nearly 14 per cent in quantity and 29 per cent in value from the production of 1915. The average price fell from \$5 a pound in 1915 to \$4.13 a pound in 1916.

The output in 1917 was 115,813 pounds, valued at \$233,626, and the total production in three years to December 31, 1917,

as closely as can be determined from reports made by producers to the Geological Survey, was 278,713 pounds or about 139 short tons. This does not include small quantities which may have been made in an experimental way before 1915, nor is it exact because some of the producers, for lack of data, could report only in round numbers. The total value of the product in the first three years of the industry, as determined from sales and from estimates based on average prices for the year, is \$985,088.

The growth of the industry and improvements resulting in decreased cost of production are reflected in the following table:

PRODUCTION OF METALLIC MAGNESIUM

YEAR	Number of producers	Quantity Lbs.	Value	Average price for pound
1915.....	3	87,500	\$440,000	\$5.00
1916.....	4	75,400	311,462	4.13
1917.....	5	115,813	233,626	2.02

Imported German magnesium was quoted at about \$1.65 a pound in 1913, but after the European war cut off the foreign supply prices rose to \$5 or even \$6 a pound for sticks and \$6.50 a pound for powdered material. These prices continued through 1915. During 1916 the price fell off, and at the beginning of 1917, 99 per cent pure bar magnesium was selling for \$2.50 to \$3 a pound. This price gradually declined, and at the end of 1917 magnesium in bars was selling for \$1.85 to \$2 a pound, according to the quantity bought.

Although the figures in the table above give an average price of \$4.13 a pound for all production in 1916, one company reported an average price of \$2.53, another \$4.25, and a third \$5. The reports for 1917 are in closer harmony, however, only one differing much from the general average of about \$2 a pound.

Cement in 1917. E. F. BURCHARD. With a section on concrete ships. R. W. LESLEY. Separate from Mineral Resources of the United States, 1917, Part II. 38 pp. Published February 4, 1919.

The total quantity of Portland, natural, and puzzolan cements marketed or shipped from the mills in the United States in 1917 was 91,342,930 barrels, valued at \$123,210,458, as compared with 95,394,433 barrels, valued at \$104,689,090, in 1916, a decrease in quantity of 4,051,503 barrels, or 4.2 per cent, but an increase in value of \$18,521,368, or about 17.7 per cent. The distribution of the main classes of cement marketed is shown in the following table:

PRINCIPAL HYDRAULIC CEMENTS SHIPPED FROM FACTORIES IN THE UNITED STATES IN 1916 AND 1917

CLASS	1916		1917	
	Quantity Bbls.	Value	Quantity Bbls.	Value
Portland.....	94,552,296	\$104,258,216	90,703,474	\$122,775,088
Natural and Puzzolan	842,137	430,874	639,456	435,370
	95,394,433	\$104,689,090	91,342,930	\$123,210,458

The average price per barrel for the whole country in 1917 was \$1.354, compared with \$1.103 in 1916, an increase of 25.1 cents a barrel, or 22.8 per cent. This represents the selling price of cement in bulk at the mills, including cost of labor and packing, but not the value of the sacks or barrels. The average price per barrel for the country was 13.4 cents higher than the average price received for Portland cement in the Lehigh district, where it was lowest, and was near the average price received in California, Illinois, Indiana, Kansas, New York, and the following districts: Illinois-Northwestern Indiana, Kentucky-Southern Indiana, Ohio-Western Pennsylvania, and Pacific coast. It was 33.3 cents below the average received in Washington, where Portland cement brought the highest price (\$11.687) of the year. The quantity of Portland cement made in 1917 (92,814,202 barrels of 376 lbs.) was approximately equivalent to 15,579,527 gross tons, and the price per ton was about \$8.07.

The average price of Portland cement in the United States has been increased slightly over the average for ordinary gray

cement by the inclusion in the total shipments of a small quantity of white Portland cement. This white cement was produced in the Lehigh district, so that the value for that district has been increased in greater proportion than that of the other districts. Two mills, both in Pennsylvania, reported the production of white Portland cement in 1917.

The total daily kiln capacity in the United States in 1917 of all the plants either active or only temporarily closed, according to manufacturers' reports, was 424,835 barrels, compared with 416,375 barrels in 1916, an increase of 2 per cent. If due allowance be made for the customary loss of time from breakdowns and from necessary shutdowns for repairs and other ordinary causes, the apparent total kiln capacity for the country in 1917 was about 136,750,000 barrels of Portland cement, compared with nearly 134,000,000 barrels in 1916. According to these figures the total production of cement in 1917 (92,814,202 barrels) was nearly 68 per cent of the total capacity, whereas the production in 1916 represented about 68.5 per cent of the apparent total capacity in that year. It is possible, however, that the actual capacity was higher than the figures estimated indicate, in which event a smaller proportion of the capacity was utilized.

The production of potash salts as a by-product of the manufacture of Portland cement continued to be a subject of interest to the cement industry in view of the shortage in potash and the military needs for it. At the end of 1917 the production of potash salts was reported by 7 plants, 4 of them in California, 1 in Maryland, 1 in New York, and 1 in Pennsylvania, and flue dust carrying soluble potash was gathered from below the kiln stacks at 1 plant in Pennsylvania and at 1 plant in Missouri. At the same time 4 plants reported the construction of apparatus for the recovery of potash under way, and 16 plants reported that this recovery was under consideration. The content of potash in raw materials and the loss through volatilization in cement manufacture is discussed in a recent bulletin of the Department of Agriculture.

In 1917 the total quantity of hydraulic cement exported to foreign countries, including the Philippines and the Panama Canal Zone, was 2,586,215 barrels, most of it Portland cement, valued at \$5,328,536 at the United States ports of shipment, or an average of approximately \$2.06 a barrel, as compared with 2,563,976 barrels, valued at \$3,828,231, or about \$1.49 a barrel, in 1916. The quantity exported in 1916 and 1917 was not quite 2.8 per cent of the total production of hydraulic cements in those years.

In 1916 and 1917 only one manufacturer reported an output of puzzolan or slag-lime cement, and in order that this quantity may be comprised in the cement totals for the United States it is included with the statistics of natural cement.

The Genesis of the Ores at Tonopah, Nevada. E. S. BASTIN AND F. B. LANEY. Professional Paper 104. 50 pp. This information was assembled in cooperation with the Bureau of Mines. The investigation was intended to supplement the important work of Spurr and Burgess by applying to the ores methods of microscopic study which were not in general use by economic geologists at the time their reports were prepared, but which, in other districts, have proved of material assistance in the interpretation of ore genesis.

BUREAU OF CENSUS

Statistics of Leather. Census of War Commodities. 11 pp. This gives the census of leather stocks on hand and in transit in the United States, May 31, 1918, taken by the bureau at the request of the War Industries Board.

BUREAU OF STANDARDS

Melting Points of Chemical Elements and Other Standard Temperatures. Circular No. 35, 3rd Edition. Published July 15, 1918.

Design and Test of Standards of Mass. Circular No. 3, 2nd Edition. 89 pp. Published December 23, 1918.

A Portable Cubic-Foot Standard for Gas. M. H. STILLMAN. Technologic Paper No. 114. 13 pp. Paper, 5 cents. Published January 28, 1919. The subject of this paper is a new type of volume standard for measuring gas which has been found to possess decided advantages as a cubic-foot standard over the apparatus of this class largely in use at the present time.

While the portability, accuracy, and ease of operation of this device adapt it especially to that class of work in which an inspector is required to make tests of gas-meter testing equipment distributed over a comparatively large territory, it has also been successfully used for other purposes in which the delivery of a comparatively small volume of gas with a high degree of accuracy was required.

A Critical Study of the Ledebur Method for Determining Oxygen in Iron and Steel. J. R. CAIN AND E. PETTJOHN. Technologic Paper No. 118. 33 pp. Paper, 5 cents. Published January 11, 1919.

Tests of Hollow Building Tiles. B. D. HATHCOCK AND E. SKILLMAN. Technologic Paper No. 120. 29 pp. Paper, 5 cents. Published February 8, 1919.

DEPARTMENT OF AGRICULTURE

The Significance of the Colon Count in Raw Milk. S. H. AYERS AND P. W. CLEMMER. Professional Paper. Department Bulletin 739. 35 pp. Paper, 10 cents. Published December 30, 1918.

A Study of Some of the Chemical Changes which Occur in Oysters during their Preparation for the Market. E. E. SMITH. Department Bulletin 740. 24 pp. Paper, 5 cents. Published January 13, 1919. This bulletin gives the results of an investigation to determine the amounts of ammoniacal nitrogen, amino-acid nitrogen, moisture, total solids, ash, and sodium chloride present in oysters under the various conditions which they pass in ordinary commercial practice in the oysterhouse, and to ascertain the effect of washing and soaking on both the chemical composition and physical condition of the oysters.

Pulpwood Consumption and Wood-pulp Production in 1917. F. H. SMITH. Department Bulletin 758. 19 pp. Paper, 5 cents. Published January 30, 1919. This is a discussion of the pulp-wood situation, and of interest to users of news-print paper.

Articles from the Journal of Agricultural Research

Determination of Acidity and Titratable Nitrogen in Wheat with the Hydrogen Electrode. C. O. SWANSON AND E. L. TAGUE. 16, 1-13 (January 6).

Ash Absorption by Spinach from Concentrated Soil Solutions. R. H. TRUE, O. F. BLACK AND J. W. KELLY. 16, 15-25 (January 6).

Effect of Carbon Disulfide and Toluol upon Nitrogen-Fixing and Nitrifying Organisms. P. L. GAINES. 15, 601-615 (December 16).

Multiple Pipette Holder for the Distribution of Serum for the Complement-Fixation Test. F. H. REYNOLDS. 15, 615-618 (December 16).

BUREAU OF FOREIGN AND DOMESTIC COMMERCE

Shoe and Leather Trade of China and Japan. C. E. BOWORTH. Special Agents Series 173. 37 pp. Paper, 5 cents. The report brings out the importance of China as an extensive potential market in sharp contrast with the restricted opportunity offered by Japan, with its growing domestic industry.

COMMERCE REPORTS—FEBRUARY 1919

A summary is given of the progress in the manufacture of paper textiles in the U. S. including data on all the important patents. (Pp. 556-559)

The cultivation of oilseeds and manufacture and uses of vegetable oils in China and Japan are described in detail. The soy bean is by far the most important. Other oils exported to the U. S. are coconut, grapeseed, cottonseed, peanut, and ferilla. (Pp. 611-616)

In addition to natural indigo, China is producing many other vegetable dyes, including blacks from gall nuts and acorns, yellow from locust flowers, red from safflower, green from the bark of buckthorn, and brown from "false gambier." (P. 622)

Paper yarn has proven unsatisfactory in Germany for use in clothing. It is used only for carpet, bags, etc., for which it is the only material available. The only other cotton substitute of importance is the "staple fiber," produced somewhat like artificial silk. At present the cost of necessary chemicals restricts the production. (P. 643)

Employees of the German dye works of Friederich Bayer have taken steps to oppose the proposed nationalization of the German dyestuff industries. (P. 735)

In a detailed report on the leather situation in Germany, the difficulty in obtaining tanning materials is emphasized. Before the war, imported quebracho was used as a filler. Fats and oils for leather were of course very scarce. (Pp. 741-749)

In connection with fuel conservation in England, it was found advantageous to reduce the normal requirement of 500 B. t. u. for gas to 450 B. t. u., while still further reduction to 400 or 350 B. t. u. was urged; the subject is now being studied by the Fuel Research Board. The practice of "steaming" retorts, both vertical and horizontal, has increased. By-product coke ovens have increased. High pressure gas cylinders are being used for propelling omnibuses and trains. Efforts to increase the production of oil and of industrial alcohol are being continued. (Pp. 769-771)

Efforts are being made to expand Australia's zinc industry. Several large concentration and smelting plants are being erected. Sulfuric acid, lithopone, zinc oxide, and zinc alloys will also be made. The zinc produced at Hobart is over 99.9 per cent zinc, and is especially adapted for rolling, etc. (Pp. 794-795)

Important mineral products of Japan are antimony, chromite, copper, gold, lead, manganese ore, molybdenum, platinum, mercury, silver, tin, tungsten, zinc, asphalt coal, graphite, petroleum, phosphate rock, pyrites and sulfur. (Pp. 796-797)

In January the chemical industries in Liverpool were suffering through shortage in labor, and a lack of lime and limestone. The chemical trade was omitted from the list of "pivotal industries" and hence has difficulty in obtaining essential materials. Future prospects for chemical industries are, however, regarded as promising. The dye works of Levinstein has made great progress and expects shortly to expand the plant. Indigo is the leading product, in addition to which a number of vat dyes are being made. (Pp. 774-775)

Details are published of the concessions to be granted for working the potash beds of Catalonia in Spain. Borings are to be made, not less than 5 cm. in diameter, or 1200 meters in depth. (P. 890)

Important mineral products of Italy are coal, antimony, iron, manganese, lead, zinc, copper, tungsten, boric acid, alunite, bauxite, graphite, mercury, petroleum, pyrites, salt, and sulfur. Efforts are being made to develop a supply of potash, *e. g.*, from the mother liquor of salt works and from leucitic rocks. It is estimated that the sulfur deposits thus far developed represent less than 1 per cent of the sulfur-bearing strata. (Pp. 936-938).

SPECIAL SUPPLEMENTS

BRITISH WEST INDIES—22a
DOMINICAN REPUBLIC—26a
BRAZIL—40a
BRITISH GUIANA—44a

BRITISH INDIA—50a
FEDERATED MALAY STATES—56b
MOROCCO—75a

JAMAICA—Sup. 22a

Annatto
Copa
Divi-divi
Hides
Leather
Logwood extract
Mangrove bark
Mangrove extract
Sugar
Fustic
Logwood
Wax

GUIANA—Sup. 44a

Balata
Bauxite
Coconut oil
Gold
Hides
Rubber
Sugar
Mangrove bark
Sisal fiber
Fish glue

EXPORTS TO THE UNITED STATES

DOMINICAN REPUBLIC—Sup. 26a

Beeswax
Chemicals
Dyewoods
Hides
Sugar
BRAZIL—Sup. 40a
Carnauba wax
Diamonds
Hides
Rubber
Sugar

BOMBAY—Sup. 50a

Casein
Drugs
Gums
Hides
Indigo
Myrabolans
Rose oil
Manganese ore
Saltpetre
Castor seeds
Thymol

BOOK REVIEWS

TNT and Other Nitrotoluenes. By G. CARLTON SMITH, B.S., Instructor in General Chemistry, School of Applied Science, Carnegie Institute of Technology, Pittsburgh, Pa. 133 pp. D. Van Nostrand Co., New York, 1918. Price, \$2.00 net.

"This little volume in which an attempt is made to gather together and correlate all accessible information on the subject, both theoretical and practical," is a recent addition to the literature of the nitrotoluenes. Unfortunately, in the field of explosives, more perhaps than in any other branch of chemistry, it has been truly said that those who have been in possession of the facts have done but little publishing, so that while the work contains three pages of references to literature it is still rather too meager a treatise to be of much practical value to a manufacturer. The chapters on manufacture and purification together cover 32 pages, but there are no illustrations or descriptions of apparatus, and the descriptions of processes are rather vague and indefinite. The chapters on inspection and testing, and on the physical and chemical properties are of interest, and the book will no doubt find a place in all explosives libraries and testing laboratories.

PAUL I. MURRILL

Modern Chemistry and Chemical Industry of Starch and Cellulose. By TARINI CHARAN CHAUDHURI, M.A., Professor of Chemistry, Krisnath College, Berhampore (Bengal). viii + 150 pp. Butterworth & Co., Calcutta, India, 1918. Price, 3s. 12d.

The author states in his preface he has attempted "to give a brief survey of the chemistry and the various chemical industries that have direct or indirect bearing on starch and cellulose, especially in the light of recent researches—theoretical and technological." The work, judging from a footnote, is a reprint, probably with expansion, of a lecture delivered before the Rajshahi Government College Union.

The theoretical part is handled in four chapters covering thirty-nine pages. The textile fibers of India are mentioned in a historical way. The sugar synthesis and its relation to the life process of the plant are briefly outlined.

The industrial part discusses the application of cellulose and starch to a large variety of industries, without any pretense of detail or any attempt to give a real insight into manufacturing processes. Enough is given to show in an interesting way a wide range of industries in which directly and indirectly starch and cellulose play an important part. The motive of the book is to stimulate enterprise for the development of the resources of India along the lines indicated.

W. R. CATHCART

Graphical and Mechanical Computation. By JOSEPH LIPKA, Ph.D., Assistant Professor of Mathematics in the Massachusetts Institute of Technology. ix + 264 pp. John Wiley & Sons, Inc., New York, 1918. Price, \$4.00.

"This book embodies a course given by the writer at the Massachusetts Institute of Technology. It is designed as an aid in the solution of a large number of problems which the engineer, as well as the student of engineering, meets in his work."

The first five chapters of the book deal with the methods of graphical representation for lessening the labor of computation. Of these devices the most rapidly constructed charts and the most easily read are the nomographic charts developed by d'Ocagne. The remaining four chapters deal with the fitting of empirical equations to data for which no rational formula is known, and with numerical, graphical, and mechanical methods of handling data when empirical formulas cannot be discovered. There are many illustrative examples in the text and a large number of exercises for the student, of which exercises several involve chemical data. This book should be of the utmost interest to the research engineer whose data are empirical and whose computations involve complex formulas.

JAMES M. BELL

The Applications of Electrolysis in Chemical Industry. By A. J. HALE. x + 143 pp. Longmans, Green & Co., New York, 1918. Price, \$2.50.

The chapters are entitled: Introduction; Methods of Generating the Current; The Electrolytic Refining of Metals; The Electrolytic Winning of Metals; Electrolytic Production of Hydrogen and Oxygen; Chlorine and Caustic Soda; Hypochlorites, Chlorates, Perchlorates; Production of Inorganic Compounds; Production of Organic Compounds.

It is difficult to see what purpose this book is to serve. All sorts of things are jumbled together without any reference to whether they are technically important. Thermopiles are certainly not used as sources of current in industrial work and dry cells are important for other purposes than this. It seems a waste of space to include in a small book Keith's and Tommasi's processes for refining lead, p. 42. So far as the reviewer knows the Browne process for refining nickel, p. 65, is not in operation, and the Darling process for production of nitric acid, p. 69, is certainly not running. There is no object in including the Borchers cell for sodium, p. 72. The drawings of the Castner cell, p. 105, and of the Castner-Kellner cell, p. 106, run back to prehistoric times. There is no mention of the Nelson cell or of any of the developments of the Townsend cell. Under white lead, p. 131, there is no suggestion that the quality of the product is important.

There are a fair number of mistakes. When aqueous sodium chloride solutions are electrolyzed, hydrogen is not due to the chemical reaction of the liberated sodium with the water, p. 2. It is not clear what is meant by the statement, p. 12, that a technical bath can take up to about 6 volts between anode and cathode; higher voltage is liable to produce shunt-current losses and excessive heating. It is not true, p. 68, that potassium is easier to get from fused caustic potash than sodium from fused caustic soda. Pure lithium cannot be obtained from a pyridine solution of the chloride, p. 77. The product is a thin film of lithium alloyed with the cathode. The spelling of cathion is wrong. The reviewer doubts whether fluorine has ever been made on a large scale by the Moissan process, p. 138.

WILDER D. BANCROFT

NEW PUBLICATIONS

By CLARA M. GUPPY, Librarian Mellon Institute of Industrial Research, Pittsburgh

- Catalysis in Industrial Chemistry.** G. C. HENDERSON. 8vo. 202 pp. Price, \$3.00. Longmans, Green & Co., New York.
- Dyestuffs: Natural Organic Coloring Matters.** A. G. PERKIN AND A. E. EVEREST. 8vo. 655 pp. Price, \$9.00. Longmans, Green & Co., New York.
- Electricity: Leçons Pratiques d'Électricité Industrielle.** 2e partie: Les Courants Alternatifs. A. SOULIER. Price, 3 fr. 90. Garnier frères, Paris.
- Organic Chemistry: Recent Advances in Organic Chemistry.** A. W. STEWART. 3rd Ed. 8vo. 350 pp. Price, \$4.50. Longmans, Green & Co., New York.
- Powdered Coal as a Fuel.** C. F. HERRINGTON. 8vo. 222 pp. Price, 12s. 6d. Constable & Co., Ltd., London.
- Surface Tension and Surface Energy and Their Influence on Chemical Phenomena.** R. S. WILLOWS AND E. HATSHIE. 2nd Ed. 8vo. 123 pp. Price, 4s. 6d. J. and A. Churchill, London.
- Synthetic Agricultural Chemistry: Preparation of Substances Important in Agriculture; A Laboratory Manual of Synthetic Agricultural Chemistry.** C. A. PETERS. 8vo. 12mo. 81 pp. Price, \$0.80. John Wiley & Sons, Inc., New York.
- Technical Handbook of Oils, Fats, and Waxes. Volume 2.** P. J. FRYER AND F. E. WESTON. 8vo. Price 15s. Cambridge University Press, London.
- Thermodynamics: System of Physical Chemistry.** Volume 2. W. C. M. LEWIS. 3 vols. 2nd Ed. 8vo. 403 pp. Price, \$4.50. Longmans, Green & Co., New York.
- Vegetable Oils: The Production and Treatment of Vegetable Oils.** T. W. CHALMERS. 165 pp. Price, 21s. Constable & Co., Ltd., London.
- Glass: Strength Tests of Plain and Protective Sheet Glass.** T. L. SORRY. *Journal of the American Ceramic Society*, Vol. 1 (1918), No. 11, pp. 801-808.
- Glass Analysis: A Contribution to the Methods of Glass Analysis, with Special Reference to Boric Acid and the Two Oxides of Arsenic.** E. T. ALLEN AND E. G. ZIES. *Journal of the American Ceramic Society*, Vol. 1 (1918), No. 11, pp. 739-786.
- Graphite: Preparation of Crucible Graphite.** G. D. DUB. *The Metal Industry*, Vol. 17 (1919), No. 2, pp. 73-74.
- Heat Treatment of Adroplane Parts.** FRED GROTT. *The American Drop Forger*, Vol. 5 (1919), No. 2, pp. 69-75.
- Hydrocyanic Acid: The Manufacture of Hydrocyanic Acid; Compressed Hydrocyanic Acid to be a Commercial Commodity.** H. A. PELTON AND M. W. SCHWAB. *Chemical and Metallurgical Engineering*, Vol. 20 (1919), No. 4, pp. 165-166.
- Leaching of Lead from Carbonate Ores.** D. A. LYON AND O. C. RALSTON. *Mining and Scientific Press*, Vol. 118 (1919), No. 9, pp. 277-282.
- Lead: Notes on the Rapid Estimation of Lead in Brasses and Alloys.** G. H. HODGSON. *The Chemical News*, Vol. 118 (1919), No. 3067, pp. 37-38.
- Manganese Alloys in Open Hearth Practice.** S. L. HOYT. *The Blast Furnace and Steel Plant*, Vol. 7 (1919), No. 3, pp. 142-146.
- Manganese Bronze.** P. E. MCKINNEY. *The Metal Industry*, Vol. 17 (1919), No. 2, pp. 71-72.
- Motor Fuel Problem.** W. R. ORMANDY. *The Chemical News*, Vol. 118 (1919), No. 3068, pp. 49-50.
- Nitrating of Woodpulp Cellulose.** S. D. WELLS AND V. P. EDWARDS. *Paper*, Vol. 23 (1919), No. 23, pp. 180-185.
- Nitrogen Compounds: Production of Nitrogen Compounds; Review of the World's Sources of Nitrogen Compounds and the Methods of Utilizing Them.** J. P. MONTGOMERY. *The Chemical Engineer*, Vol. 27 (1919), No. 2, pp. 35-39.
- Paper: Analytical Methods for the Paper Industry; Report on Standard Methods of Testing Materials Used in the Manufacture of Paper.** W. H. GESSELL. *Paper*, Vol. 23 (1919), No. 23, pp. 26-32.
- Paper: The Manufacture of Book Papers from Wood Fibers.** A. O. BOWNESS. *Pulp and Paper Magazine*, Vol. 17 (1919), No. 8, pp. 195-199.
- Porcelain: Some Types of Porcelain.** F. H. RIDDLER AND W. W. McDANIEL. *Journal of the American Ceramic Society*, Vol. 1 (1918), No. 9, pp. 606-627.
- Potassium Ammonosulfate, Potassium Ammonolithiate, Rubidium Ammonosulfate, and Rubidium Ammonolithiate.** E. C. FRANKLIN. *Journal of Physical Chemistry*, Vol. 23 (1919), No. 1, pp. 36-53.
- Refractory Materials and the Glass Industry.** J. W. COBB. *Journal of the Society of Glass Technology*, Vol. 2 (1918), No. 8, pp. 262-270.
- Refractory Materials: Influence of Temperature upon the Action of Slag upon Refractory Materials.** R. M. HOWE. *Chemical and Metallurgical Engineering*, Vol. 20 (1919), No. 4, pp. 167-168.
- Rust-Proofing of Iron and Steel; A Description of the Parker Rust-Proof Process.** E. S. WHITTIER. *The Metal Industry*, Vol. 17 (1919), No. 2, pp. 79-72.
- Saccharin: Analysis of Commercial Saccharin; The Detection and Estimation of Impurities.** H. D. RICHMOND AND C. A. HILL. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 8, pp. 84-101.
- Salt-peter: Production and Uses of Salt-peter.** H. S. GALE. *Engineering and Mining Journal*, Vol. 107 (1919), No. 9, pp. 385-388.
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- Soda Pulp Manufacture.** E. SUTHERMEISTER. *Pulp and Paper Magazine*, Vol. 17 (1919), No. 9, pp. 215-218.
- Sulfur Dyestuffs.** J. F. SPRINGER. *Color Trade Journal*, Vol. 4 (1919), No. 3, pp. 54-57.
- Sulfuric Acid Manufacture by the Chamber Process.** G. CHRISP. *The American Fertilizer*, Vol. 50 (1919), No. 4, pp. 29-31.
- Thermometers: Standardization of Thermometers.** P. V. ROSEWARNE AND G. P. HAM. *Canadian Chemical Journal*, Vol. 3 (1919), No. 2, pp. 60-61.
- Transformer Oils: Some Characteristics of Transformer Oils.** O. K. ESCHBOLZ. *The Electric Journal*, Vol. 16 (1919), No. 2, pp. 74-76.
- Water Softening.** P. E. KING. *The Chemical News*, Vol. 118 (1919), No. 3065, pp. 14-16.
- Woodpulp Manufacture in France: Review of Conditions and an Account of Available Woods and Processes.** PIERRE ROCHON. *Paper*, Vol. 23 (1919), No. 22, pp. 11-15.
- Zinc: Metallurgy of Zinc.** W. R. INGLETS. *Engineering and Mining Journal*, Vol. 107 (1919), No. 2, pp. 87-88.
- Zirconium Oxide: Partial Purification of Zirconium Oxide.** A. J. PHILLIPS. *Journal of the American Ceramic Society*, Vol. 1 (1918), No. 11, pp. 791-800.

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- Alcohol from Waste Sulfite Liquor.** V. K. KRIEBELE. *Paper*, Vol. 23 (1919), No. 23, pp. 153-162.
- Bessemer Process: Present American Acid Bessemer Process; Reversibility of Manganese Oxidation Reaction.** R. S. MCCAFFERY. *The Blast Furnace and Steel Plant*, Vol. 7 (1919), No. 3, pp. 140-142.
- Carbon Monoxide: The Accurate Determination of Carbon Monoxide in Gas Mixtures.** J. I. GRAHAM. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 2, pp. 101-104.
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- Clay in Glass: Note on the Solubility of Clay in Glass.** J. H. DAVIDSON AND W. E. S. TURNER. *Journal of the Society of Glass Technology*, Vol. 2 (1918), No. 8, pp. 280-284.
- Coal: On the Oxidation of Coal.** J. R. PARTINGTON. *The Chemical News*, Vol. 118 (1919), No. 3068, pp. 50-51.
- Colloid Chemistry: Properties of the Colloid State and Their Application to Industry.** W. C. M. LEWIS. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 2, pp. 34-41.
- Colloids: Colors of Colloids, Reflection and Refraction.** W. D. BANCROFT. *Journal of Physical Chemistry*, Vol. 23 (1919), No. 1, pp. 1-35.
- Colloids: The Degree of Dispersion of Colloids and Its Determination.** GEORGE KING. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 2, pp. 41-71.
- Die Castings and Their Application to the War Program.** CHARLES PACE. *The Metal Industry*, Vol. 17 (1919), No. 2, pp. 75-78.
- Electrolytic Deposition of Zinc. Preparation of Cell Liquor from Fumes Collected as a Sludge in the Acid Chambers.** H. E. BROUGHTON. *Chemical and Metallurgical Engineering*, Vol. 20 (1919), No. 4, pp. 155-163.
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- Ferromanganese in Blast Furnaces. Concluding Installment of Bureau of Mines Report on Investigation of Eighteen Blast Furnaces Producing Ferromanganese.** P. H. ROYSTER. *The Iron Trade Review*, Vol. 64 (1919), No. 7, pp. 439-443.
- Flotation of Oxidized Ores of Lead; Process of Sulfidizing Ores such as Cerussite, Wulfenite, and Cerargyrite.** G. L. ALLEN. *Chemical and Metallurgical Engineering*, Vol. 20 (1919), No. 4, pp. 169-175.
- Gases Occluded in Steel; Composition and Volume of Occluded Gases and Their Effect upon the Physical Properties of the Metal.** THOMAS BAKER. *The Blast Furnace and Steel Plant*, Vol. 7 (1919), No. 3, pp. 156-157.
- Gilding Aluminum. Some Valuable Hints as to How to Perform This Operation.** C. H. PROCTOR. *The Metal Industry*, Vol. 17 (1919), No. 2, p. 78.
- Glass: The Identification of Stones in Glass.** N. L. BOWEN. *Journal of the American Ceramic Society*, Vol. 1 (1918), No. 9, pp. 594-605.
- Glass: Note on the Determination of Boric Oxide in Glass.** J. D. CAUWOOD AND T. E. WILSON. *Journal of the Society of Glass Technology*, Vol. 2 (1918), No. 8, pp. 246-252.

MARKET REPORT—MARCH, 1919

WHOLESALE PRICES PREVAILING IN THE NEW YORK MARKET ON MARCH 15, 1919

INORGANIC CHEMICALS

Acetate of Lime, Basis 50%.....	100 Lbs.	2.00	@	2.05
Alum, ammonium, lump, U. S. P.....	100 Lbs.	5.00		
Aluminum Sulfate, (iron free).....	100 Lbs.	4.50	@	4.75
Ammonium Carbonate, domestic.....			nominal	
Ammonium Chloride, white.....	Lb.	19	@	20
Aqua Ammonia, 26°, drums.....	Lb.	7	@	9
Arsenic, white.....	Lb.	9	@	11
Barium Chloride.....	Ton	80.00	@	85.00
Barium Nitrate.....	Lb.	12	@	14
Barytes, prime white, foreign.....	Ton	30.00	@	35.00
Bleaching Powder, 35 per cent.....	100 Lbs.	1.60	@	2.50
Blue Vitriol.....	Lb.	7 1/4	@	8
Borax, crystals, in bags.....	Lb.	7 1/4	@	10 1/4
Boric Acid, powdered crystals.....	Lb.	7 1/4	@	8 1/4
Bromine, crude, domestic.....	Long Ton	28.00	@	35.00
Bromine, technical, bulk.....	Lb.	75	@	
Calcium Chloride, lump, 70 to 75% fused.....	Ton	18.00	@	22.00
Caustic Soda, 76 per cent.....	100 Lbs.	2.65	@	2.95
Chalk, light precipitated.....	Lb.	4 1/4	@	5
China Clay, imported.....	Ton	20.00	@	30.00
Feldspar.....	Ton	8.00	@	15.00
Fuller's Earth, foreign, powdered.....	Ton		nominal	
Fuller's Earth, domestic.....	Ton	20.00	@	30.00
Glauber's Salt, in bbls.....	100 Lbs.	2.10	@	3.00
Green Vitriol, bulk.....	100 Lbs.	2.00	@	2.25
Hydrochloric Acid, commercial, C. P.....	Lb.	8	@	8 1/4
Iodine, resublimed.....	Lb.	4.25	@	4.30
Lead Acetate, white crystals.....	Lb.	14	@	15
Lead Nitrate, C. P.....	Lb.		85	
Litharge, American.....	Lb.	10	@	11
Lithium Carbonate.....	Lb.		1.50	
Magnesium Carbonate, U. S. P.....	Lb.	25	@	30
Magnesite, "Calcedined".....	Ton	60.00	@	65.00
Nitric Acid, 40°.....	Lb.	7 1/4	@	8
Nitric Acid, 42°.....	Lb.	8	@	
Phosphoric Acid, 48/50%.....	Lb.	35	@	40
Phosphorus, yellow.....	Lb.	55	@	75
Plaster of Paris.....	100 Lbs.	2.00	@	2.50
Potassium Bichromate.....	Lb.	37	@	38
Potassium Bromide, granular.....	Lb.	1.25	@	1.30
Potassium Carbonate, calcined, 80 @ 85%.....	Lb.	16	@	17
Potassium Chlorate, crystals, spot.....	Lb.	40	@	41
Potassium Cyanide, bulk, 98-99 per cent.....	Lb.		nominal	
Potassium Hydroxide, 88 @ 92%.....	Lb.	60	@	70
Potassium Iodide, bulk.....	Lb.	3.75	@	4.00
Potassium Nitrate.....	Lb.	27	@	30
Potassium Permanganate, bulk, U. S. P.....	Lb.	85	@	1.05
Quicksilver, flask.....	75 Lbs.	72.00	@	
Red Lead, American, dry.....	100 Lbs.	11.25	@	11.50
Salt Cake, glass makers'.....	Ton	17.50	@	22.00
Silver Nitrate.....	Oz.	63 1/4	@	65
Soapstone, in bags.....	Ton	10.00	@	12.50
Soda Ash, 58%, in bags.....	100 Lbs.	1.60	@	1.65
Sodium Acetate, broken lump.....	Lb.	8 1/2	@	10 1/4
Sodium Bicarbonate, domestic.....	100 Lbs.	2.75	@	2.85
Sodium Bichromate.....	Lb.	11	@	12
Sodium Chlorate.....	Lb.	18	@	19
Sodium Chromate.....	Lb.	30	@	32
Sodium Fluoride, commercial.....	Lb.	14	@	15
Sodium Hyposulfite.....	100 Lbs.	2.60	@	3.60
Sodium Nitrate, 95 per cent, spot.....	100 Lbs.	4.07 1/2	@	
Sodium Silicate, liquid, 40° Bé.....	Lb.	2	@	2 1/2
Sodium Sulfide, 60%, fused in bbls.....	Lb.	4 1/2	@	4 1/4
Sodium Bisulfite, powdered.....	Lb.	6	@	8
Strontium Nitrate.....	Lb.	25	@	30
Sulfur.....	100 Lbs.	2.25	@	4.60
Sulfuric Acid, chamber 66° Bé.....	Ton	25.00		
Sulfuric Acid, oleum (fuming).....	Ton	25.00		
Talc, American, white.....	Ton		15.00	
Terra Alba, American, No. 1.....	100 Lbs.		1.17 1/2	
Tin Bichloride, 50°.....	Lb.	26	@	28
Tin Oxide.....	Lb.	70	@	80
White Lead, American, dry.....	Lb.	10	@	10 1/2
Zinc Carbonate.....	Lb.	18	@	20
Zinc Chloride, commercial.....	Lb.	14	@	14 1/2

ORGANIC CHEMICALS

Acetanilid, C. P., in bbls.....	Lb.	48	@	49
Acetic Acid, 56 per cent, in bbls.....	100 Lbs.	7.00	@	7.50
Acetic Acid, glacial, 99 1/2%.....	100 Lbs.	14.50	@	15.00
Acetone, drums.....	Lb.	15 1/2	@	16
Alcohol, denatured, 180 proof.....	Gal.	40	@	43

Alcohol, sugar cane, 188 proof.....	Gal.	4.90	@	4.95
Alcohol, wood, 95 per cent, refined.....	Gal.	1.22	@	1.24
Amyl Acetate.....	Gal.	4.20	@	4.50
Aniline Oil, drums extra.....	Lb.	24	@	25
Benzoin Acid, ex-toluol.....	Lb.	1.50	@	1.60
Benzene, pure.....	Gal.	22	@	22 1/2
Camphor, refined in bulk, bbls.....	Lb.	1.24 1/2	@	1.25
Carbolic Acid, U. S. P., crystals, drums.....	Lb.	10	@	15
Carbonyl Bisulfide.....	Lb.	9	@	10
Carbon Tetrachloride, drums, 100 gals.....	Lb.	14 1/2	@	15 1/2
Chloroform.....	Lb.	63	@	70
Citric Acid, domestic, crystals.....	Lb.		1.27	
Cresosote, beechwood.....	Lb.	2.00	@	2.10
Cresol, U. S. P.....	Lb.	18	@	20
Dextrine, corn (carloads, bags).....	Lb.	8	@	9
Dextrine, imported potato.....	Lb.		nominal	
Ether, U. S. P., 1900.....	Lb.	23	@	24
Formaldehyde, 40 per cent.....	Lb.	22	@	23 1/2
Glycerin, dynamite, drums extra.....	Lb.	14 1/2	@	15 1/2
Oxalic Acid, in casks.....	Lb.	36	@	38
Pyrogallol Acid, resublimed, bulk.....	Lb.	2.85	@	2.90
Salicylic Acid, U. S. P.....	Lb.	40	@	45
Starch, corn (carloads, bags) pearl.....	100 Lbs.	6.00	@	7.00
Starch, potato, Japanese.....	Lb.	13	@	14
Starch, rice.....	Lb.	12 1/2	@	13
Starch, sago flour.....	Lb.	9 1/4	@	10 1/4
Starch, wheat.....	Lb.		nominal	
Tannic Acid, commercial.....	Lb.	65	@	80
Tartaric Acid, crystals.....	Lb.	84 1/2	@	85

OILS, WAXES, ETC.

Beeswax, pure, white.....	Lb.	50	@	55
Black Mineral Oil, 29 gravity.....	Gal.	24	@	25
Castor Oil, No. 3.....	Lb.	22	@	23
Ceresin, yellow.....	Lb.	16	@	17
Corn Oil, crude.....	100 Lbs.	16.75	@	17.7
Cottonseed Oil, crude, f. o. b. mill.....	Lb.	22	@	23 1/2
Cottonseed Oil, p. a. y.....	Lb.	21 1/4	@	22
Menhaden Oil, crude (southern).....	Gal.	90	@	1.00
Neat's-foot Oil, 20°.....	Gal.	2.00	@	
Paraffin, crude, 118 to 120 m. p.....	Lb.	8 1/2	@	9
Paraffin Oil, high viscosity.....	Gal.	40	@	41
Rosin, "F" Grade, 280 lbs.....	Bbl.	12.75	@	13.00
Rosin Oil, first run.....	Lb.	75	@	76
Shellac, T. N.....	Lb.	52	@	53
Spermaceti, cake.....	Lb.	31	@	33
Sperm Oil, bleached winter, 38°.....	Gal.	2.03	@	2.05
Spindle Oil, No. 200.....	Gal.	38	@	40
Stearic Acid, double-pressed.....	Lb.	18	@	18 1/2
Tallow, acidless.....	Gal.	1.15	@	1.20
Tar Oil, distilled.....	Gal.	36	@	38
Turpentine, spirits of.....	Gal.	79	@	80

METALS

Aluminum, No. 1, ingots.....	Lb.	31	@	32
Antimony, ordinary.....	Lb.	7 1/4	@	8
Bismuth, N. Y.....	Lb.		nominal	
Copper, electrolytic.....	Lb.	23	@	nominal
Copper, lake.....	Lb.	20	@	23
Lead, N. Y.....	Lb.	5.00	@	5.25
Nickel, electrolytic.....	Lb.	55	@	56
Platinum, refined, soft.....	Oz.		nominal	
Silver.....	Oz.		1.01 1/2	
Tin, Straits.....	Lb.		nominal	
Tungsten (WOs).....	Per Unit	15.00	@	20.00
Zinc, N. Y.....	100 Lbs	9.40	@	9.60

FERTILIZER MATERIALS

Ammonium Sulfate.....	100 Lbs.	4.75	@	—
Blood, dried, f. o. b. New York.....	Unit	6.00	@	6.25
Bone, 3 and 50, ground, raw.....	Ton	37.00	@	37.50
Calcium Cyanamide.....	Unit of Ammonia		nominal	
Calcium Nitrate, Norwegian.....	100 Lbs.		—	
Castor Meal.....	Unit		—	
Fish Scrap, domestic, dried, f. o. b. works.....	Unit		nominal	
Phosphate, acid, 16 per cent.....	Ton	17.00	@	18.00
Phosphate Rock, f. o. b. mine.....	Ton		nominal	
Florida land pebble, 68 per cent.....	Ton	5.00	@	6.00
Tennessee, 78-80 per cent.....	Ton		nominal	
Potassium "muriate," basis 80 per cent.....	Ton	265.00	@	275.00
Pyrites, furnace size, imported.....	Unit		nominal	
Tankage, high-grade, f. o. b. Chicago.....	Unit	5.00	@	5.50

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VICTORY MEETING AMERICAN CHEMICAL SOCIETY

A REAL VICTORY MEETING

It was indeed a Victory Meeting at Buffalo! From every section of the country there came chemists, men and women, patriotically conscious of great deeds accomplished for the national welfare, inspired by the rapidly rising tide of public appreciation and cooperation, and determined that past accomplishments should prove only a forerunner of still greater things to come.

Numbers, of course, are not the final test of the solid worth of a meeting, but they are strongly indicative. For this reason the record-breaking attendance at the Council Meeting, 92, gave instant conviction that a remarkable week lay ahead. These expectations were fully realized as the registration rapidly mounted from day to day until it passed 1100, thus breaking all records for a Spring Meeting. As a result of this unprecedented attendance all meeting places were filled to overflowing. The exhortation of the evangelist, "Come early if you want a back seat," had no place at this meeting, as the rush for front seats insured promptness in beginning all programs.

The true measure of the meeting lay in the business accomplished and the inspiration imparted to those in attendance. Judged by these standards it was undoubtedly one of the greatest meetings ever held by the AMERICAN CHEMICAL SOCIETY.

Thanks to the new machinery provided through the creation of the Advisory Committee, a mass of routine matter was disposed of at the meeting of that Committee on Monday in advance of the Council Meeting. This gave time and opportunity for deliberation on the many matters which came before the Council. A partial record of this is given in another column.

The presence of representatives of the U. S. Tariff Commission and of the Alien Property Custodian's office gave national significance to the opening session, and intense interest was shown in the debate which developed between Mr. Culbertson and Mr. Choate, following their formal addresses. Evidences of the importance of the divisional meetings were furnished by the complete absence of the "hall bunch," and by the continued discussions following each adjournment. The most salient feature of the divisional programs was the brilliant paper by Dr. Irving Langmuir, which, on request, was repeated the following day before a crowded meeting of the Division of Industrial Chemists and Chemical Engineers.

The scientific and technical tension of the meeting was abundantly and frequently relieved by delightful entertainments and well-managed excursions arranged by the Local Committee, whose superb organization carried out the extensive program so smoothly that everyone became a booster for the Section of Western New York.

Programs for the Fall Meeting in Philadelphia began taking definite shape during the Buffalo meeting. Still greater things are evidently ahead. Let's go!

COUNCIL MEETING

The meeting of the Council was held in the spacious reception rooms of the University Club of Buffalo, with President Wm. H. Nichols presiding. The rare ability of Dr. Nichols as a genial and efficient presiding officer exercised its full influence in carrying through during the afternoon and evening sessions an unusual number of important actions. The lengthy session was relieved by a delightful dinner served in the Club dining room, at which the Western New York Section proved charming hosts.

INTERNATIONAL MATTERS

Among the matters of international bearing acted on favorably by the Council was the recommendation to the members in General Meeting of the election of Professor Giacomo Ciamician, of the University of Bologna, Italy, as honorary member of the SOCIETY, in recognition of his brilliant work in the field of organic chemistry.

The death on April 4 of Sir William Crookes, of England, an honorary member, was announced, and a committee consisting of Drs. Charles Baskerville, A. D. Little, and I. K. Phelps was appointed to draft appropriate resolutions.

Dr. Charles Baskerville spoke of the Ramsay Memorial Fund and urged a generous response by the American chemists to the memorial to this eminent chemist who not only inspired the world by his scientific accomplishments but endeared himself to American chemists by his charming personality.

The action of the Division of Chemistry and Chemical Technology of the National Research Council concerning the publication of compendia of chemical literature was approved. This report appears on page 481, this issue.

The Council also expressed its approval of the steps being taken by the National Research Council for the formation of an International Research Council to which representatives of neutral nations should be admitted on conclusion of peace. Similar action was taken regarding the formation of an International Chemical Council. Details of these two important matters will be found on page 481 of this issue.

NATIONAL MATTERS

As a basis for governmental action the SOCIETY urged the appointment by the President of the United States of a High Commission to formulate a general policy and plan for the coordinated development of the resources of this country. It was the general feeling that only through the creation of such a Commission could the work of the reconstruction period be most efficiently conducted.

At the meeting of the Council in New York City last December the conviction was expressed that in order to develop domestic sources of supply of apparatus and chemicals it was necessary that Congress repeal that section of the tariff legislation which gives to educational institutions the privilege of importing

such material duty-free. To make still clearer the ground on which this conviction was based the Council has now added, by a most emphatic vote, its belief that this duty-free privilege has furnished an important medium for foreign propaganda, creating in the minds of the youth of this country an impression of the superiority of such foreign-made material.

Grave apprehension was felt over the action of the War Department in so quickly demobilizing the Chemical Warfare Service, and a committee was appointed to urge upon the proper authorities the necessity of the continuance, in an intensive form and under a distinct organization, of chemical work as affecting the Army.

The chairman of the Committee on the Census of Imports, and Dr. B. C. Hesse, a member of the Committee, informed the Council of the rapid progress of this work of compilation and announced that the page proof of the forthcoming bulletin of the Bureau of Foreign and Domestic Commerce had been received, and that the bulletin would be available to all in a very short time.

SOCIETY MATTERS

Affecting more particularly the work within the Society's organization, the scope of the Committee on Standard Chemicals was enlarged to include apparatus. The hope was expressed that through cooperation with this committee, manufacturers would be aided in bringing their products to the highest standards.

In order to enable individuals and local sections to cooperate more fully with the various committees of the Society the secretary was directed to print each month in the *Journal of the American Chemical Society* on the fly-leaf immediately following the list of officers, a full list of committees, together with the name and address of the chairman of each.

In connection with the matter of committees, President Nichols announced that committees for the coming year would be appointed at the meeting of the Advisory Committee to be held in New York City on April 26, and stated that suggestions from members as to the composition of committees would be welcome.

The following resolution regarding the publication of papers presented at the meetings was unanimously adopted:

Resolved: The Society reserves the right of original publication in its official journals of all papers appearing on the programs of its general meetings, divisions, and local sections. The editors are requested to inform authors promptly of decision regarding publication of such papers. This decision can be facilitated by authors sending duplicate copies of their papers in advance to the editor of that journal in which publication is desired.

The Secretary is requested to give proper notice of this action by printing this resolution on the preliminary and final programs of all general meetings.

The editors of the Society's journals were instructed to have all foreign language quotations contained in articles submitted for publication translated into English, unless in the judgment of the editor there is a good reason for publication in that foreign language.

The matter of a suitable standard for polariscopes to be manufactured in this country was referred to a

committee which will report at the next meeting of the Council.

The County of Warren, New Jersey, was added to the territory of the Lehigh Valley Section, and the territory in Pennsylvania was arranged on the basis of counties.

Following the favorable report of the committee to which had been referred the proposed by-laws, the Rubber Chemistry Section was advanced to a Division of the Society. This Division is planning an important program for the Philadelphia meeting in September.

As a result of the interest shown in the dyestuffs symposium at the Cleveland meeting, a Dyestuffs Section was created, of which officers were elected as follows: *Chairman:* Dr. Charles L. Reese, Wilmington, Del.; *Secretary:* Mr. R. Norris Shreve, 136 Liberty Street, New York City.

Invitations for the Annual Meeting of the Society in September 1920 were received from the Chicago Section and the Rochester Section. Under the constitution, which prescribes that invitations cannot be accepted more than one year in advance of the date of meeting, action upon these invitations was postponed.

COMMITTEE REPORTS

Reports of all committees were in the hands of the president, and were read in abstract form by the secretary. Of the many important reports submitted, four are printed in full (page 410, this issue).

GENERAL MEETING

The ballroom of the Statler Hotel with its encircling tier of balcony boxes made a fit setting for the General Meeting of the Society on Tuesday morning. Dr. C. G. Derick, the chairman of the Local Executive Committee, presided at the opening. With gracious words he welcomed the members and introduced the mayor of Buffalo, Hon. George F. Buck, who expressed his pleasure and that of his fellow-citizens in having such a body of men as guests. On behalf of the Society President Nichols responded in happy manner—and the game was on.



Courtesy of Buffalo Evening News
PARTICIPANTS IN THE GENERAL MEETING, TUESDAY MORNING. LEFT TO RIGHT: MESSRS. CULBERTSON, NICHOLS, BANCROFT, CHOATE, PARSONS



The chief item of the business session, which immediately followed, was the unanimous election to honorary membership of Professor Giacomo Ciamician, of the University of Bologna, Italy, following the unanimous recommendation by the Council. The heartiness of the vote indicated something more than perfunctory compliment—perhaps it was an echo of that spirit of coöperation which led Americans and Italians to die together on the western battlefield in defense of civilization.

Following the business session, addresses on economic questions affecting the chemical industries of America, particularly the dyestuff industry, were delivered by Dr. William H. Nichols, president of the SOCIETY, Mr. William S. Culbertson, member of the U. S. Tariff Commission, and Mr. Joseph H. Choate, Jr., in charge of the chemical investigations of the Alien Property Custodian's office. These addresses are printed on pages 399 to 405.

Unusual interest was evinced in the address of Dr. Nichols, as it was his first address delivered personally to the members of the SOCIETY, though this is the second year of his presidency, no Spring Meeting having been held in 1918 because of the war, and he having been unable to attend the Fall Meeting in Cleveland because of the unfortunate injury to his leg while on a vacation in Canada. Mr. Culbertson was received as a friend of former days, for his fine address at the Chemical Exposition in 1917 was remembered by all. Mr. Choate, however, was a stranger to most of those present. He had spoken only a few moments, however, before it was evident that he had the meeting with him, and at the conclusion of his address all realized that a valuable addition had been made to the list of those who are seeking to guard the interests of the American chemical industry. At the conclusion of the addresses, President Nichols

suggested that questions from the floor were in order. Many were asked and were responded to by the speakers. The keenness of the impromptu debate between Mr. Choate and Mr. Culbertson brought all forward to the edges of their chairs. Mr. Choate was awarded the popular verdict, as he advocated not only all that Mr. Culbertson did in the way of adequate tariff and effective anti-dumping legislation, but supplemented these by urging further protection of the American industry by a system of import licenses. Three battleships are better than two, the members seemed to think.

The General Meeting was continued at the afternoon session in the auditorium of the Technical High School, the subject being a symposium on mustard gas, under the chairmanship of Lt. Col. W. D. Bancroft. This first-hand information from men who had created the industry in this country aroused great interest, but perhaps chief interest centered in the address of Lt. Col. B. C. Goss, chief gas officer of the Second American Army. The address and its illustration by lantern slides and by motion pictures taken at the front during battle gave a vivid portrayal of the tactics and strategy of gas warfare. Inability to complete this program led to the transfer of many of the papers to the appropriate divisional programs.

DIVISIONAL MEETINGS

The divisional meetings were held in various classrooms of the Technical High School. Information concerning the program numbers of the papers being read in each division was greatly facilitated by the inter-room telephone system, a decided advance over the courier system formerly employed. The complete program of the several divisions is printed on pages 480 and 481 of this issue.

In the Division of Biological Chemistry a lively



discussion was held, which can easily be understood in view of the fact that Col. Bancroft and Dr. Clowes were present.

In the Division of Industrial Chemists and Chemical Engineers a new departure was made in the form of a symposium on Library Service in Industrial Laboratories. An informal symposium by members of the Industrial and Organic Divisions followed the formal symposium on the Future of Certain American-made Chemicals. This subject is discussed in an editorial in this issue, page 419, entitled "Rocks Ahead."

In the Division of Pharmaceutical Chemistry an interesting discussion was held on the subject of Possibilities in Drug Research. By unanimous vote the Division adopted the following resolution:

Resolved, That the Division of Pharmaceutical Chemistry is heartily in sympathy with the movement to establish an institute of drug research and pledges itself individually and collectively to do all in its power to further this end.

PUBLIC MEETING

On Wednesday evening the auditorium of the Hutchinson High School was crowded to hear the address of Dr. Edgar Fahs Smith, Provost of the University of Pennsylvania. As Dr. Smith rose, following his introduction by President Nichols, the entire audience rose and cheered, thus testifying to the love and esteem for the former president of the SOCIETY. Under the thrill of his stirring peroration the audience again rose in token of appreciation of his message. His address is printed on pages 405 to 410.

SOCIAL FEATURES

The social features of the week were admirably planned and carried out in a manner full worthy of the reputation of the Section of Western New York for geniality and good fellowship.

Under the experienced leadership of Buffalo's distinguished citizen, Mrs. John Miller Horton, the ladies were given a round of entertainments in the various clubs, which left no dull moments on their hands.

For the men, chief interest centered in the smoker on Tuesday evening. Advance reports had leaked out of the lavish preparations, both of roasts and refreshments, for this event. It was therefore with feelings of keen anticipation that the members gathered together early, adorned, on entrance, with fancy paper caps. Just to the left of the stage, behind a protective barrier resembling a pulpit, sat his reverence, Mr. L. E. Saunders, whose never-ending stream of loquacity gave ample opportunity for the display of his native wit and at the same time served as a filler whenever it was necessary to reset the stage, with its complicated array of ultra-modern testing apparatus. Conveniently near the stage was an orchestra of "our own" and a chemists' glee club, which would have filled with envy the leaders of great choral societies. "It sounds feasible—absolutely." From the snappy glance of Mr. F. A. Lidbury's eye it was not hard to guess whose mind had planned the varied program which followed. Roars of laughter greeted the many quips in song and story, while the revelations of the psychological tests exhibited on apparatus new to all were such as to give new light on many hitherto unknown traits and tendencies. It was some smoker, believe us! In the midst of the fun an unexpected turn was given by the presentation of a silver loving cup to Dr. John A. Miller by the members of the Local Section. Dr. Miller responded in words that showed how deeply he was touched by this beautiful evidence of the love and esteem of his colleagues.

On Wednesday evening the Council was entertained at dinner by the authorities of Canisius College,

with Father Ahern acting as host. All present agreed that this dinner was one of the jolliest and happiest events of the meeting.

During the forty-eight hours intervening between the smoker and the banquet, Mr. Lidbury had time to transform himself into the dignified toastmaster of a banquet which filled every available table. The chief speaker was Mr. Samuel Botsford, president of the Buffalo Chamber of Commerce. Mr. Botsford was evidently at home in this rôle, for his light railleery captivated all and led him naturally into an earnest and serious discussion of the repression of Bolshevism in this country. One flippant diner suggested that after all perhaps Mr. Botsford was not discussing real but near-Bolsheviks, like Saunders and Lidbury, who, at the smoker, had destroyed every good man's reputation. Under the summons of the toastmaster five-minute addresses (strictly by the bell) were made by representatives of the various local sections. To cap the climax of unexpected events, the toastmaster, happily broke all precedents and established Mrs. John Miller Horton as the pioneer woman speaker at a banquet of the AMERICAN CHEMICAL SOCIETY. The time was propitious, for Mrs. Horton responded in an inimitable vein and brought the conviction that the latter-day woman (we won't say modern) can meet any call made upon her.

EXCURSIONS

The varied character of Buffalo's industries gave ample opportunity for a diversified program of excursions. Early in the week the Division of Water, Sewage, and Sanitation inspected the Buffalo Pumping Station and Chlorine Treatment Plant. While there was no water on the program of the local committee, still as this excursion was on Wednesday, the day after the night before, we suppose this one break in the program was condonable.

The chief event of the excursions was reserved for Thursday afternoon. Through the courtesy of the citizens of Buffalo an imposing array of automobiles was provided for the trip through the city and visits to the plants of the National Aniline and Chemical Co., Inc., and the Buffalo Foundry and Machine Company. Under the skilful guidance of the well-coached and courteous guides provided by the National it is a safe bet that none who had visions of cunningly acquired information as to secrets in methods of manufacturing dyestuffs found such visions realized. The Buffalo Foundry and Machine Company had made model arrangements for the visit to their plant. There were no secrets there, and the sight of the preparations for the massive castings and the festive journeyings of the huge ladles of molten iron proved fascinating to all. Heartiest congratulations to Messrs. Miles and Rippel and their associates for the thorough arrangements! By means of the arrows directing the flow of foot traffic you couldn't get lost, even if you tried, while the booklet with descriptions of the prominently numbered pieces of machinery gave opportunity for a liberal education in large-scale chemical apparatus.

Inside these two plants one could not repress the

thought that the ground was historic, for each has played so important a part in the romance of American chemical development during the war period.

During these excursions another innovation was made, consisting of the movie-man with his camera. What effect the chemist as such will have upon a film remains to be seen. At any rate the movie-man felt that the public should know something of the personality of the men who have been doing the real stuff for the country's welfare.

Friday was devoted entirely to excursions. In spite of the steady rain of the early morning, large groups assembled for the excursions to the plants of Spencer, Kellogg & Sons, Pratt & Lambert, the Larkin Company, the Lackawanna Steel Company, and to Niagara Falls. A special feature of the visit to the Falls was the complimentary luncheon tendered by the Niagara Falls Chamber of Commerce, whose president and Mr. Walter Wallace extended a hearty welcome to the visitors. In the auditorium where this ceremony took place, Mr. Frank Low had arranged an attractive display of the products manufactured at Niagara Falls. Particularly instructive were the charts on the walls showing by whom these products were manufactured and in what industries each was utilized. What matter if, because of former sad experiences, the plants themselves were closed to us! The main thing is that they told the story of the greatest electrochemical industry in the world, one which had served this country so thoroughly and so importantly during the days of great preparations for a world war. If copies of those charts could be hung in every schoolroom in America we would be a wiser and a safer nation.

AN APPRECIATION

It was our good fortune to be in Buffalo a few hours after the final excursions were completed. Chatting with members waiting for trains and with members of the Local Committee who were on hand to see to everyone's comfort and happiness up to the very last moment, one could not fail to be impressed with the thorough manner in which every detail of the meeting had been attended to by those in charge of the meeting. The Local Committee consisted of

C. G. DERRICK, Chairman, Executive Committee
J. F. SCHOELLKOPP, Treasurer, Chairman, Finance Committee
E. K. STRACHAN, Secretary, Chairman, Registration and Information Committee
D. H. CHILDS, Chairman, Arrangements for Meetings
W. H. WATKINS, Chairman, Excursions and Exhibits
A. M. WILLIAMSON, Chairman, Sub-Committee, Niagara Falls Excursion Committee
JOHN A. MILLER, Chairman, Hotels Committee
F. A. LIDBURY, Chairman, Smoker Committee
WALTER WALLACE, Chairman, Banquet Committee
F. S. LOW, Chairman, Sub-Committee on Niagara Falls Exhibit Committee
H. G. SAUNDERS, Chairman, Publicity Committee
D. W. SOWERS, Chairman, Invitation Committee
MRS. JOHN MILLER HORTON, Chairman, Ladies Entertainment Committee

These were assisted by G. P. FULLER, L. E. CHAMBERLAIN, H. S. LITCHENBERG, A. C. PARSONS, R. E. FOWLER, A. F. SNY, E. B. STEIGENS, A. H. HOOKER, F. S. TONE, L. E. SAUNDERS, LEE SMITH, and E. G. RIPPET.

The work of the committee was made particularly difficult by the fact that only ten per cent of those in attendance had notified Secretary Parsons, on the

blanks mailed to each member for that purpose, of their intention to attend. This fact fully justified the appeal of the secretary during the meeting that in the future members give notification of such intention whenever possible, so that our hosts may have at least an approximate idea of the scale on which preparations for the meeting should be conducted.

THE CHEMIST AND RECONSTRUCTION

By WILLIAM H. NICHOLS, President, American Chemical Society

In accordance with the plans outlined by the Council at its December meeting, the Spring Meeting of this Society, now beginning, will devote itself in particular to questions of reconstruction facing us at the termination of the most destructive war that the world has ever seen. The solution of these questions will influence for good or evil the next century of the world's history. The chemist will have a very responsible part not only in the discussion, but in the work which will follow; and it is, therefore, with feelings of earnestness, soberness, and eagerness that we should approach the deliberations of the coming days. In all human probability, it will not be long before terms of peace have been agreed upon, and peace itself take the place of the unspeakable horrors of the years since August 1914. During that period, every public and private interest has been subordinated to the one question of winning the war for right and justice, thereby providing the firm foundation on which to build for the future. All over the world, civilized and uncivilized, there has been derangement beyond conception, and the first part of the reconstruction problem is to get back as soon as practicable to an approximation of the conditions of five years ago. Aside from the impossibility of restoring the millions of human lives which have been lost, and the other millions which have been tortured, and homes made desolate, the question of destruction, wanton and otherwise, of untold billions of dollars of property, cannot be adjusted by resolutions to be good in the future, even though regret for the past be honestly felt by the chief sinners, which I fear is not the case. The property has been destroyed and most of it can never be replaced, but out of it all has come the victory of liberty and freedom, the fruits of which if wisely directed will bring a new and better era to the world. Conversely, if directed unwisely or selfishly, we will have a new era just the same, but one which may put civilization back a hundred years.

We will be falling far short of a proper understanding of the difficulties and needs for reconstruction if we consider the task simply of putting back what has been displaced. We might just as well meet the matter fairly and squarely by recognizing at the outset that the world can never go back to where it was five years ago; too many things have happened in the interval, and too many thoughts and ideas have been in process of development during the preceding fifty years. A revolution has taken place, none the less effective because so much of it has been below the surface. It is perfectly true that a number of pressing matters on which the very life of the people depend must be settled, at least temporarily, before we can begin to live even ordinary lives, but we must not deceive ourselves with the thought that having temporarily settled these matters the whole question is out of the way. Let us set ourselves to briefly consider some of the forces that have been at work during the last half century, with the knowledge that whatever form of reconstruction the future has in store, these things cannot be left out of our calculation. Let us look at a few of the elements of this quiet revolution, in order that we may not be taken unawares at a later period by the inrush of some crushing force of whose existence we were wholly ignorant.

Enormous sums have been added to public debts during the last five years, but we must not forget that during a long preceding time this condition of mortgaging the future has been in somewhat steady and continuous practice. I have seen it estimated that public debts of countries and municipalities to-day exceed \$315,000,000,000. I do not know how correct that estimate is, but I imagine it is below rather than above the mark. That is what the future has got to pay for what the past, including this terrible war, has done for it. Any honest consideration of reconstruction must contemplate a gradual lowering of this terrible debt, and its ultimate extinction. We have used a large part of our assets, and have gone in debt doing it—not good business practice you will agree, but one in keeping with age-long traditions.

An unknown force confronts us in this country by the gradual growth of sentiment which has resulted to a large degree in giving the vote to women. The question is not whether they are qualified to vote, but rather what will they do with the vote, and what effect will it have on our public life? As far as we have gone, it does not appear to have produced any startling changes in results, but I am not so sure that it will not eventually produce changes that will surprise us. Whatever the effect, it is a new and a little understood question, and must be taken into very careful consideration. Allied with this is the forced necessity of employment of women, in many instances to do the work previously done by men. Our experience of this phase has not been nearly as extensive as that of some of our allies, and yet the question is here, and has got to be considered if we are to make correct diagnosis of the future.

Employers of labor have realized for a long time that they have a problem to solve which is not an easy one. It is perfectly clear that we have passed the stage of public enlightenment which justified the employer, in his own mind at least, of looking upon his workmen as so many hands. It seems likely that the swing of the pendulum has carried it to the other side in which labor feels its ability to lead rather than follow. One of the greatest problems in the reconstruction period will be to find the point where both sides (if we can properly use that term) are fairly and justly treated. We have accustomed ourselves too much, I think, to consider the rate of wages paid to workmen as differentiated from the results the payment of a dollar will produce. We have got to learn, if we have not already done so, that labor efficiency is of much more importance than the rate of wages. The problem, therefore, must be solved not by one side yielding to the other, but by both meeting on terms of mutual friendship and understanding, so that the employer can pay the largest possible share to labor which, on its part, is rendering the largest possible amount of return. When this happy state is reached, it will be found, in my opinion, that labor in this country will receive higher reward than anywhere else in the world, and the employer of labor will at the same time be able to compete with any country in the world.

A careful study of this question cannot be made without due consideration being given to the change in the character of our population within the last fifty years, rendered inevitable by the large influx of immigrants, many of whom have remained to become incorporated into our body politic, but many of whom, I fear, have not lost the old world notions which they brought with them and which they strive, by unlawful methods, to force upon the freest people on the planet.

One of the recent questions which has unsettled our minds, as much as almost any other, has been the apparent necessity of the Government taking over the management of railroads and other public utilities. While this was done doubtless as a war measure, although it had been long in the air, there is an overwhelming feeling that we have had enough of it. This is a question which must be decided promptly and for all time.

It does not stand alone, but is part of a larger question, namely, whether ours shall be a government "of the people, by the people, and for the people" or something sadly different.

For many years, there has been a feeling, shared by a small but respectable minority, that the manufacture and sale of all alcoholic beverages should be prohibited. Suddenly, and to the surprise of the country, our Constitution has been amended to that effect, and whether it be the will of the majority or not, prohibition is in sight. This is no place to discuss the morals of that question, or whether light wines and beer should be excepted. It is the place, however, to point out that alcohol has many uses of great importance entirely aside from its occurrence in beverages. It is essential in so many of the arts and manufactures that a list of them here would be tiresome, even if it were not already well known to you. To any one not familiar, I recommend a study of an excellent chart prepared by the Industrial Alcohol Company. I hope that in the reconstruction period, no legislature can be fooled into forgetting this fact, or making it more difficult for the chemist and manufacturer to obtain at reasonable cost this highly important raw material.

We have heard much in recent years on the general subject of conservation of natural resources, including the utilization of our water powers. This has had the effect of bringing the importance of this question more or less to the attention of a great many people, but it has not yet led to a thorough appreciation of the vital importance of close attention to making the most of what we have left, after the extravagant uses to which we and our forebears have made of these resources. Petroleum, natural gas, anthracite coal, forest products, and ores of all kinds, hitherto considered to be inexhaustible, we now realize have very decided limits. Most of these when once taken from the ground can never be replaced, but this is not true at least of our forests or our water powers. Yet what have we done to replace the tremendous waste which our utilization of our forests has witnessed? In our reconstruction of the future, we should not only see to it that we use no ores or fuels wastefully, but that our forests should be regularly and methodically replanted and thus, climatic changes prevented, while forest products are produced sufficient for all needs.

Particular attention should be paid our magnificent stores of sulfur which, in spite of apparent abundance and cheap production, should be conserved to the extent that they should not be used where any other form of the element, such as pyrites, blende, etc., can fulfil its functions. At this stage of knowledge, the world should be too intelligent to wait until it has used up its resources before it awakens to the fact that the damage has been done, and nothing is left but to mourn. The reconstruction period will see a great deal done in lines of conservation, and it is on these lines in particular that the chemist will find his opportunity.

We hear a great deal about the unrest of the masses which comprise many of the workers, and much fear is entertained about what this will lead to. There are various reasons for this unrest, and some of these point to unfairness of certain employers of labor, particularly in the past. There is something in this, but not as much as many suppose. The condition of the worker and his reward have been steadily improving for as long as I can remember, and yet we hear of unrest. You ask why, if the present system results in continuous improvement, should it be changed for something which, as far as evidence shows, produces nothing but sorrow and destruction? I think the answer to the question will be found in the propaganda of men and women who can make an easier living by talking than by working. During the reconstruction period, we must learn how to prove conclusively that our present civilization is based on justice and equity for all and thereby nullify much of the eloquence of the professional agitator.

There are many conditions, not enumerated, that have been quietly developing during the past fifty years, but I have cited enough to indicate the size of the task before us. It is a man's job. All can help who will, by the practice of very old virtues, which never need reconstruction, such as thrift, prudence, and regard for the rights of others. But the chemist can do all of these and much more, which no one else can do. Let him think of the factories to be run on constantly improved methods, the farms and enterprises of all kinds to be made more productive, the wonders to be unbarred by research, the future of the whole world to be ameliorated and broadened by his discoveries, and he may well feel proud of his profession. Joined in a great society like this, with twelve thousand of his fellows, no task should daunt him. He has not failed hitherto; he will not fail in performing his unique and absolutely essential part in solving the problems facing the world.

AMERICAN CHEMICAL INDUSTRIES AND THE TARIFF COMMISSION

By WILLIAM SMITH CULBERTSON

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The two outstanding general forces that operated during the war to modify and, in some branches, revolutionize the American chemical industries were the isolation of the Central European Powers which cut off their overseas trade and the enormous demand for chemical products in the prosecution of the war. How far-reaching these influences were I need not discuss in detail before this learned society. You are more familiar with them than I, and your work has been a determining factor in assisting our industries to meet the crises through which we have passed. The American public now realizes as never before that the chemical industries are in many particulars essential in the pursuits of both war and peace.

Of the industries affected by the war conditions, the coal-tar dye industry is the most familiar to the general public. The months of famine which followed the last direct shipment of dyes from Germany in March 1915 were more potent arguments for the diversification of American industrial life than a flood of oratory. An infant industry came into being and thrived under the protecting influences of the restrictions on the commerce of foreign competitors. The new industry has shown some of the failings of youth, but it cannot be gainsaid that it has met the situation and that to-day the production of intermediates and dyes represents an important American industry.

Not so spectacular but nevertheless significant was the development under the war influences of many other chemical products—potash, synthetic nitric acid and ammonia, barium salts, synthetic phenol, thorium nitrate, phosphorus, oxalic acid, and chlorine and its products. The natural disadvantage under which some of these products—potash, for example—are produced, makes their production in the United States in the future highly problematical. Others, however, will remain a permanent and important part of our industrial life. Thorium nitrate represents an interesting case of the effect of the removal of German competition. With the exception of the thorium nitrate produced by one large-scale manufacturer of incandescent gas mantles for his own use, our supply formerly came from Germany. But at the present time the monazite sand of Brazil, which before the war was shipped to Germany and there by complicated processes converted into thorium nitrate, is now shipped direct to this country and is being consumed by our own enlarged industry. Such changes as these had taken place in our industrial structure before April 1917. Our entrance into the war brought added complications. War restrictions in some lines delayed development or diverted energy. The progress of the new dye industry was, for example, hampered

by scarcity and high prices of raw materials; especially was this true in the case of toluol. In other lines, there was an unprecedented stimulus of production. The Government demand for explosives and other chemical products was heavy. Old industries expanded to meet the emergency. New plants were erected by private companies and by the Government. Nitric and sulfuric acids, acetic acid and acetone, phosphorus, and chlorine and chlorine products were produced in enormous quantities.

ADJUSTMENT TO NORMAL TIMES

No industries, taking the world over, have been as profoundly modified by the war as have the chemical industries. Changes have taken place not only in the United States but in foreign countries. German chemical industries have been drawn into an even closer business combination than existed before the war, and they have doubtless made progress in technical research and mechanical processes. Although they will suffer from the crisis through which Germany is passing, they will adjust themselves more readily to normal times than the German textile and steel industries. In other countries the same influences which established new and expanded old industries in the United States were operating. Norway, Japan, Canada, and particularly Great Britain have made great progress in many chemical lines and, now that the war demand has ceased, are seeking new markets for their increased productive capacity. The same forces, therefore, which have affected our chemical industries constructively have raised up competing firms in other countries and an era of severe competition is unquestionably ahead. This situation requires, in the first place, a reconsideration of measures of commercial policy, and in the second, a careful investigation of the facts.

MEASURES OF COMMERCIAL POLICY

Let me turn your attention then to some aspects of commercial policy as they relate to our chemical industries. So fundamental were the changes wrought by the war that a measure entirely adequate to pre-war conditions cannot be assumed to meet our present needs. In the field of chemistry the war solved some problems, modified others, and created still others. It is peculiarly our task to face the new situation squarely and to consider the proper answers to the pressing questions before us. I am sure that you realize better than anyone else that the future of the chemical industries of the United States depends primarily upon the research work of chemists, the designs of engineers, and the organizing skill of business men. Industries which do not show vitality and growth in these respects should not be maintained by legislation. With this qualification, however, national policy warrants the enactment of tariff and unfair competition laws which will enable essential and desirable industries to become an effective, permanent part of our industrial life. The *laissez-faire* attitude has no place in the reconstruction period.

THE TARIFF ON CHEMICAL PRODUCTS

Among the most—perhaps the most—urgent tariff problems which Congress will be called upon to consider fall within the chemical schedule. The reason for this is obvious. The war's effect was, as I have suggested, more revolutionary among the chemical industries than elsewhere. I wish it were possible for me to discuss a number of chemical products worthy of consideration but this cannot be done within the limits of this address. Not all the items in the chemical schedule have an equal claim to legislative assistance. A few have none. Each should be considered on its own merits, keeping in mind the advantages of production, the availability of foreign supply, the needs of the American consumer, and the diversification and development of the structure of our industrial life. I shall speak specifically of the industry producing coal-tar products, for I regard it as a clear case deserving of legislative help.

Before hostilities ceased, Great Britain had declared the industry producing synthetic dyes essential to her national well-being. For its protection she has made a radical departure from her traditional policy of *laissez faire* in trade. She has provided state aid for the dye industry in the form of loans and grants for buildings and research. The importation of all dyes is prohibited except under license granted by a licensing committee. No dye is to be imported which the domestic industry is able to supply or for which an adequate substitute is made in the country. I believe that such a plan has been suggested as desirable for this country. For my part, I cannot regard it with favor. In Great Britain the plan is in the early stages of experimentation. There the firms are comparatively few and the government is closely associated with them in the enterprise. In the United States our industry is too diversified and varied, the problems of administration too vast, the political considerations too uncertain to warrant meeting the dye problem with prohibition, importation licenses, and direct federal supervision.

The alternative is a tariff which will equalize, with a fair margin, the conditions of competition between this country and abroad. The rise of the dye industry has given a new significance to the "infant-industry" argument for the tariff. In many phases of research and engineering, this industry in the United States is in the experimental stage. The selling of the German patents to the Chemical Foundation, Inc., by the Alien Property Custodian is of great assistance but we are not as yet in a position to compete on an equality with the old well-established concerns abroad. It is first necessary to determine by tireless and expensive experiment the best conditions for the manufacture of each product and to train a staff to put into effect the results of such experimentation. Although American chemists deserve congratulations on their success in making so many varieties of dyes, nevertheless, many important and much-needed dyes are not yet being made in the United States. An encouraging sign is that the American dye industry is not slavishly following the methods of Europe. Already American chemical engineers are installing larger units than were ever used abroad. Mechanical stirrers are replacing hand stirrers and pipe lines are replacing buckets. In the end American mechanical genius will surely bring supremacy in the design and operation of equipment. An insight into the structure of the molecule, such as comes to a chemist only after long training, is necessary to make new dyes which will surpass the products of nature in quality. The rapid progress of this new dye industry is sufficient proof that America possesses chemists of a caliber to win success in this more difficult field. The American industry, however, cannot be expected to do in four years what Germany has done in forty years. During its development even the advocate of free trade would admit that the new industry is entitled to legislative consideration. Assistance to the dye industry may also be justified, from a national standpoint, on the ground that the industry is essential to both our military and industrial organization. It is well known that the preliminary processes for making certain dyes and high explosives are identical and that the machinery and technical staff of a dye plant may with comparative ease be turned to the production of explosives. The war has taught us also that it is not a wise policy to have our great textile and other dye-using industries rely wholly on foreign sources for their dyes. Finally, I regard the dye industry as necessary to the normal development of our industrial life. Diversification of industry develops the productive power of our nation. It awakens the spirit of invention and enterprise. It calls into play latent talents. The progress of the dye industry has demonstrated how these conditions come about, and I believe that we should recognize and maintain the industry as a desirable and permanent part of our industrial structure.

UNFAIR METHODS OF COMPETITION

A tariff designed to maintain American industries—not only the dye industry, but others equally entitled to consideration—should be supplemented with laws carefully devised to prevent unfair attacks on them against which a tariff, unless it is prohibitive, affords no safeguard. A reasonable tariff and adequate legislation against dumping and other unfair practices go together. Unfair competition—commercial bribery, deceptive labeling, full-line-forcing, and other practices—can be prevented by our courts and particularly by the Federal Trade Commission in all cases where the offending parties can be reached by legal process. It is not these cases which are grounds for concern. It is those directed by individuals in foreign countries beyond the jurisdiction of our domestic tribunals. Dumping, that is, selling in this country at a price less than that which prevails in the country from which the goods are exported, and similar practices can often be dealt with only by means of additional tariff duties or prohibition. For years our law has provided for countervailing duties to be levied on bounty-fed products which are imported into the United States. These afford protection against one form of dumping. In the Act of September 8, 1916, a provision for a double duty, to be assessed against goods improved under a full-line-forcing agreement, was enacted. At the same time an attempt was made to deal with the dumping evil. It was declared criminal to dump goods systematically into the United States with the intent of destroying, injuring, or preventing the establishment of an American industry. But some additional measures are needed.

Canada was a pioneer in the enactment of anti-dumping legislation. Her act provides that in the case of articles exported to Canada of a kind made or produced in Canada, if the export or actual selling price to an importer in Canada be less than the fair market value of the same article when sold for consumption in the country whence exported, there shall, in addition to the regular duties, be levied, collected, and paid a special duty. Effective administrative machinery has been devised for enforcing this law. It is comparatively simple and in Canada has proved effective. It is, however, inflexible and tends to increase the burden on the Canadian consumer beyond the point necessary to protect the Canadian producer.

Another method for handling dumping is suggested by the inadequate American legislation of 1916. In order to be effective this law should be modified both in substance and procedure. At the present time it prevents only those forms of dumping wherein the intent of the foreigner is to destroy or injure, or prevent the establishment of an American industry. It should cover, however, not only such intentional unfair acts of foreign competitors but also all selling in the United States at prices below those that prevail generally abroad. When an American producer is injured it makes no difference to him what the intent of the foreign rival is. The result only is significant. In procedure, also, this law of 1916 should be more flexible. At the present time the law makes criminal the type of dumping which it prohibits and places its administration under the Department of Justice. There are objectionable cases of dumping, however, which cannot be proved under the strict procedure of criminal law. Nor is it always possible to bring the offending party before our courts as he may be in another country. The criminal provisions of the law should be supplemented by a law which would authorize the President to levy by proclamation additional duties on goods which are being systematically dumped into the United States, or to prohibit their importation, in case he has reason to believe that the result will be to injure, destroy, or prevent the establishment of an American industry. The law might also be made to cover other unfair practices, such as full-line-forcing and deceptive labeling,

which are only partially provided against now. The United States Tariff Commission, already authorized to investigate dumping, should be designated to hear and consider complaints and to report its findings to the President for his consideration and action. A law containing these provisions would be more flexible than the Canadian method. It could be adapted in its administration to meet effectively every objectionable case. This power to prevent unfair practice by proclamation at the discretion of the President, together with the power of the Federal Trade Commission to prevent all unfair methods of competition done by persons who can be reached by its legal processes, should provide sufficient security for American industry and prevent effectively all unfair attacks upon it.

INVESTIGATIONS OF THE TARIFF COMMISSION

The new conditions in the chemical industries which confront us require not only a consideration of policy but, as I have said, an investigation of the facts. The Tariff Commission has undertaken this task. We are collecting and analyzing data on the chemical industries in so far as such information bears on tariff and kindred subjects. We need the coöperation of you and of every manufacturer and chemist. Conditions in the country—both political and economic—led the Tariff Commission, soon after it was established, to give an important place to the investigation of coal-tar products. Our reports, already published, have dealt with two aspects of the problem arising out of the dyestuffs tariff act of 1916. We were directed by the President to take the census of intermediates and dyes which will assist him in determining whether the special rates provided in the present dyestuffs tariff are to continue in effect after the expiration of the five-year period (September 8, 1921). Our investigations were then directed toward improving the classification and making more effective the dyestuffs tariff act of 1916. Our report on this subject is now before Congress. It discloses many ways in which the obvious intent of Congress in passing the act of 1916 can be evaded. It suggests forty-five amendments to the law which we believe will improve the classification, prevent evasions, and assist in curbing unfair methods of competition. When Congress takes up the revision of the tariff on intermediates and dyes, this report will provide the structure of the law framed with scientific and technical accuracy.

The chemical investigations of the Tariff Commission, however, have not been confined to coal-tar products. The wider problem of the reclassification and revision of the whole chemical schedule of the tariff act in order to meet the conditions of the reconstruction period has been constantly before us. We have in our files, available for the use of Congress, valuable information on many branches of the chemical industries. We have prepared for early publication reviews of different phases of the chemical tariff. One of these reports, for example, dealing with a group of acids covered by paragraph 1 of the tariff act is practically ready for the printer. It contains discussions of boric, formic, oxalic, citric, lactic, tartaric, tannic, gallic and pyrogallie acids.

In the case of each commodity or group of closely allied commodities, we have prepared an industrial survey. These constitute the chemical section of our tariff information catalog. In each of the encyclopedic units we have attempted to assemble and to edit carefully the available information which is pertinent in tariff making. Statistics on imports, exports, production, and prices are, of course, being arranged in a readily usable form. The nature and sources of raw materials, a brief non-technical discussion of the processes of manufacture, and the uses of the commodity are stated. In addition, there is a review of the competitive conditions in international trade, a discussion of the tariff history, and a compilation of the treasury and

court decisions relating to each article. A large number of these surveys are completed or in process of preparation, but much remains to be done. Completed surveys include most of the heavy chemicals, chlorine products, fertilizer materials, wood distillation products, sulfur, barium salts, thorium nitrate, and many drugs.

PROJECTED INVESTIGATIONS

For many articles these industrial surveys will provide adequate information for the tariff maker. Policy and sometimes the amount of tariff, if any is to be levied, can be determined from the careful analysis of the chief facts of production, trade, and consumption. In the case of other articles, however, these surveys are not sufficient. A more detailed investigation is necessary, particularly on contentious articles. The Tariff Commission is, therefore, taking steps to investigate domestic costs and domestic and foreign prices of certain chemical products. We realize that the problem of coal-tar products—to take a specific case—is not completely solved by showing, as we have done, how the present law may be made more effective. Congress may think that conditions require a revision of the tariff rates. Costs and prices have played a large part in American tariff controversies. I consider the comparison of domestic and foreign costs or of domestic costs with foreign prices of primary value in tariff making, for they enable the rates to be made to equalize effectively conditions of competition between the United States and abroad. The investigation of domestic costs alone, even, has its value. It did not seem wise to the Tariff Commission to undertake during the war extensive cost investigations. Conditions were abnormal and the results would have been of doubtful significance. We are now, however, beginning to make plans for analyzing the basic facts of certain industries by studying costs and prices. Unfortunately, it will not be possible, except in rare instances, to ascertain foreign costs. Although desirable, foreign costs are not indispensable. If we have domestic costs properly subdivided into raw materials, labor, and overhead expenses, including depreciation, they and known prices of raw material, wages, and other expenses in foreign countries may be used as a basis for estimating foreign costs. Then, too, the value in tariff making of a comparison of domestic costs with foreign prices must not be overlooked. It is the foreign price not the foreign cost with which the domestic manufacturer has to compete. But we must know the domestic cost in order to know what tariff is necessary to enable the domestic industry to compete on an equality and stay in business. A study of domestic costs will also be valuable in determining the proper relationship of tariff duties on allied products. For example, a cost study will assist in determining the relation between the duties on intermediates and dyes, and it may disclose the necessity of dividing these products into subgroups carrying different rates of duties.

The appropriation of the Tariff Commission is at present on a wartime basis. We hope and expect that after July first funds will be available which will enable us to begin cost and price investigations on a fairly comprehensive scale. Much preliminary work, however, may be done in the meantime. It is here we need your counsel and cooperation. You will, of course, appreciate that it is not sufficient to secure merely total costs. It is essential to subdivide material, labor, and overhead costs. Considerable detail even in the cost of materials is essential in many cases where the raw material is an imported article, in order to determine the proper relationship between the duty on the raw material and the finished product. Citric acid is a case in point. Citrate of lime from which the acid is made comes almost entirely from abroad. The tariff duties on these two related products can be determined satisfactorily only when we know the yields of citric acid from a unit of citrate of lime and also the portion of the total cost charged to raw

materials. In many cases, such as the manufacture of caustic soda and chlorine, joint products are secured from the same raw materials and operations. The ratio to be used in subdividing the joint costs to the different products is largely arbitrary. We have found that different companies use different ratios. If one of the joint products is sharply competitive in the international markets and the other is not, the ratio used in determining the cost of each becomes of great significance in tariff making.

Still another perplexing problem is the best way to bring the results of our investigations to the attention of Congress without disclosing publicly the cost data of individual manufacturers. We hope to work out a plan of stating the unit costs in the form of averages or ranges without disclosing the figures of individual companies. A general statement may also be made showing the fraction of the total cost chargeable to labor, materials, and overhead. The selection of the products to be investigated constitutes another problem. We are agreed that a representative list of intermediates and dyes should be studied but which particular intermediates and dyes are to be selected is still an open question. Other products for detailed investigation will probably be chosen from this list: barium salts, thorium nitrate and incandescence mantles, citric acid, caustic soda, and chlorine and chlorine products.

The Tariff Commission is fully conscious of the difficulties which lie in the path of the proposed investigations of costs and prices. I have suggested only a few of the industrial and accounting questions involved. We need—we invite—the cooperation and active assistance of the chemists and manufacturers whose closeness to the problems makes their advice invaluable.

A PROBLEM OF THE PRESENT

Let me, in conclusion, emphasize the pressing importance of the situation in which the war has left the American chemical industries. That it be met promptly and adequately is necessary not only because men have invested, chemists have investigated, and labor forces have been assembled and trained, but also because many of these industries are essential, vital parts of our industrial life. I have endeavored to make clear the measures of commercial policy which should be adopted and the lines of investigation which should be pursued. The determination of the former, I need hardly state, rests with Congress; the latter is the peculiar task of the Tariff Commission. You may be assured that so far as we can we shall do our part in this important work of reconstruction.

GERMAN METHODS AND OUR PRESENT SITUATION

By JOSEPH H. CHOATE, JR.

Alien Property Custodian Office, Washington, D. C.

I come before this formidable gathering to-day with trepidation. It is a bold and brazen man, in this day of specialization and division of labor, who brings coal to Newcastle, and that is what you have asked me to do. There can hardly be one among you who does not know from personal and often bitter experience, more about German methods in the American chemical industry than I do. All that I can offer is a sketch of the general view obtained by us in the Alien Property Custodian's office, with the hope that though each of you knows some of the facts better than we, each will still find in it something unfamiliar.

At the outset we were in a state of lamentable ignorance. None of us knew dyes from inks, or sulfo-acids from sulfuric acid. We know little more now of the technical side of the industry, but thanks to the patriotic labors of many of you gentlemen (notably your past president, Dr. Herty) who sacrificed no end of time and toil in the Herculean task of educating

us, we finally learned enough to understand and piece together the main facts in the vast masses of information which were placed before us.

Of course we instantly saw that the whole industry was permeated with German influence, that German chemists were ubiquitous, and that the myth of their superiority had been so industriously propagated that it had become almost an article of the American business faith. Most people (especially those who knew nothing about it) thought that nothing chemically good could come out of any other country than Germany. Nevertheless there was a surprising lack of apparent German ownership. The law required, under stringent penalties, immediate report of all such property, yet months after the passage of the Act, only a negligible few of such reports had been filed. The Hun ownership seemed to have evaporated. This, however, did not stop Mr Palmer or Mr. Garvan for an instant. They commenced to dig, and called me in to man one of the shovels, and in the end we rooted out a mass of hidden property sufficient to have gravely endangered the industry if it had remained undiscovered.

From the first our efforts were centered on the dye industry. The other branches of the profession, except that of pharmaceuticals, which was closely allied with dyes, seemed as a whole safe, and genuinely American, and while we did eventually detect and take over a few large concerns in this field, like, for instance, the Heyden Chemical Works, it did not worry us. The dye industry, however, did. Our national manufacture in this line had been for years a puny and delicate infant, wholly at the mercy of the Hun. It had been allowed to do no more than finish or assemble German intermediates, and though, since August 1914, its growth had been phenomenal, we felt that its hold on life was of the feeblest. No one could study it as we did, for even a single day, without seeing that it was indispensable to other industries producing billions of dollars' worth of goods each year; that it only could insure to us, in war, adequate supplies of explosives; and that it alone offered, in and by its immense research requirements, insurance of the progress of the country in industrial and medical science. No one could see it as we saw it without coming to believe that it was perhaps the most essential of all the key or pivotal industries. The dye industry, therefore, had the most and the best of our efforts.

We found, of course, that the production of coal-tar dyes was practically a German world monopoly. Starting with every advantage—cheap raw material, cheap labor, above all, cheap chemists, government subsidies, transportation at or below cost, and close cooperation with the universities—the German makers had made a determined and successful effort to enslave the whole world to German dyes. They had stuck at nothing. Combined as our law forbids us to combine, in two strong cartels, they had deliberately assaulted, with intent to kill, every nascent foreign dye industry, including ours. Wherever anyone started making anything that would be useful in dyemaking, they instantly cut its price in half. Protected in their high prices at home, and amply strong financially, they could afford to take severe losses for the short time required to drive out the newcomer, after which they could quickly recoup by doubling the original price. Where this method was unavailable they used full-line forcing, refusing to sell their patented colors except to those who would buy their other goods. Added to this was incessant, unlimited, bare-faced graft—the wholesale bribery of dyers. Finally, in 1916, the two cartels, with all the outside large concerns, had combined in one gigantic trust, which issued new securities to double its capital, and united companies whose assets totaled half a billion dollars. This monstrosity was organized avowedly to fight to win back the export trade. Its production is so huge that it must win or go bankrupt. How it will fight we now know. Its share of the war after the war will be utterly ruthless. The American industry must be helped or it will be "spürlos versenkt."

The strength of the trust lay in its largest six members—Bayer, Badische, Berlin, Hoechst, Kalle and Cassella. Each had a flourishing agency corporation here. Three of these—Bayer, Berlin, and Kalle—early reported themselves as German-owned. The other three did not. Investigation, however, showed actual German ownership in all, and in its course revealed nearly all the pet methods of Hun camouflage.

First, and easiest to deal with, was the pretended transfer of stock by which stock really German-owned passed on the books to dummies in this country. This was generally shown up as soon as the real contract was developed, since it always turned out to leave the alleged Hun seller of the stock everything he had before the sale. More difficult was the oral option method under which the stock was placed originally in American hands subject to purchase on nominal terms at will. More difficult still was the outright secret trust which, like the option, left the stock in apparently American hands from the first, but held for the German. In some such cases we proved the trust and the Hun ownership only after an accounting which showed that unless such ownership existed, the president of the company had robbed his stockholders, paying over to Germans money which on the face of the books belonged to the record owners of shares. Most difficult of all was an underground method, peculiarly Hunnish, discovered in the companies which reported at the outset. These surrendered with such ease as to put us on our guard, and eventually we found, in the case of Bayer, that the Hun officers of the American company had all arrangements made for scuttling their abandoned craft and piping all its cargo of business to a new company which they had bought with its money. This was detected just in time and the new concern was seized and sold with the old.

But if I should try to tell you half the methods of fraud and trickery which we had to combat, this meeting would not be over in time for next year's to begin. Hun methods in business were like Hun methods in war. Either could be deduced from the other; and neither knew any limit of decency or self-respect.

Coming to realize this, we came to the conclusion that although it was perhaps none of our business, we ought to do what we could for the dye industry, doomed as it was to fight against such odds. We could see that no tariff alone would ever help it. The German monster fighting for its life would mind duties no more than postage. But studying the situation we saw one gleam of light. That was the patents. There were thousands of these, many of them product patents. They were taken out, we thought, more to prevent import than to stop manufacture, since the Huns were not afraid of our makers. If they would stop imports for Germans, they would stop them by Germans. So we got the law amended so that the Custodian could seize the patents. He seized them.

Then it became necessary to get them into American hands strong enough to protect them. No ordinary sale would do, since sale to a weak company would be useless and to a strong company would create a dangerous monopoly. At that stage the fertile brain of Mr. Garvan conceived the idea of a sale to a trustee corporation formed for the purpose. This idea germinated with remarkable speed and met an astonishing response: and the Chemical Foundation, Inc., is the result.

This corporation thus formed at the suggestion of the Custodian is capitalized at \$500,000 and to it the patents—4000 of them—and trade-marks have been sold in one block for \$250,000. It holds them subject to an obligation to license under them, on equal and reasonable terms, manufacturers of undoubted competence and 100 per cent Americanism, and to defend them by instantly proceeding against anyone who imports or makes infringing goods. Since many of the patents are product patents, this should serve to keep out some of the more recent and important German dyes.

The stock of the Foundation is limited to 6 per cent dividends so that it can never be a profit-making company, and it is non-transferable without consent of the company, so that control may not be purchasable. The preferred stock is to be retired as soon as possible, and the common, which alone votes, is to be placed in a voting trust for 17 years, the trustees being Messrs. Otto T. Bannard, George L. Ingraham, Cleveland H. Dodge, B. Howell Griswold, Jr., and Ralph Stone. The officers and directors are: *President*: Mr. Garvan; *Vice President*: Col. Douglas I. McKay; *Secretary*: Mr. George J. Corbett. Mr. Ramsay Hoguet is its patent counsel, and I am its ordinary legal adviser. The Foundation is thus assured, for a long period, of absolutely impartial control; and since no one is to be allowed to buy more than a share or two of the voting stock, the impartiality should continue.

The charter provides that after the redemption of the preferred stock the income of the Foundation shall be used for research and the advancement of science; and on this line we see infinite possibilities of service. If, as we hope, its income is large, it can stimulate invention by buying new discoveries, can co-ordinate research by bringing together academic, governmental, and industrial laboratories, and can collect and render accessible information as to laboratory facilities now nowhere available. It can, we hope, license the use of German trade-marks and trade names and insist on the quality of the goods on which the marks are to be used. It can take over copyrights and use them to make more accessible the best of scientific literature. By reason of its unique combination of industrial connections and impartial control it lends itself to a hundred different public services for which no other organization is adapted.

The Custodian's study of German methods has thus led to what seems an important constructive work. It stands to-day as the sole defense of our new dye industry against the onslaught that will fall upon us on the signing of peace. It is a partial and imperfect defense only. The patents cover but a fraction—though the most important fraction—of the dyes the country needs. Unless Congress awakes to the fact that nothing but a license plan like the British can stop the flood, the defense may be utterly submerged.

On this question I must differ with Mr. Culbertson. A tariff alone will be no defense against the German attempt to secure its world trade. In order to get back their market they will undersell, even with a tariff of 100 per cent, thereby destroy domestic competition, and then jump their prices, even as they have been known to do in the past, and thus recoup whatever the fight may cost them.

The Chemical Foundation and tariff provisions will help, but are they to be the only protection? Do you suppose the Germans are doing nothing at this time? Do you suppose they will quietly submit to the loss of their trade, without an effort to recover it? The best information which the Property Custodian's office can secure reports large stocks accumulated in Germany, both of intermediates and finished dyes. Both the Foundation and the tariff will do something, but we cannot save the industry without more protection than either or both will provide. I state this not alone as my own opinion, nor as that of the A. P. C. Office, but as an opinion shared by those whose interests might be adversely affected. When the man on the outside of a protective wall approves its erection there is something in it. I have never heard of a case where the man who buys goods affected by a protective measure and whose costs will necessarily be increased by the measure has come to advocate that measure except when that measure was demonstrably and certainly right. Now in this case our judgment is fortified by that of the dye-consuming industry. I have addressed meetings in Boston, Providence, New York, and Philadelphia, and as a result a cable has been sent to the President, signed by 95 of the most important firms in the country, the men who

must buy the dyes, and who will have to pay more if the license plan comes into effect, and who will suffer if they cannot get all the goods they want. It is the most remarkable example of patriotism in commerce I have seen

March 25, 1919

To the President of the United States:

The undersigned, representing various branches of the textile industry, respectfully submit that in their opinion an independent, self-sustaining, American dye manufacturing industry is a national necessity; that such a dye industry cannot be established unless competition from German factories, including those in occupied territory, be cut off for a period of years; that no tariff will furnish protection against the enormous resources and unscrupulous methods of the German trust fighting to regain its foreign market; and that only a licensing plan like the British, excluding all foreign dyes reasonably obtainable in the United States, will save the new industry. We respectfully urge that immediate steps be taken to procure both in the peace treaty and in legislation the measures necessary to establish such a plan.

We advocate this not merely because a domestic dye industry is essential to the independence of the American textile industry and manufacture generally, but chiefly because we believe that only through an established dye industry can the nation secure the progress in chemical education, in the application of chemistry to the arts, and above all in curative medicine, which are indispensable to the national welfare.

That, gentlemen, is what the dye-consuming industries think of it, the manufacturers of textiles, woolens, cottons, silks, hats, inks, leather, printing, in fact every dye-using industry. This is the way they have put themselves on record. When they say that this measure is right, I believe it. If you want to save this industry the way to do it is to get at your congressman, and whisper your views in his ear. Put it as strongly as you can, and you will get such legislation.

In conclusion, it is clear that great progress has been made in the development of this industry, which truly represents a national necessity. American manufacture is free in almost the whole dye field, and is already on its way to fill our every want. With all the forces now at work in its defense, it will—it must—be saved. German methods will never again be allowed to do to the American chemical industry those things which they have done in the past.

THE AMERICAN SPIRIT IN CHEMISTRY

By EDGAR F. SMITH

Provost, University of Pennsylvania, Philadelphia, Pa.

Sitting daily within arm's reach of a little, priceless chemical balance, brought in 1794 by Joseph Priestley to this country; surrounded by pictures, ancient volumes, prints, and letters, sear and yellow—all reminders of Joseph Priestley, whose great-great-grandson, also Joseph Priestley, it is my privilege to-day to instruct in the ways of the chemist, is it to be wondered that interest in the man who revealed oxygen to us should have caused me to seek further knowledge regarding the influence he exerted upon those about him? His radicalism, his inborn dissenting spirit, led him, against all good advice, to project himself into that cauldron of seething national politics which reigned in the last decade of the eighteenth century in America, until sharply rapped on the knuckles by those in high places, with broad hints that Americans be permitted to conduct their own government and be let live and move, undisturbed by unnaturalized sojourners—then Joseph Priestley turned to our science, but began by tantalizing its professed followers with a re-statement of his remarkable ideas on phlogiston, the intangible. We may rejoice that it was America's good fortune to have this crude theory held aloft and talked about and written about almost incessantly for a period of years. It was the old European struggle or controversy transported to America and here it was—here on American soil—that it was settled for all time. But of this interesting fact, many, yes, too many, American chemists were never aware. He who speaks to you

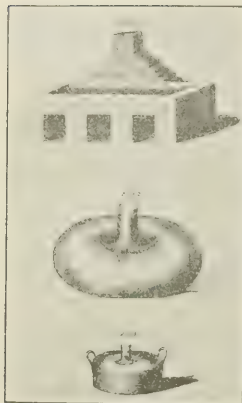


FIG. 1—SECTION OF THE FURNACE, SUPPORTING A SAND BATH

The ash pit may be separated from the place where the fuel is lodged, according to the fancy of the manufacturer. The fuel may be either wood, charcoal, or pit coal

FIG. 2 GLASS VESSEL

FIG. 3 IRON PAN, CONTAINING ONE OF THE VESSELS

was born and grew up in this country, received his training here, and studied in a distant land, returned, and taught our science, but, through it all, was as ignorant as a new-born babe concerning the consequences of Joseph Priestley's advent in the young Republic. There seem to have been others who were no wiser than he on this particular subject. At least, association with colleagues through many years has demonstrated that they, like he, were pretty certain that chemistry had no past in this country, that if its beginnings were placed in the eighteen-fifties, the announcement might go unchallenged, but just what the character of chemistry was at that period was in doubt. However, here in America, great things in chemistry

were achieved in the very dawn of the life of the Republic. And, as lovers of our country, is it not due the rising and future generations that these facts should be spread before them? If we would be true to our science and true to our country we must do this, remembering that

"From the old soil doth thy new corn grow."

When, in the seventeen-nineties, Joseph Priestley threw down the gauntlet of "Phlogiston Established" it was not men of 40, 50, or 60 years of age who were arrested in their thought. No, they continued in their customary way of presenting chemistry as they had learned it; but it was the young men, men in their twenties, and boys—yes, boys in their teens—who, alert, inquisitive, bubbling over with energy, full of initiative, proceeded to test out the aged champion's thought, and in time utterly routed him. The honor of this signal victory falls in large measure upon one of whom I have written more fully elsewhere, but for a brief space I am constrained to ask your indulgence for a few words more about James Woodhouse, then 24 years of age. Why have no chemical texts told of him and of his wonderfully good fortune in overcoming Priestley? Why has no mention ever been made of his isolation of potassium and his explanation of the rôle plants play in their imbibition of carbon dioxide? Why have we been—may I say it?—ignorant of his presence? And further, that one of the most striking features of his career was his ceaseless efforts to utilize chemistry for the benefit of his country and its people. Witness in this connection his suggestions, the result of experiment, and not of speculation, relative to breadmaking, beginning with the study of the flour, then the raising of the bread, and finally its actual baking. The yeast introduced into it came under his survey, and as one reads one is reminded of similar, more far-reaching studies in breadmaking, carried on at the Mellon Institute. Visiting there not long ago, my thoughts turned back to Woodhouse and, in silence, I pronounced him a pioneer in the chemistry of the bakery!

Upon another occasion after remarking that there were not more than eight persons in the United States capable of refining crude camphor, he proceeded to describe how this might

easily be performed in a very simple contrivance consisting of a furnace supporting a sand bath, glass vessels, and iron, copper, or earthen pans (Figs. 1, 2, 3).

His description of the furnace ran thus:

A furnace sufficiently large for one active and industrious man to attend, will occupy the space of eight feet nine inches in length, and two feet six inches in breadth. It must be made of seven cast iron plates, half an inch thick, thirty inches long and fifteen broad. These plates are to be placed upon eight piles of bricks, parallel to each other, and nine inches apart. The bricks are to be ten inches high, thirty long, and six broad. Great care must be taken, that the lower sides of the plates meet each other exactly midway on the upper side of the bricks, which should be well covered, with a thick bed of mortar. Bricks serve to confine the sand. When the furnace is connected with a wall, there is no occasion for more than a single row of them: and to obtain a considerable draught of air, a chimney should be carried from the fourth plate, with an aperture four inches in diameter, and the flues of the third and fifth plate may communicate with this chimney. Two separate flues may be carried from the second and sixth plates, and the first and seventh should enter the second and sixth.

The chimney, if convenient, may be made to enter into that of the house, but if not, it should be about fifteen feet high.

The glass vessels are procured at a glasshouse, and are made of green glass. They should be blown as thin as an oil flask. They are of circular form, shaped flat like a turnip, and have a neck from one to three inches high, with an aperture from half an inch to one inch in diameter. Their bottoms should be eleven inches broad, and the top ought to be four inches from the bottom.

They cost twenty-five dollars a hundred in Philadelphia.

Fourteen pans may be made of iron, copper or earth. Sheet iron is the best material. They should be round, one foot in diameter, with a rim pecked on four and a half inches high, and ought to have two small handles. They cost one dollar apiece in this city (Philadelphia).

Having prepared this necessary apparatus, the next thing is to make use of it in such a manner as to refine the camphor.

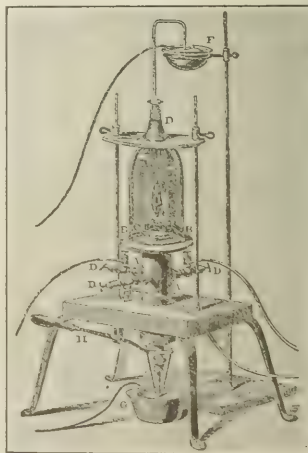


FIG. 4—HARE'S ELECTRIC FURNACE

Having taken the article out of the tubs, the glass vessels are to be filled two-thirds full of it, and the apertures in the necks, slightly stopped, with paper or cotton plugs. They are then to be placed on the bottom of the pans, and covered near to the base of their necks with sand.

The pans, holding the vessels containing the camphor, are to be carried to the sand bath, and surrounded near to the top of the rim with sand.

A gentle fire is to be kindled in the furnace, at four o'clock in the morning, and gradually increased until the camphor melts, which it does when it arrives at 304° of Fahrenheit's thermometer. It will first rise in flowers, which will dissolve,

and run down the sides of the vessel. When it has melted, or is boiling, the glass is to be elevated in such a manner that the hot sand may reach only to the middle of its belly, in order that the cool air may be admitted to the upper surface of the glass, to congeal the camphor as it sublimates.

Having kept it in a liquid or boiling state, from eight to ten hours, the refined camphor will be found adhering to the upper side of the vessel, and is to be taken from it by breaking the glass while hot, or it may be kept until cool and then broken. The glass is easily separated from it, by means of a knife.

The foul parts which adhere to the bottom of the glass, and which cannot be easily parted from it, are to be broken into pieces, and sublimed a second time, with an additional supply of camphor.

When the crude camphor is of a white color, or contains little foreign matter, no addition is to be made to it; but when it is brown or black, one ounce of slacked or quick lime, is to be mixed with every three or four pounds of it. The utility of lime in this operation is noticed by Margraff.

One man can refine and pack up from eighteen to twenty-five pounds every day.

If any of the glass vessels holding the melted camphor should crack, which sometimes happens, and which is discovered, by the flowers rising into the air from their sides and tops, the pans containing it are to be immediately removed to a cool place; and if the camphor is found mixed with the sand, the whole is to be put into other vessels, and the operation conducted as before.

The loss in refining one hundred weight of this article cannot be accurately ascertained, as it depends upon the purity of the crude material, and the care in conducting the process. It cannot be very great.

Perhaps the greatest discovery made by Woodhouse was Robert Hare. Of him also I have made abundant mention elsewhere and introduce his name now merely to emphasize one or two contributions which relate to operations at present in process not many miles from here—over at Niagara Falls.

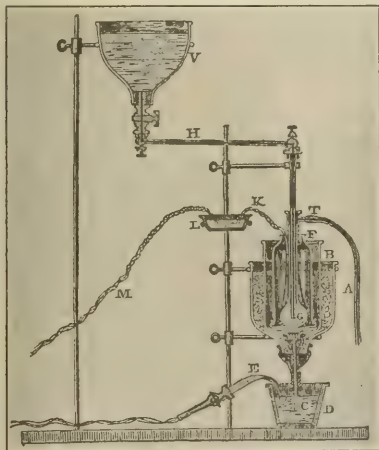


FIG. 5—HARE'S ELECTROLYSIS APPARATUS, USING MERCURY CATHODE

There the electric furnace is well known. Everybody in the vicinity is familiar with it. There, too, caustic is produced from common salt using a mercury cathode. With no idea of disturbing the calm equanimity of those who are intimately concerned with these applications in the science of chemistry, I make bold to assert, for the purpose of historical accuracy, that the first electric furnace ever built was constructed by Robert Hare. Look well at the slide before you (Fig. 4), for in the device it represents, charcoal was converted into graphite—artificial graphite—and, in the hands of Robert Hare, that graphite wrote the characters of a note to his devoted friend Silliman, announcing the wonderful transformation. In the same ap-

paratus calcium metal was obtained from its cyanide. But prior to all this Hare had used mercury as cathode in the electrolysis of a concentrated aqueous solution of calcium chloride, obtaining a calcium amalgam which, upon subsequent distillation, gave as residue, calcium (Fig. 5).

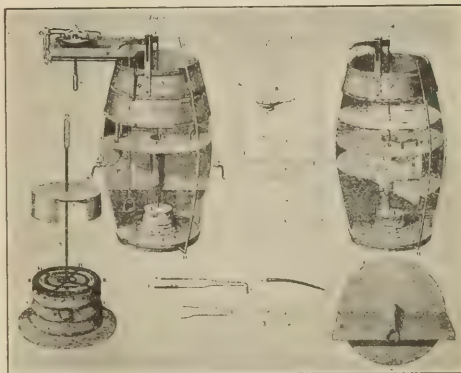


FIG. 6—OXY-HYDROGEN BLOWPIPE INVENTED BY HARE AND ATTACHED DEVICE TO PRODUCE THE OXY-HYDROGEN FLAME

These things were done nearly 70 years before present-day chemists—chemists of our generation—rediscovered them. Dr. Bancroft has well said:

Hare was in many respects the precursor of Moissan, though a much more brilliant man than the latter. Hare was born too early. * * * * If we call Moissan the Christopher Columbus of the electric furnace, we must call Hare the Leif Ericsson of the same.

How many reasons could each one of us advance for the fact that Hare's observations had to be remade? In my study I have quietly gathered many, and yet there clings to me the thought that these discoveries should have been widely known and been followed up, but perhaps the world was not ready for their consequences.

To this same Robert Hare the world is indebted for the oxy-hydrogen flame and all its recent modifications—the oxy-acetylene torch, etc.

What must have been Hare's feelings when, at but 20 years of age, he had the honor of standing in the presence of Joseph Priestley and demonstrating to him the wonderful dynamics of the oxy-hydrogen flame, when platinum and the most refractory substances were melted and flowed like water? All this was done on American soil by a native American. You will pardon me if once again I let the slide before you exhibit the primitive contrivance, the compound blowpipe, the oxy-hydrogen blowpipe invented by Hare, and the attached device to produce the oxy-hydrogen flame. It marked an epoch in chemical and philosophical thought in our country (Fig. 6).

Woodhouse and Hare have become chemical heroes with me. I have many of their printed contributions and as I have studied these, I have really marveled at their contents. These two men were American-trained. Neither cared for foreign lands. This in a measure explains the fact that comparatively little is known of their work. Hare in particular was a pamphleteer, until his friend Silliman began, in 1818, the publication of the *Journal of Science and Arts*.

If it be theory in which we delight, what can be more refreshing than to studiously peruse Hare's thought on double halides, e. g., K_2PtCl_6 ? While thus engaged it must not be forgotten that his opponent was no less a distinguished personage than John Jacob Berzelius. The latter would express this salt as

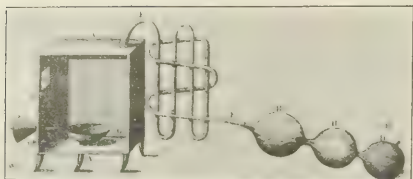


FIG. 7.—APPARATUS FOR OBTAINING SULFURIC ACID WITHOUT NITER

2KClPtCl_6 , but Hare wrote it K_3PtCl_6 , potassium chlorplatinate as experimentally demonstrated many times since the day of Hare, whose remarkable discussions may now be dismissed, so that some curious efforts by American chemists along other lines may receive attention. For example, in an old, out-of-the-way publication of 1790, I discovered the following method of obtaining sulfuric acid without niter. It reads as follows:

The present mode of obtaining a vitriolic acid, by the combustion of Niter and Sulphur, is so very expensive, that an economical method has long been sought for by Chemists.

Sulfur is a substance composed of vitriolic acid and phlogiston, or, according to the pneumatic doctrine, it is vitriolic acid deprived of air. In combustion the phlogiston is supposed to be dissipated, or the air absorbed by the acid. Sulfur, like all combustible bodies, will not burn in closed vessels. Niter contains a large quantity of pure air—hence the practice of combining them together, in order to maintain the combustion by a supply of air. If it can be supplied by any other means, we save the expense of an article hitherto found to be necessary.

When I first used the apparatus * * * * * I expected either to be suffocated by the fumes of the sulfur, or knocked down by the bursting of the balloons; but neither of these things happened, and from one pound of sulfur $15\frac{1}{2}$ parts of acid were obtained (Fig. 7).

AAAA is a stove made of iron or copper, or of iron coated with lead or copper, one of the side-plates is wanting in the drawing, B is a door through which the sulfur is placed and lighted in the dish C. DD, the spaces between the stove and dish, contain a small quantity of water, that part of the fumes, which are not carried through the copper pipe EE, may be absorbed and condensed. F is a small cock to draw off the water at the end of the operation. G is a funnel, the end of which is divided into a number of conical points, pierced with small holes. HHH are three receivers of brass or copper, the last of which is tubulated to prevent any mischief when the fumes are not readily condensed. Upon lighting the sulfur the air is immediately rarefied in the pipe, and so great is the draught through the funnel, that the combustion is continually maintained, and the fumes prevented from flying into the room.

We smile, but this occurred 129 years ago, when it met with approval. Americans were then just getting on their feet in the technical world.

And now turn for a few minutes to the *Emporium of Arts and Science*. In this publication was clearly expressed the burning desire of American chemists for the promulgation of a knowledge of the application of chemical principles. Note these topics:

Manufactures dependent on copper; on lead; on tin; on gold, silver, mercury, antimony, and bismuth.

Color making; carmine; red lakes, yellow lakes; copper brown; Frankfort blacks; Spanish white; white from barytes and strontium; Saxon blue; Dutch and rose pinks; French green; Brunswick green; Olympian green; smalt; bice; cinnabar; vermilion; colored chalks, etc., etc.

Thought was also given to chemicals in a large way:

Pot and pearl ash; pure alkali; soda; ammonia; oil of vitriol; cream of tartar; sugar; benzoil; sulfate of manganese; preparations of antimony; elastic gum tubes; common quack medicines; detection of adulterations in medicines; chemical manufactures with reference to the law of nuisance.

Bleaching; dyeing; printing; cotton; pottery; etching on copper and glass, etc., etc.

As an example of the effort in bleaching observe the apparatus shown in Fig. 9.

As an exhibit of another form of apparatus to be used in the bleaching of stuff for paper Fig. 10 has much interest. It consists of:

A the cap of the still. B the body of ditto, which stands 7 or 8 in. above the surface. The cap is in the form of a hive, entirely hollow, with the tundishes soldered, as you see, one for the use of charging the still with the vitriol, and the other takes off the inflammable air, which is C, then it enters the intermediate box, through which it passes through the pipe D, and enters the vessel by the reservoir, which is E. The pipe stands about 11 or 12 in. above the surface, 1 in. bore, but does not dip in the reservoir; it drops its strength in its reservoir, while the motion of the wheel circulates the body; the wheel or windlass, is the letter F, which is only the handle and a boy continually turning it during the whole process; Xz the wheel is in this form, with the arms the full diameter of the vessel; the intermediate box, as you see: the pipes or tubes stand 12 in. at the top, from the horizontal of the top of the vessel. The center pipe, which is H, dips in the water which is in the intermediate box, and has two nostrils which give air, although being under water; the intermediate box has always 4 in. of water, which is put in every time the still is charged; and has a cock at the bottom to empty it occasionally; there is also the consolidate vessel, which is G, it stands about 7 in. high, but made fast to the top of the reservoir. The consolidate vessel has a lid, and the lid is taken off to put the lime water in: also there is another pipe which stands 3 in. on the top, and in that pipe fits a tube which dips in the pitcher as you see in the draught; the lid of the consolidating vessel fits in a cavity the same as the cap of the still; and the cavity is filled with water to keep it staunch; also there is a cock at the bottom of the reservoir to rack off the liquor, and another at the bottom to cleanse it out. The letter K is the vessel which the old lees are thrown into as before mentioned. As to the proportions of the vessels—the depth of the still is 2 ft. 5 in.; the diameter, 2 ft. 3 in.; the cavity where the lid fits is 13 in. deep; the proportions of the intermediate vessel are 16 in. long, 12 in. broad, and 11 high; the reservoir is in depth 20 in., diameter 4 ft. 8 in.; the consolidating vessel which dips in the water is 14 in. square, 7 in. high at the top, and the lid has two handles to take it off. To introduce the lime water, the cap of the still is elevated by a pulley, while at the top of D^o you see a hook made fast to D* for the same purpose, to put it on and take it off without any further trouble. The still is laid in a metal boiler and underneath the still is 4 in. of sand, but the body is a cavity all round to the top, which is inclosed with brick work; the whole apparatus is lead. N. B.—The reservoir is also lined with lead, as also the cistern which the old lees is thrown into. The reservoir is a wooden vessel, lined with sheet lead.

An apparatus designed for the liberation of coal gas, to be used in that far-away period, is represented in Fig. 11.

This was described as follows:

The retort is filled and the cork taken out at D, which should be 4 in. diameter, stopped with an iron plug. The tar and liquid partly runs down the tube with a stopcock, next the furnace, but some of it mounds with the gas, and being cooled in the bent part of the tube runs down at the second tube with the stopcock into the barrel B, which is inserted in an outermost barrel, and surrounded with water to condense the contents. The gas-holder C is suspended with its balance weight from the ceiling. The rest is obvious. The gas holder and its containing vessel may be tin, copper, sheet iron, or simply casks. The perpendicular tube that rises into the chimney is designed to carry off the carbonic gas and water which rise at the beginning of the process, and which if mixed with the carburetted hydrogen

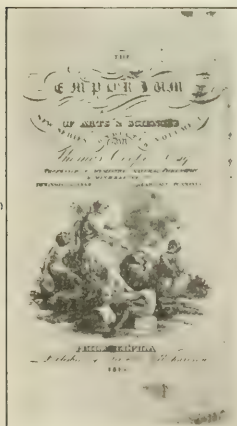


FIG. 8.—TITLE PAGE OF THE EMPORIUM OF ARTS AND SCIENCES

would hurt the combustible quality of the gas sought for. The tubes may be lead, tin, or copper.

The distilled products will pay a great part of the expense.

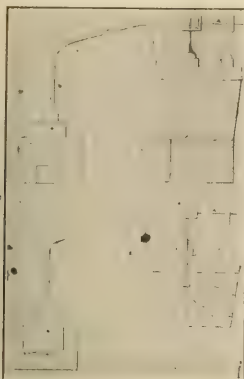


FIG. 9—BLEACHING APPARATUS
AA is the machinery to agitate the limewater within the cask in which it turns around. BB is the still holding the materials. 1, 2, 3, 4, 5, 6, 7 places made air-tight with water to prevent escape of the gas

for me to tell you the pleasure that has been mine in mulling over the contents of this ancient, hoary book. A few of the titles of papers in it are:

- 1—Remarks on the Phlogistic and Anti-Phlogistic Systems of Chemistry.
- 2—Speculations on Lime.
- 3—Remarks on Heat.
- 4—An Inquiry whether M. Berthollet was warranted, from Certain Experiments, in Framing the Law of Chemical Affinity, "That it is Directly Proportional to the Quantity of Matter."

Yes, to read at random in moments when the mind was overburdened and wearied by other arduous duties, brought peace and rest, while there was simultaneously developed a most profound admiration for the earlier members of the Guild of American Chemists.

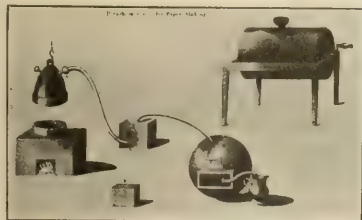


FIG. 10—APPARATUS FOR THE BLEACHING OF MATERIAL FOR PAPER

For instance, we hear James Cutbush calling reagents "the compass by which the chemist steers," and then he launches forth into a description of the production of oxyacetate of iron which in his words, "I propose as a test for arsenic," and Thomas Cooper suggests neutral soluble chromates for the detection of this same element. And, by the bye, on having this reagent tested quantitatively for the recognition of arsenic, it was demonstrated that $1/100,000$ part of it could be easily found.

Further, John Manners was convinced "that oxygen is not only unessential to putrefactive fermentation, but has, when in actual contact with putrefying substances, no influence on that process * * * * * but to magnify and render more conspicuous, any absorption in consequence of a diminution of the included atmospheric air, by the combination of its oxygen with the animal flesh."

Of the apparatus shown in Fig. 12 he speaks as follows:

I invented an instrument which I shall now describe. I took a cylindrical bottle (A) perfectly transparent, and put half a pound of muscular flesh (a portion of the diaphragm of a bullock) in the bottom of it, and secured it there. (B) The flesh was taken, while warm, and cooled under mercury to prevent the access of air. To the bottle was adapted a cork which was perforated, and a bent tube passed through the perforation, the other end of which was hermetically sealed. (E) Some mercury was then put into the bottle, the bottle corked, and made perfectly air-tight by luting and sealing. The bottle was now inverted. The mercury filled about two inches of the neck of the bottle, (D) and was made to pass up the glass tube by heating it, and expanding the air and thus expelling a portion of it, to a proper distance. (F) In this situation the bottle was put to rest in a fixed position.

A thermometer (I) was included within the bottle in order to note its temperature.

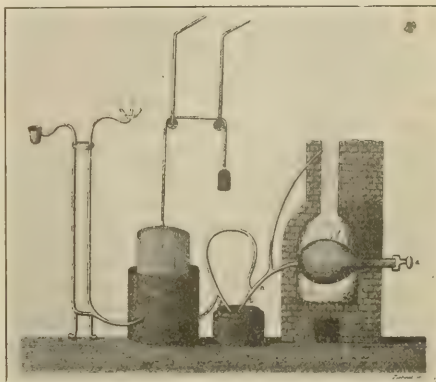


FIG. 11—COAL-GAS APPARATUS

The bottle and curved tube in some measure represented Mr. Leslie's differential thermometer. Here barometrical influence was perfectly excluded. And as the variations in the temperature equally affected both the air included in the tube, (G) and that in the bottle, (C) it is evident that thermometrical influence could not affect the experiment.

To the tube was adapted a graduated scale which would mark any rise or fall of mercury in the tube.

Now it is clear that the smallest diminution of air in the bottle would be marked by a corresponding fall of the mercury in the tube, the calibre of which was not more than one line. Or on the contrary, any evolution of gas would raise the mercury in the tube.

The apparatus remained three days without any change of mercury in the tube. On the fourth day the mercury began to rise and continued to rise until the experiment was suspended; which proves that there was no absorption of oxygen gas by the putrefying substance.

Presumably all of us have determined carbon in the wet way and we may have made aldehyde by oxidizing alcohol with chromic acid, and did these things wholly ignorant of the fact that they were first suggested by an American chemist.

It is also a fact that the fathers thought on the speed of reaction, and that the discovery of chloroform, independently of Soubeiran, Liebig, and Dumas, was made by an American.

No harm would be done if this were mentioned in our textbooks.

And this completes my chemical story. It is a mere fragment. Hours might be filled with additions, but the purpose I had in mind, I trust, is evident, namely, to demonstrate that there is an American spirit in chemistry, as there is an American spirit in literature so entertainingly revealed by Bliss Perry in his recent volume, "Chronicles of America." And it is that spirit which should constantly be held before students of chemistry and before every man, woman, and child who is engaged in any of the great industries founded upon chemical principles.

Therefore, I am prompted to make an appeal. Let every college, university, and works laboratory minutely record the story of the work done in it annually, not for publication, but for the sake of preserving for future students of chemistry in this country source-data from which may be drawn the material for a great history of the science. Let the apparatus used be accurately delineated, and its modifications and developments be truthfully outlined. And last, but not least, make biographical sketches of the directors and workers in such laboratories, mindful that the charm of biography consists of minor truths neglected by graver history. The human side in all history illuminates as nothing else can. As a result, theories, failures, achievements, all possess life, and in turn encourage, incite, and inspire to press on, emulate, and even surpass each preceding generation. In addition there is created, fostered, and perpetuated a solidarity in our Guild which will surely culminate in stupendous endeavors, to be eventually crowned with undreamed success and national glory.

As one looks backward to the days in which "my heroes" and their associates lived and one searchingly scrutinizes their work, it will be seen that it bears the stamp of marked originality. The Republic was then young. It was not sure of the genuine friendliness of the then great nations of the world, and our early chemists, heeding the spirit of the immortal Washington's admonition relative to "entangling alliances," were trying out their skill and knowledge alone. Many undertakings were crude and came to naught, while many brought success. Perhaps if our chemical fathers had been disposed to avail themselves of the helps they might easily have had from foreign sources, chemistry in this country would have advanced by leaps and bounds. However, they were content to go their way. Anyone who will turn over the pages of Hare's "Compendium of Chemistry" will be profoundly impressed with its striking originality. The various forms of apparatus employed by him in chemistry and physics are his own thought and made by his own hands. Most of it is cumbersome, but it answered superbly the purposes for which it was designed. How this remarkable individual was able to adhere so closely to his own plans is astonishing when it is recalled that he was the American editor of several standard English works before he wrote the Compendium. An examination of other early texts will disclose a like tendency and you will sympathize with me when I say that as I have slowly read the earliest writings of our earliest chemists—the writings of those who taught and the writings of those who were applying the principles of the science in industrial operations—and noted this truly independent American spirit, I thrilled with joy to ob-

serve that while the little Republic was struggling heroically to develop its new form of government, to grow up, and to utilize its great, God-given resources, the science dear to me was being most earnestly cultivated.

And how many of us gathered here to-night found in our student days the impression all around us that other lands must be sought that we might be inoculated with the genuine inspiration to go forward in our science? Never was it said that our forefathers had done anything in this domain and so we went on, but at last a rude awakening came to us. The talent in our land was per necessity compelled to face serious, old and very new, unimagined problems, and how splendidly these have been solved. The early spirit of the fathers, who assisted in the upbuilding of the Republic, reappeared. And it is not too extravagant to declare that there is nothing in the category of chemical enigmas which American chemists cannot solve. While glorying in this magnificent exhibition of intellectual, inventive power and skill, let us be sure to review what the fathers did and in this manner incite eagerness for the fray before us, now that we have tested out our powers. Let the old American spirit become our spirit in chemistry. We must not step backward. Let us resuscitate old industries, if desirable, and develop new industries. Let us jealously protect those in this country who came forward with financial aid to further the industries which are and may be inaugurated. Let us also generously promote chemical teaching and, among other things, bid the youth look back to the early representatives of our science who wrought quietly, thoughtfully, and unceasingly, thus giving us a past of which we may be justly proud, for

"These are deeds which should not pass away,
And names that must not wither. . . ."

REPORT OF OMNIBUS COMMITTEE

We have carefully considered a total of 178 suggestions from 20 sections, 8 individuals, 2 outside organizations, and 5 unidentified sources. Of this total, 57 suggestions fall naturally within the 9 group-suggestions, for which provision was made at the Council Meeting of December 14, 1918, as recorded in the minutes and published in the *Journal of the American Chemical Society*, Proceedings for 1919, pp. 2-4. The subject matter of these group-suggestions may be summarized as follows:

- 1—Publication of compendia and monographs under the auspices of the AMERICAN CHEMICAL SOCIETY.
- 2—Annual formula index to *Chemical Abstracts*.
- 3—Duty-free importations of chemicals, apparatus, etc., by colleges and other educational and scientific institutions.
- 4—Fellowships and relations between the industries and educational institutions.
- 5—Federal aid to scientific and industrial research.
- 6—Metric system to be made United States standard.
- 7—Developing work of Division of Chemicals and Chemical Technology, National Research Council.
- 8—Coordination of chemical work in the War Department.
- 9—Recording and publishing, so far as public interest permits, of the work of the Chemical Warfare Service.

The remaining suggestions, numbering 121, cover, as might be expected, an extremely wide range of subject matter. Some are obviously outside the province of the SOCIETY, and many involve the expenditure of SOCIETY funds to an amount which, though indeterminate, is certainly far beyond our present income or resources. The remaining suggestions naturally range in present interest and importance from the intensely practical and desirable to the obviously futile, but your committee is glad to testify to the evident care with which most suggestions have been formulated and to their high average of value.

The 121 suggestions have been somewhat arbitrarily classified by subject matter into 7 groups, which your committee has de-

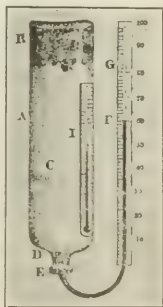


FIG. 12—MANNERS'S APPARATUS TO SHOW OXYGEN NOT ESSENTIAL TO PUTREFACTIVE FERMENTATION

fined and summarized as follows, reaching in the case of each group, the conclusions and recommendations thereto appended:

GROUP A—ORGANIZED PUBLICITY COUPLED WITH EFFORT TO
RAISE THE STANDARDS AND STATUS OF THE
PROFESSION

The suggestions reveal a general appreciation of the need and value of wider publicity regarding the relation and importance of chemistry to industrial and national welfare. They urge that a serious endeavor be made to raise the standards of the profession and suggest the formulation of definite standards as in other learned professions. They would endeavor to build up a background of understanding and appreciation in the public mind through the wider dissemination among the general public of information concerning chemistry and its specific applications and accomplishments. Much of this effort would be directed to business men and managers, and the earning power of chemistry, as well as its fascination and industrial importance, should be more adequately placed before students in universities and technical schools.

It is proposed to accomplish these objects by furnishing cheap reprints of popular addresses from the chemical journals; by popular articles on chemistry and its applications in selected mediums; by magazine write-ups of the war contributions of American chemistry and industry; by the early publication of the magazine, "Popular Chemistry;" by the issue of "Who's Who in Chemistry;" the publication of special volumes, as one containing accounts of medalists in their relation to chemistry in America, or one similar to the English "What Industry Owe to Chemistry." A running account of the influence of chemistry on the industries on the model of Nicholson's Magazine is advocated, and the publication in 1926 of a Jubilee Volume. A publicity bureau of enlarged scope is advocated.

Your committee assumes that no question will be raised as to the desirability of these proposals in and of themselves. To carry them into effect, however, obviously involves organization, great expenditure of effort, and far more money than the SOCIETY now has available. Your committee may, however, be permitted to point out that the standards of the profession are in the keeping of its individual members and that the matter of the formulation of standards has already been settled by the vote on the Code of Ethics.

GROUP B—EXTENSION OF LIBRARIES AND PUBLICATIONS

In addition to the 29 suggestions for the publication of compendia, monographs, handbooks, and other works of reference assigned to Group 1, and coming within the province of the committee for which provision was made at the Council meeting of December 14, 1918 (Proceedings, 1919, p. 2) eight suggestions have been segregated in Group B. These cover proposals for the organization of a scientific and technical publishers' association, the assistance of libraries and lecture bureaus in the selection of books and publications, the establishment of a central circulating library and of libraries as nearly complete as possible at various centers, the furnishing of translations by men assigned to the office of *Chemical Abstracts*, the annual publication by the *Journal of Industrial and Engineering Chemistry* of comprehensive and elucidative articles and compilations on the domestic and international trade of the preceding year in chemicals and chemical products throughout the countries of the world, the segregation in *Chemical Abstracts* of conservation methods under the heading "Utilization of Waste Products," and finally the preparation and publication of a successor to Winter's correlation of chemical patents, but extended to include Japanese, Canadian, and other patents.

In the absence of funds for the indicated activities your committee makes no recommendation regarding those suggestions which obviously involve large expenditure. It would seem to be only necessary for the Council to express its wishes as to the others.

GROUP C—CLOSER CONTACTS WITHIN THE SOCIETY AND SPECIAL
NEW ACTIVITIES

A number of sections, notably those in the West and on the Pacific Coast, feel the need of new agencies to develop and sustain the interest of members. To meet this need it is suggested that a special fund be created to cover partially traveling expenses incurred in visits to the more isolated sections of delegates from the more active sections, or the editors of the journals of the SOCIETY should be required to visit personally each local section once a year, or the SOCIETY should maintain one or more traveling secretaries to establish liaison between the sections.

The very rapid growth of the SOCIETY and its expanding activities have led to the suggestion of a permanent home in which its activities might be centralized, and the possibilities of Washington as a location are emphasized.

A clearing-house committee for chemical information is regarded as desirable or a central exchange or consultation bureau within the SOCIETY, to which each local section might apply for technical help on special problems. Other proposals are for a mediation bureau or combined personnel census and employment bureau under the management of the SOCIETY. One of the functions of the bureau should be the control and allocation of the chemical man-power of the country, and provision for the classification of chemists should be made.

The Council is urged to consider the establishment of a Dyestuffs Section in the SOCIETY and also to review the claims to its support of the Museum of Substances and of a general Institute for the History of Science.

It is suggested that a committee of the SOCIETY be appointed with broad power of action to consider reconstruction problems and the relation of the SOCIETY thereto as they may arise during the coming peace, and the belief is expressed that the organization of our industries should be built not on the ideal of national isolation and preparation for war, but on the expectation of permanent peace and that we should look forward to an organization of the relations of the world on the basis of justice, co-operation and good will.

Your committee recommends discussion of the proposal for a traveling secretary, but would point out that such an official could hardly be maintained for less than \$7500 a year and that it would not presumably be feasible for him to visit a section more than once in 6 months. At the conclusion of this report a motion for the establishment of a Dyestuffs Section is desirable to determine the wishes of the Council.

GROUP D—COMMERCIAL STATISTICS

The desire is frequently expressed for an extension and permanent organization of the chemical census initiated and outlined by Dr. Hesse for the listing and classification of all chemicals and materials involved in chemical commerce and manufacture. It is suggested that the second step should be the segregation of these into groups representing those which offer commercial possibilities and those which do not. Obviously, in the opinion of your committee, such a segregation is not feasible since commercial possibilities change with each advance in knowledge and are modified by many other variable factors. The third step proposed involves the organization of such further effort as may be indicated to render possible the successful production and marketing of commodities promising adequate return to capital or otherwise required in the interest of the country. In the opinion of your committee this third step may easily necessitate an amount of effort far greater than all the other activities of the SOCIETY combined and of a sort which might better be left to private initiative or governmental action.

To ensure the collection and regular publication of complete statistics covering import, export, and production in chemical and allied industries several alternative suggestions are offered: namely, an annual census similar to the Norton Dye Census; that the SOCIETY recommend to Congress and the executive

departments improvement in the organization of existing governmental agencies; that the SOCIETY by committee or representation cooperate permanently with the Bureau of Foreign and Domestic Commerce and other departments of the Government in the collection and publication of this statistical material; that a statistical bureau be organized within the SOCIETY to furnish information to manufacturers regarding imports and exports; that the *Journal of Industrial and Engineering Chemistry* present, with suitable explanatory matter and at approximately annual intervals, the statistical position of chemical and allied industries in foreign countries; that the SOCIETY appoint a committee to cooperate with the Committee on Chemicals appointed by the Chamber of Commerce of the United States. It is finally pointed out that much data on chemical compounds might be brought together under supervision of the SOCIETY through a periodical list of problems for graduate students and others.

Your committee recognizes the vital importance to American chemical industry and to industrial research of accurate, complete, and up-to-date statistics of the sort under consideration and recommends such action as in the judgment of the Council is most likely to promote their collection and publication by the Government.

GROUP E—COOPERATION WITH THE GOVERNMENT AND EXTENSION OF GOVERNMENTAL ACTIVITIES

This group includes an unusual proportion of ambitious and far-reaching suggestions, some of which would seem to your committee to demand especially careful and serious consideration.

It is suggested that the SOCIETY shall announce as its specific policy that it stands ready at all times to appoint committees of specialists to consult and advise with any executive or legislative officers of the federal or state governments or with any chemical department of the Government or any state in connection with the drafting of bills involving questions of a chemical nature or in connection, otherwise, with questions relating to the chemical industries.

Your committee regards this proposal as one of fundamental importance and believes that its effective realization would result in great benefit to the country and to this SOCIETY, but feels under obligation to point out that the engagements likely to result thereunder may easily involve the SOCIETY in large expense and otherwise bear heavily upon individual members of the SOCIETY. Your committee therefore recommends the appointment of a special committee of five to consider the matter in all its bearings with a view to formulating, if possible, a definite proposal which shall permit such general cooperation.

Other suggestions call for the coordination of the chemical industries under one bureau or division of the Government; a survey by the SOCIETY designed to promote better coordination among the chemical bureaus of the Government; or more broadly still, the unification of all the scientific resources and activities of the Government by the early creation of a new department of applied science and education with a secretary who shall be a scientist or engineer of note. In the opinion of your committee this suggestion in its broadest aspect should be thoroughly discussed and arrangements made for giving wide publicity to the conclusions of the Council.

The Industrial Survey and the Man-Power Survey of the Government should, it is suggested, be made available for utilization in consideration of reconstruction problems. An employment bureau should classify chemists from data in the recent government and AMERICAN CHEMICAL SOCIETY censuses.

Several suggestions have reference to improvement in the practice of the Patent Office and may be summarized in the recommendation, in which your committee heartily concurs, that the SOCIETY stand squarely in support of the Committee on Patents of the National Research Council in its efforts to improve the patent system and its administration.

It is suggested that discussion is desirable at meetings of the SOCIETY and in the journals in order to determine the consensus of opinion regarding the desirability of action to provide for Pan-American patents.

The appointment of a committee is suggested to formulate a bill for introduction in Congress and designed to encourage the manufacture of chemicals and apparatus of highest attainable quality for research and analytical purposes and placing these products under scrupulous official inspection.

A suggestion in which your committee concurs advocates effort directed toward securing the appointment of chemical specialists in our consular service as an aid to the development of foreign trade and as a means of providing for adequate reports on chemical industries.

Other suggestions stipulate that the Government maintain in the United States Mint a supply of platinum adequate for the purposes of science and industry and that the SOCIETY or the Government establish an institution to provide the rarer chemicals.

A considerable and important sub-group of suggestions deals with the need of making government publications and the work of government bureaus more generally available. Your committee recommends the appointment of a special committee of five to formulate and present to the Council a plan to secure this object.

GROUP F—PROTECTION AND DEVELOPMENT OF AMERICAN CHEMICAL INDUSTRIES

Eight sections urge in general terms the encouragement to the utmost of the use of made-in-America products or the necessity for adequate tariff protection for our chemical industries and especially for those of recent development. Chemical control of industry should be fostered and information furnished as to utilization of by-products. A general chemical survey of the country is proposed and local surveys of chemical industries urged for local sections as a means of developing local industry and rendering us independent of foreign raw material. Potash and nitrates should be developed, radium and vanadium ores conserved, and the peroxide industry continued, better reagents of domestic make are desired, and a great development of the manufacture of organic chemicals. The SOCIETY should establish standards of purity and conduct an educational campaign to enlighten the public as to the American chemical industry and the quality of its products.

It is further suggested that the SOCIETY take active membership and interest in national trade and manufacturing associations and specifically in the Chamber of Commerce of the United States. Means should be provided whereby manufacturers can make known their needs both as regards personnel and as to the solution of specific problems.

Your committee would direct your particular attention to the suggestion that national legislation should be secured which clearly recognizes the right of competing firms to combine and avoid destructive competition, while subject to Federal regulation and surtaxes.

GROUP G—PROMOTION OF RESEARCH

This section is prefaced by a warning suggestion to beware of the nationalization of chemistry, since any action which involves central supervision, either of research or of the activities of the members, will be unsuccessful in the higher values if it has any tendency whatever to control the ideas or ideals of the general investigator.

It is further suggested that the SOCIETY conduct a general survey and determine the particular lines of research work which are most important at this time. So far as financially possible the SOCIETY should support such research. Some improvement in standards of research work might be accomplished by the appointment of a committee to take cognizance of good research.

whether in schools or technical laboratories, or a research advisory board should be appointed by the president of the SOCIETY and assigned the duty of publishing from time to time reviews of research in particular fields, together with suggestions for work desired. The SOCIETY might find ways to impress upon the presidents of many small colleges the need and value of research in chemistry as in all departments of science, and the Carnegie Institution might be asked to report on the status of research in our various educational institutions.

It is proposed to encourage the training of women in chemistry and that the SOCIETY should aid and encourage the more general teaching of the science in high and other secondary schools. The SOCIETY should recommend definite policies concerning chemical education to educational institutions, and universities and colleges should be requested to inform the SOCIETY of their facilities for research by students with a view to cooperative effort. Finally, an education committee within the SOCIETY is suggested in order to develop standardized methods for administration and teaching.

Two sections united in urging the development of plans for the establishment of a research institution to aid, under the supervision of the SOCIETY, in upbuilding the American drug industry, through systematic research on the fundamental problems involved in the action of drugs upon the body. Such endowment is required as will ensure the service of the ablest scientists and such equipment that manufacturers through fellowships may have means for the study of their individual problems.

Having summarized in this very cursive and necessarily inadequate way this unassigned portion of the great wealth of suggestion received from the sections and membership of the SOCIETY, your committee feels that, with the few indicated exceptions, it would be generally undesirable and premature for it to make specific recommendations. It is obvious that with the utmost endeavor of our membership only a few of these proposals can be brought to an effective and concrete scheme of action. They show, nevertheless, in a gratifying and striking manner the interest taken by our membership in plans for constructive effort and it is believed by your committee that this report may have served its purpose and justified the great amount of effort which it has entailed if it aids in the gradual development and focusing of opinion concerning the more important and practicable of the suggestions submitted for its consideration.

To focus attention, the following specific queries are now submitted to this Council:

(a) ORGANIZED PUBLICITY COUPLED WITH EFFORT TO RAISE THE STANDARDS AND STATUS OF THE PROFESSION

1—Shall there be an institution like the Bar Association to determine and enforce standards of qualifications to practice publicly as a chemist, consulting, analytical, or otherwise?

2—Shall we have a Jubilee Volume in 1926?

(b) EXTENSION OF LIBRARIES AND PUBLICATIONS

1—Shall we extend the special service of *Chemical Abstracts* by supplying photo copies and translations from current publications against special fees?

(c) CLOSER CONTACTS WITHIN THE SOCIETY AND SPECIAL NEW ACTIVITIES

1—Shall the SOCIETY provide funds to defray traveling expenses of selected or invited individuals to remote sections of the SOCIETY?

2—Shall we have a traveling secretary or secretaries?

3—Shall we have a Dyestuffs Section?¹

(d) COMMERCIAL STATISTICS

All of this is now out of the way through the work of the Chemical Alliance, and of the Division of Planning and Statistics.

(e) COÖPERATION WITH THE GOVERNMENT AND EXTENSION OF GOVERNMENTAL ACTIVITIES

1—Shall the Society announce as a standing policy its readiness to appoint committees of specialists to consult and advise with any executive or legislative officers of the Federal or State Governments, or with any chemical department, or any State in connection with the drafting of bills involving questions of a chemical nature?

2—Shall we recommend to the Department of Commerce and also to the Treasury Department, and if need be to the State Department, the appointment of chemists for investigation of chemical, commercial, and industrial matters abroad? If so, shall we offer to nominate three desirable candidates for each available post?

3—A committee of five composed of the editors of our three publications (the editor of the *Journal of the American Chemical Society* to be chairman) and these three to select two additional members to investigate ways and means of making government publications more generally available, and with power to install such plan or plans so far as any or all of the publications of this SOCIETY are concerned.

(f) PROTECTION AND DEVELOPMENT OF AMERICAN CHEMICAL INDUSTRIES

1—Membership in the Chamber of Commerce of the United States is too expensive—being either \$600 or \$900 a year.

(g) PROMOTION OF RESEARCH

1—Shall our SOCIETY take active directive interest in American chemical research? If so, how?

2—Shall our SOCIETY take active directive interest in American chemical education and training? If so, how?

3—Shall our SOCIETY take active directive interest in advancing the position of women in American chemistry? If so, how?

A. D. LITTLE, *Chairman*

REPORT OF THE COMMITTEE ON WAR SERVICE FOR CHEMISTS

Many articles have appeared in the *Journal of Industrial and Engineering Chemistry* during the war regarding the war work of the chemists, many of which were put out by the chairman of the committee or by the editor of the *Journal of Industrial and Engineering Chemistry* in cooperation with him. The work was summarized by the chairman of your committee and presented in the form of an address, entitled "The American Chemist in Warfare," at the Cleveland meeting of the AMERICAN CHEMICAL SOCIETY and published in the *Journal of Industrial and Engineering Chemistry*, October 1918. The following additional data should now be put on record and this will complete the committee's work.

The AMERICAN CHEMICAL SOCIETY's plan of handling information concerning chemists, in the army or in civil life, who desired to make their services available to the Government in case of need, has been as follows:

When a chemist wrote that he expected to be drafted or inducted into the army, or that he was ready to serve where and when needed, a card, with the record obtained from the questionnaire sent out by the Bureau of Mines and the AMERICAN CHEMICAL SOCIETY was placed in the *Chemists' Reserve Group*. In case no record of birth, parentage, graduation, experience, etc., was found in the file, a blank questionnaire was sent with the request that it be filled out and returned promptly and record was made accordingly.

When word was received that the chemist was in military service, his card was transferred to the *Chemical Military Reserve Group* as being available for transfer to chemical assignment, and action looking toward the proper utilization of the chemical man power thus made available, was started immediately.

¹ Organized at Buffalo meeting.

The SOCIETY had many requests from different War and Navy Departments for information concerning the location and availability of chemists trained in special branches. Therefore, as soon as the data were at hand, a statement concerning the individual was sent to interested parties and his record card moved to the *Recommended Group*.

In this connection, it should be said that where personally unknown to the chairman of the committee the information furnished by the individual chemist concerning himself was taken at face value, to be investigated as seemed necessary by departments concerned, and it is a real tribute to the American chemist that the cases of overestimates or misstatements have been so rare as to be entirely negligible. As a whole, what the American chemist says he is, he is. What he says he can do, he can do. More than this, tell him what you want done and he'll do it. The achievements of the chemist in war work have amply demonstrated this.

Frequently need arose for a man of certain qualifications not found in the *Military Available Group* and it was necessary to have recourse to the *Chemists' Reserve Group*, and, in the majority of cases, it was possible to suggest suitable men. In every instance, it has been the function of the SOCIETY to try to place the government officials in touch with the required chemical ability and personality, without regard to individualism. In no case has membership in the SOCIETY been a factor in making these references, but most good up-to-date chemists were members of the SOCIETY.

If the chemist to whom the inquiring department was referred was found to have the necessary training and experience, a request for his transfer to chemical assignment was made by the department interested. In the early part of the war considerable difficulty was encountered in securing the transfer of the men for special, and hitherto considered un-military, duty for the simple reason that no machinery for such action existed. Unavoidable delays, therefore, unfortunately resulted in losing certain chemical man power to other duty overseas. How the overseas chemist was followed up will appear shortly. At all times, the greatest weight has been given to recommendations of the SOCIETY by the war officials.

On May 28, 1918, orders were issued which simplified and expedited the needed transfers. In fact, from that date no graduate chemist who had made known his training was permitted to leave for line duty in France, except those who were already in replacement detachments. Until this order was issued, a large part of the chemical need of the government war work was supplied by inducting into the service men who volunteered.

In any event, whether the man was obtained by transfer from a training camp, depot brigade, or from civil life, his record card was placed in the *Chemical Assignment Group*. This group included men having chemical work in practically every branch of the Army and Navy. Here the man was not lost sight of, for often as the war chemistry grew reassignments resulted in more efficient use of a man's ability.

If, for any reason, the request for a man's transfer to chemical work was not effected promptly, his card was removed from the *Recommended Group* and again placed in the active, available list. In this way, men with good chemical training, fitting them to serve almost equally well in somewhat different lines of work, were often recommended four, five, and six times as opportunity arose.

From the hundreds of chemists who either for a time were left in the training camps for lack of transfer machinery, or whose transfer was prevented by the signing of the armistice, tales of anxiety to get to the front, tales of experiences new to the highly trained scientist or of discouragement at the slowness of transfer to active chemical duty would show with what spirit these chemists hoped to do their part, even to ultimate sacrifice.

For instance, one man writes about a college instructor of chemistry as follows: "You should see Professor G. scrubbing the tables and cleaning the pans in the kitchen, or Dr. R. acting as chamber-maid to the Quartermaster's horses. Never having worked around them he is, like myself, not exactly at ease when they object to our methods of cleaning them. Still, he will say to a horse, 'Don't be afraid, nobody is going to hurt you,' and then 'Halt, Halt,' or at someone's suggestion, 'Attention.'" Chemists were held in the Depot Brigades five, ten, and twelve weeks, chafing to get into the fight at the front, or the laboratory—anything but inaction.

There was scarcely a chemist but in his own secret heart and sometimes not so secret, personally hoped for overseas duty in preference to assignment to some steel plant as inspector or analyst, or to some crowded government laboratory to do his share in winning the war. And why not? Who can but admit the "Glory of the Trenches?" One man answered the question, "In case of emergency where do you feel you can best serve the country?" with the reply, "Right up on the firing line, with a gun in my hands." Or as another said, "I'll do my duty, but no pen-pushing job for me." Indeed, at first thought, these might serve as the answer for many, since every chemist wanted only to lend a hand to whip the Hun, and there never was a chemist who hesitated an instant at the stories of hardship, horrors, and suffering. But in the light of the truly remarkable achievements of the chemists who, often against their protest, were put to chemical assignment, no American can question the general wisdom of assigning them then to the work they were trained to do.

That important, epoch-making order which went to the camp commanders said to the chemists, "You! who have trained yourself in this science have builded more than you knew; you may not seek hardship and glory on the soil of France or the snows of Italy or Russia; you must stay at home and man the laboratories of our poisonous gas plants, our munition factories, our steel mills, and research laboratories; you must turn the wheels of chemical industry that there shall be no lack of those supplies so intimately connected with and dependent on a chemist's knowledge, a list of which, by the way, would extend into every commodity necessary for winning the war. For you there will be glory only in the knowledge of service, far from the sound of guns but without which the guns would be as silent as the tomb."

How well the chemists responded is now a matter of history that some day will be written where all may read. In taking up the duties of warfare chemistry, a man entered into a field of activity, not of safety, comfort, and convenience, but of danger, discouragement, and exposure. How the chemist in this country has paid for the liberty of the world by personal sacrifice and danger as well as service, will form a story full of endurance, courage, sacrifice, and heroism, a second to none on the field of battle.

It must be remembered, too, that for every chemist serving in the honored uniform of the United States, another no less loyal chemist served equally in civilian garb. In the granting of honors, it is hoped that the sun's ray of glory will rest on the breast of some of these painstaking, self-sacrificing, devoted chemists, who gave of their best that Germany's guns might be out-shot, her airplanes out-flown, her submarines discouraged, her eyes blinded with smoke, her poison gas made harmless, her lungs filled with gas she could not combat.

Before the machinery for prompt transfer of chemists to chemical assignment was fabricated, many were ordered for overseas line duty. A card from the soldier to that effect was followed by sending a statement of his training, etc., to the officers in charge of the various lines of chemical work in France, and as a result, the needs abroad were sometimes conveniently sup-

plied by men on the ground. However, transfers of chemists with the American Expeditionary Force did not occur frequently for it can be readily understood that once a man had been trained for months on this side and still more "over there" for a specific military duty, his services might well have become so essential that a transfer to any other field or duty would be unwise. Hence a large part of the American Expeditionary Force chemists were inducted for chemical duty.

A word should be said about the unfortunate cases of misassignment, of which there have been two types and which were more or less inevitable in raising an army of several million men. When the Adjutant General's call for graduate chemists was sounded throughout all the training camps on May 28, 1918, hundreds of young men stepped forward to offer such chemical ability as they possessed and from these graduate chemists were to be selected and sent to Depot Brigade Headquarters for assignment to chemical work. At this point, an error was made, either due to lack of care in selecting those who were really graduate chemists, or due to the all too prevalent misconception that druggists and pharmacists, as well as one- and two-year chemical students were really chemists. Generations ago, the Town Pharmacist was the Town Chemist, but now all is changed. While they know some chemistry, their function is to know the properties of medicinals and methods of compounding them. The average druggist is no more a chemist to-day than the physician. Nevertheless, many were assigned to posts as chemists, and, since they were not suitable for the chemical duty, had to be used to whatever advantage possible, often as laborers. But they did their duty. On the other hand, many a well-trained graduate chemist was detailed only to find no place or need for a chemist or sometimes even to be used as a laborer where laborers were scarcer or more needed than chemists. Some of these misfits were adjusted and every effort was being made to reassign these men in the best interests of the service, when suddenly, as sunshine through a thundercloud, came the signing of the armistice and put an end to all these needed readjustments.

Below is a summary of the AMERICAN CHEMICAL SOCIETY records to date:

SUMMARY OF AMERICAN CHEMISTS IN THE MILITARY SERVICE	
On Chemical Assignment, U. S. A. I.	3841
On Chemical Assignment, A. E. F.	116
On Chemical Assignment in Navy	46
TOTAL IN CHEMICAL ASSIGNMENT.....	4003
Data sent to France, A. E. F., but transfer not effected.....	181
Officers and Elementary Chemists, A. E. F., not recommended transfer.....	58
Chemists in Aviation; A. E. F., and U. S. not on chemical assignment.....	29
Chemists in Navy, not on chemical assignment.....	23
Chemists in U. S. recommended for chemical duty, but whose transfer to chemical assignment was not effected.....	598
Chemists who expected to be drafted and probably did go into the Army—military assignment unknown.....	393
In Military Service, address unknown.....	5
TOTAL IN A. C. S. FILES NOT IN CHEMICAL ASSIGNMENT....	1287
Chemists on indefinite furlough.....	4
Chemists in Canadian service.....	6
Chemists discharged for physical defects, etc.....	26
TOTAL IN MISCELLANEOUS ASSIGNMENT.....	36
Chemists who were drafted and put in deferred classification (List very incomplete).....	78
TOTAL ON RECORD.....	5404

With the signing of the armistice came again the call of industry and many chemists, who could be spared, were promptly given honorable discharge to return to the factory, plant, or college, and so some of the record cards have found

¹ Some of these went to France in the last months of the war.

a resting place in the *Honorable Discharge Group*. The reuniting of chemists and industry is now being ably handled by the Industrial Relations Committee of the Chemical Warfare Service in full cooperation with the AMERICAN CHEMICAL SOCIETY.

Before the signing of the armistice, many chemists were taken from necessary positions in industry and were, therefore, granted indefinite furlough to return to those duties. For like reasons, large numbers of chemists were placed in *Deferred Classification* on account of the importance of their work. In this way, nearly every chemist in the country, in uniform and out, contributed his best to the winning of the war.

The committee wishes to express its sincere appreciation of the assistance of Mr. Harry A. Carpenter who, while acting as assistant to the Chief Chemist of the Bureau of Mines, put in much time and effort and assisted with valuable advice in the work of our committee.

MARSTON T. BOGERT
WILLIAM H. NICHOLS
A. A. NOYES

JULIUS STIRGLITZ
CHARLES L. PARSONS,
Chairman

REPORT BY THE COMMITTEE ON PUBLICATION OF COMPENDIA OF CHEMICAL LITERATURE, ETC.

I—PREAMBLE

A—The committee recommends cordial and effective cooperation in suitable ways by the AMERICAN CHEMICAL SOCIETY and other American scientific and technological bodies with the efforts of the chemists of Great Britain to organize the work of publication in English of compendia of chemical literature, and to encourage the production of chemical literature in English.

In presenting the whole problem of the organization of compendia, monographs, etc., in English by the British as well as by ourselves, the committee would urge that the question be considered from the point of view of national (cultural) importance as well as from that of scientific utility. The almost exclusive use of German compendia and monographs in all countries has given the German scientists an influence in foreign countries (from China to Argentina, Spain, and Russia, and all lands between these countries) entirely out of proportion to their real share in scientific productiveness—leading to the migration of foreigners to Germany for their advanced studies, with resultant serious influences, political, commercial, and cultural, in these countries. We must recall, too, that in their compendia and monographs, German chemists have been wont to ignore to a certain large extent, or to underrate, the work done in other countries, especially perhaps that done in the United States.

B—In pursuance of such cooperation with Great Britain, the committee recommends that power be given to the committee or to a new committee (a) to present the plans of the American chemists to the Executive Committee of the British organization of chemists dealing with this subject with a request for suggestions as to changes and elaboration which would make the cooperation more effective, and (b) to give a definite and binding pledge on behalf of the SOCIETY of cooperation within the limits of the plans as approved by the Council and Directors of the AMERICAN CHEMICAL SOCIETY.

C—The committee recommends that it be empowered likewise to lay its plans before some appropriate French body of chemists, with the assurance that while the present organized movement is primarily concerned with the compilation of compendia and monographs in the *English language*, the American chemists are anxious to cooperate effectively also with the French chemists as far as the difference in language makes such cooperation feasible, as in the preparation of certain tables of physico-chemical constants, in the organization of propaganda for the study of the French language by students in colleges and technical schools, in bringing to the attention of American chemists and of colleges standard authoritative works of French origin, etc.

II—COMPENDIA

A—The committee considers that the most effective and smoothest working cooperation with the British chemists in the matter of compendia of chemical literature, etc., would be secured by a *division of the fields of effort*. Each country would undertake the preparation of definite volumes with independent financial and scientific organizations for the carrying out of the work, but each country would also undertake to organize support of the work in the other country. Such support would consist (a) in cooperation in the matter of sales; (b) in organized scientific support by consultation as to plans, by scientific collaboration when deemed desirable by responsible editors (experts in either country should be invited *freely* to take part in their special branches of the volumes), by official recognition and recommendation of the volumes issued by the respective organizations.

B—The committee would recommend that the American part in the undertaking be the preparation of *critical volumes on physical and chemical constants and related numerical data* (besides monographs in other varied fields as discussed below), leaving to the British Commission the preparation of compendia of inorganic and organic chemistry, and leaving to the central French Secretariat of the International Commission on Annual Tables of Constants, etc., the continued compilation of non-critical abstracts of constants, numerical data, etc. This division is recommended on the grounds:

1—(a) That the plans of the British for the compilation of the inorganic and organic compendia are already practically perfected and their interest seems to lie chiefly in these volumes; (b) that the weight of interest in the United States seems to have settled itself on the volume of physical chemical data; (c) that we are most likely to secure adequate financial support for such an undertaking; and (d) that at the present moment the available forces in this country would probably be able to undertake this share of the work most effectively.

2—(a) That the French chemists, especially through the loyal efforts of Dr. Charles Marie, have continued the preparation of the Annual Tables of Constants, etc., and have already organized the work to bring the Tables through 1919, which work we heartily endorse; (b) The Americans can take on the editing of *critical data tables*, which had been planned by the International Commission, but which have not yet been realized. The contemplated division should save time and expense and should prevent friction and promote cordial relations of cooperation.

C—The committee makes the following recommendations as to the character of the compilation of the physico-chemical work:

1—The work should not be a mere compilation, but should represent a critical digest of physico-chemical constants.

2—The compilation should be published (and sold) in separate parts. This would greatly facilitate the editing, greatly accelerate the publication of certain most important parts, and greatly facilitate the problem of keeping the work up-to-date without incurring the necessity of reprinting a large volume.

3—The *business control* of the publication should be placed in the hands of three trustees, of whom one (the chairman) should be nominated by the president of the National Research Council and one each by the president of the AMERICAN CHEMICAL SOCIETY and the president of the American Physical Society (by invitation). These trustees shall be nominated for one year and be eligible for re-appointment. The trustees should have the power to interest scientific bodies (such as the National Research Council, the Smithsonian Institute, government bureaus, etc.) or some publishing house in the preparation and publication either of the whole compilation (subject to the scientific control discussed below) or of individual parts of the compilation, or to recommend any plan of financing the undertaking that they

may deem wise. The undertaking is to be considered primarily in charge of the National Research Council with the support of the AMERICAN CHEMICAL SOCIETY, the American Physical Society, and other scientific societies.

4—The *scientific control* of the preparation of the volume on physico-chemical constants shall be vested in a committee of seven to be appointed by the president of the National Research Council; three members on nomination by the Division of Chemistry and Technology and three members on nomination by the Division of Physical Sciences. The chairman of the committee will be the paid editor-in-chief of the work and will be selected by the president of the National Research Council in conference with the three trustees. (Interested scientific societies, including the AMERICAN CHEMICAL SOCIETY, the American Physical Society, the American Electrochemical Society, the Institute of Chemical Engineers, etc., are represented in the Divisions of Chemistry and Technology and Physical Sciences of the National Research Council.) The members of the committee are to be appointed for one year and are to be eligible for re-election.

5—The British Executive Committee and some appropriate French body should be invited to appoint each two co-members or advisory members of the scientific control committee, who shall be kept informed of the progress and the specifications of the scientific control of the undertaking, and who shall transmit to the committee the recommendations of the British and the French chemists. (The carrying out of this provision should be subject to an agreement by the British chemists to have similar American representation as co-members or advisory members on the scientific control committees of the volumes for inorganic and organic chemistry and to an agreement by the French chemists to give similar representation to American chemists on the scientific control committees of similar undertakings in France.)

III—MONOGRAPHS

Your committee recommends that the AMERICAN CHEMICAL SOCIETY undertake to have two series of monographs prepared and published under its supervision. To give effect to this general recommendation, it would recommend that the following specific steps be taken:

A—That three trustees be appointed, two, including the chairman, by the president of the AMERICAN CHEMICAL SOCIETY and one by the president of the National Research Council, to organize and control the business side of the undertaking. These trustees shall be named to serve for one year and shall be eligible for re-appointment. Subject to the approval of the Directors of the AMERICAN CHEMICAL SOCIETY, in all matters leading to expense, the trustees shall have the power to enter into negotiations with publishing houses for the publication of the series or to develop any other plan of financial administration. In particular, it is urged that the trustees should attempt to raise funds from which advance payments of royalties (say of \$500) may be made to each author (selected under II) invited to prepare a monograph and second payments of the same amount to each author when his monograph has been accepted. The trustees in return will receive all royalties accruing on the sale of a given monograph until the sums paid to an author of the monograph have been liquidated (without interest); later royalties are to go to the author. Royalties received in this way by trustees shall serve for the endowment of further monographs.

B—That two control committees be organized, one for a series of technological monographs, another for a series of scientific monographs. Each committee is to consist of five members to be elected by the Council of the SOCIETY (as in the case of the editors of our journals). The chairman of each committee shall be the editor of the corresponding series, and shall receive compensation of the same nature as the editor of the *Journal of the American Chemical Society*. The com-

mittee shall select men who are to be invited to prepare monographs on selected topics and shall pass on the final acceptance of such monographs or of such other monographs as may be offered for publication. Decisions as to the business arrangements for publication will rest with the trustees rather than with the scientific control committees.

E. C. FRANKLIN
JOHN JOHNSTON
JAMES KENDALL

J. C. OLSEN
JULIUS STIEGLITZ,
Chairman

REPORT OF THE COMMITTEE ON COÖPERATION BETWEEN THE UNIVERSITIES AND THE INDUSTRIES

1—The most important contribution which the universities can make to the development of industry in this country is to supply the industries with sufficient numbers of men thoroughly and broadly trained in the principles of chemistry. All other considerations must be subservient to this fundamental purpose.

2—There is a strong tendency at the present to draw men, who have been particularly effective in research work, away from the universities by the payment of salaries for industrial work far in excess of the salaries paid to the same men in a university. While we cannot, perhaps, expect as large salaries for university as for industrial work, it seems evident that unless a very considerable increase in the salaries of teachers of chemistry can be secured, the next generation of chemists is likely to be trained by a set of mediocre men. Such a result would be disastrous to our industries and every possible effort should be made to meet this danger. We urge most earnestly that the presidents and trustees of our universities should give this question a very careful consideration.

3—Fellowships which leave the student and his teacher entirely free to select for research some topic in which they are mutually interested are most desirable, and are likely to be most successful both in the training of the student and in contributing to the development of chemical science.

4—Fellowships designed to promote the solution of some problem which is of interest to a specific industry are also desirable. Valuable results are most likely to be obtained if the incumbent is already a well-trained chemist, and does not have to divide his time between graduate studies and his research. The results of an investigation of this type should be freely published for the benefit of the industry and should not, in general, become the property of a single firm.

5—Fellowships which are designed to secure the solution of some problem for the benefit of a single firm or individual should be subject to very careful restrictions. It must be remembered that a university supported by private benefactions or by a state has no right to use its funds for the benefit of a private firm. If such a fellowship is accepted at all, the firm should not only pay the stipend of the fellow, but it should pay for the work of the professor who gives advice about the work and should also pay for the use of laboratory facilities and for other expenses involved. In addition to the above, the results should be published within two years after the expiration of the fellowship.

Fellowships to prepare men for specific industries are desirable, provided the industry is a large one and the character of the training is left under the direction of the department. In particular, emphasis should always be placed on the broadest possible theoretical training. The holder of such a fellowship should be free (not under contract) at the end of his period of study.

6—In passing upon candidates for the degree of Ph.D., emphasis should always be laid on a thorough training in the fundamental principles of chemistry and of related sciences and upon high attainment in research, rather than upon the period of study. The tendency of many universities to refuse to give

any recognition to training or attainment in research acquired in other than a regular academic manner is not consistent with the proper significance of the doctor's degree. The requirements for the degree should be more, rather than less, severe than they now are, especially as regards breadth of training and independence in research, but emphasis should be laid on genuine attainment and not on the method by which such attainment is secured.

7—Apart from the establishment of fellowships it may be possible, in some cases, to secure coöperation between a university and those interested in the development of some industry by the appointment of committees in the various local sections.¹ The committees should be selected so as to include 3 to 5 members representing typical industries of the locality and 3 to 5 members representing those colleges or universities which might assist in the solution of problems which are submitted.

The Council at its meeting on December 14, 1918, authorized the appointment of such subcommittees in local sections. The initiative for the appointment should be taken in the sections which wish them. The members of the general committee of the Society will assist, as far as possible, in the organization of the committees. These subcommittees should report to the chairman of the main committee in order that the work of the various committees may be coördinated and duplication avoided. In some cases questions originating in one committee may be transferred to another for investigation.

R. F. BACON	ALEXANDER SMITH
W. D. BANCROFT	JULIUS STIEGLITZ
C. G. DERRICK	H. P. TALBOT
JOHN JOHNSTON	T. B. WAGNER
G. N. LEWIS	W. R. WHITNEY
W. H. NICHOLS	W. A. NOYES,
T. W. RICHARDS	<i>Chairman</i>

¹ Our committee is indebted to Dr. T. B. Wagner for this suggestion. The following quotation from his letter will help to explain what it is intended to accomplish.

"A subcommittee made up of 3 or 5 representatives of the state universities and other institutions of learning in a particular state, and of 3 or 5 members representing typical industries of that state would soon be placed in a position to do constructive work. The universities would learn of the problems to be worked out in certain industries, and the industries would learn, probably for the first time, of the facilities which the universities have at their command not only with respect to the physical features of research work, but particularly with respect to the talent available among the student corps, or among the graduate students.

"Let us take a concrete case, and because of my familiarity with the industry of corn products, permit me to choose this industry as an illustration: A subcommittee in Illinois or Iowa, both great corn-producing states, would meet and discuss some of the problems of the corn products industry—less those directly connected with the operation of their plant than those of a strictly research nature: In the process of producing starch and glucose, the corn is first steeped in water acidulated with sulfur dioxide, and when steeping is finished this extract has a density corresponding to about 4° or 5° B_x. This extract contains the highly valuable organic phosphorus salts of the phytin type, potash salts, amino compounds, and other ingredients of scientific interest and commercial value. Up to a relatively short time ago, this extremely valuable material was allowed to run to waste, but it is now carefully conserved, concentrated to a heavy syrup, and then incorporated with gluten feed, which is a well-known cattle feed. This product alone would keep a number of chemists occupied for a considerable length of time, especially students in physiological chemistry, as some of these products are of marked therapeutic value. The gluten of the corn is another substance that warrants the attention of chemical investigators, because while at present a comparatively low-priced product, it is conceivable that this same gluten might be converted into human food or into commercial articles, such as a shellac substitute, etc., in which cases its commercial value would be greatly enhanced. I could go on reciting a number of cases, but the above, I believe, will suffice for the purpose of illustration.

"I have selected the industry of corn products because of my familiarity with it, and also because it is one of the leading industries of Illinois. There are other important industries in Illinois based upon organic and inorganic chemistry alike, and what has been said for the corn products industry applies with equal force to these other industries.

"I believe that in this manner two great objects would be attained, first, the resources of the individual states would be developed, and secondly, research work would receive a new stimulus. Both of these factors are essential to the development of our industries and the growth of our nation."

EDITORIALS

A REAL TRANSFORMATION

The transformation of a jazz band into a well-balanced orchestra would constitute a real stunt in musical circles. A similar process has been quietly taking place in certain lines of scientific research. The Chemistry Division of the National Research Council, as originally promulgated, was so busy talking about what it was going to do and so concerned with organizing a multiplicity of committees to handle every subject under the sun that it had no time left to do any effective work. Gradually its several functions were taken over by other bodies which were found to operate at a pace better suited to pressing war conditions, and so it was practically lost sight of by chemists.

The fundamental idea, however, was sound, and fortunately the services of Dr. John Johnston were secured as chairman. In a quiet, efficient, and thoroughly tactful manner Dr. Johnston began the work of rehabilitation—and lo and behold! he has created an orchestra whose repertoire is by unanimous vote confined to such arias as are demanded, and whose ambition is to prove a real service.

In doing this Dr. Johnston not only kept himself in the background, but has purposely succeeded in eliminating himself from further direction of the undertaking. A worthy successor has been found in Lieutenant Colonel W. D. Bancroft, who assumes the chairmanship of the Division as soon as his editorial duties for the Chemical Warfare Service are ended, about July 1, 1919. The versatile character of Col. Bancroft's mind, his broad sympathies, and his ability to secure coöperation insure a sound development, in matters chemical, of the coordinative principles of the National Research Council.

A ROLL OF HONOR

Once in a while, amid the humdrum affairs of everyday routine, something startling occurs. So, too, amid the stress and turmoil of this agitated period in American chemical effort, from out the shadows of doubt and ofttimes sedulously propagated distrust, there looms a brilliant light beckoning us on to that haven of full national service where we would be.

Such a light was the message cabled on March 29, 1919, direct to President Wilson, at Paris, urging the protection by every means possible of the new American dyestuff industry. The signers include not a single producer of dyestuffs. This urgent appeal, carrying so broad a vision of what the industry means to the national welfare, represents the views of consumers of dyestuffs, and constitutes an unexampled measure of coöperation which should inspire the American chemist to redouble every effort to give to American consumers the best and cheapest products the world has ever known.

The list of those who signed the cablegram represents by no means a complete canvass of the country. It was necessary to work rapidly. We believe; how-

ever, it is representative of a new spirit of coöperation which insures success. The message and its signers follow:

To the President of the United States:

The undersigned, representing various branches of the textile industry, respectfully submit that in their opinion an independent, self-sustaining, American dye-manufacturing industry is a natural necessity; that such a dye industry cannot be established unless competition from German factories, including those in occupied territory, be cut off for a period of years; that no tariff will furnish protection against the enormous resources and unscrupulous methods of the German trust fighting to regain its foreign market; and that only a licensing plan like the British, excluding all foreign dyes reasonably obtainable in the United States, will save the new industry. We respectfully urge that immediate steps be taken to procure both in the peace treaty and in legislation the measures necessary to establish such a plan.

We advocate this not merely because a domestic dye industry is essential to the independence of the American textile industry and manufacture generally, but chiefly because we believe that only through an established dye industry can the nation secure the progress in chemical education, in the application of chemistry to the arts, and above all in curative medicine, which are indispensable to the national welfare.

Allentown Silk Dyeing Co.	Middlesex Bleach, Dye & Print Works
American Piece Dye Works	Millbank Bleachery
American Printing Co.	Millville Mfg. Co.
Apponaug Co., The	Minot Hooper & Co.
Arnold Print Works	Myrick & Rice
Aspinook Co., The	National Silk Dyeing Co.
Baily, Joshua L., & Co.	New Cumberland Knitting Co
Bancroft, Joseph, & Sons Co.	Oriental Silk Printing Co.
Barrett, Nephews & Co.	Pacific Mills
Barretts, Palmer & Heal	Parker Wilder & Co.
Cronx Co.	Penn. Dye & Finishing Co.
Bannon Mills	Providence D. B. & Calendering Co.
Catlin & Co.	Putnam Hooker Co.
Cheney Brothers	Rockland Bleach & Dye Works Co., The
Chester Paper Co.	Sayles Finishing Plants
ClaySmith Co.	Schmidt & Ault Paper Co.
Collins, Clarence L., & Co.	Scranton Lace Co., The
Columbia Mills, Inc.	Shetucket Co., The
Cone Export & Commission Co.	Skinner, Wm., & Sons
Conestoga Hosiery Co.	Slater, S., & Sons, Inc.
Converse Co.	Smith, Albert D.
Converse Stanton & Co.	Smith, Hogg & Co.
Davis & Quick	Southbridge Printing Co.
District of Columbia Paper Mfg. Co.	Springett Mills, The
Duplan Silk Corporation	The Standard Bleachery Co.
Eddystone Mfg. Co., The	Standard Silk Dyeing Co.
Farrish Co., The	Stearns, F. U., & Co.
Georgelood Sons & Co.	Sterson, John B., Co.
Great Falls Bleachery & Dye Works	Stevens, J. P., & Co.
Green, S. H., & Sons Corp.	Stewart Silk Co.
Haines, Moorehouse & Woodford	Susquehanna Woolen Co.
Harris Co., Inc.	Tatum Pinkham & Greey
Haywood, T. Holt	Union Bleaching & Finishing Co.
Hobokus Bleachery	United Piece Dye Works
Hunter Mfg. & Commission Co.	United States Finishing Co.
Hussong, Jas., Co.	Utica Willowvale Bleaching Co.
Iselin, Wm., & Co.	Waltham Bleachery
Jordon Silk Dyeing Co.	Warren Mfg. Co.
Knight, B. B. & R.	Weidman Silk Dyeing Co.
Laanett Bleachery & Dye Works	White, James F., & Co., Inc.
Lehigh Silk Dyeing Co.	Whitman, Clarence, & Son, Inc.
Leslie Evans & Co.	Wilson, James L., & Co.
Lewiston Bleachery & Dye Works	Wilson & Bradbury
Liondale Bleach, Dye & Print Works	Windsor Print Works
Lorraine Mfg. Co.	Woodward Baldwin & Co.
Lowell Bleachery	Wyoming Valley Lace Mills
Lyons Piece Dye Works	York Haven Paper Co., The
Meyer, John H., & Co., Inc.	

THE SAME OLD STORY

In the *New York Globe* of March 27, 1919, its Berlin correspondent, Ben Hecht, reported by cable an interview with Professor Walther Nernst. The interview concludes with the following paragraph:

I am unable to talk to American scientists. The AMERICAN CHEMICAL SOCIETY expelled Professor Fischer and myself six months before the end of the war. We were honorary members of the Society. Scientific American men like Professor Millikan and dozens of others were our pupils and studied in my laboratory. I am an honorary member of the French chemical society. They did not expel me. The English society only suspended our relations, but the American society expelled me on the ground that I was working to help my country, as the members of the same society were doing to help theirs.

Working to help his country! The same old justification of those who exulted in the treacherous murder of helpless women and children on the Lusitania; who outraged the women and maimed the little ones of France and Belgium; and who, in milder moments, destroyed orchards and gutted industrial plants.

Happily the power to continue such outrages has been denied by the conquering arms of those who helped their countries as benefactors to whom right is might; but unhappily there is yet no indication of any change of heart in those who without scruple strove for world domination and—lost.

Outlaws among civilized people! The realization of that fact has not yet struck home. The presence of the names of Nernst, Ostwald, and Fischer among the ninety-three German professors who soon after the beginning of the war signed the notorious manifesto to the civilized world seeking to cover Germany's rapacious designs under a cloak of injured innocence is abundant justification of the resolution striking these names from the list of honorary members of the AMERICAN CHEMICAL SOCIETY. The preamble states clearly the ground on which the action was taken. Let the resolution be repeated here.

WHEREAS, The behavior in war of the German people has dishonored them among the enlightened nations of the earth and proved them unfit to associate with civilized men and women, and

WHEREAS, Walther Nernst, Wilhelm Ostwald, and Emil Fischer have been actively associated with the German government and its people in their conduct and offenses, now therefore be it

Resolved, That the names of the said Nernst, Ostwald, and Fischer be dropped from the rolls as honorary members of the AMERICAN CHEMICAL SOCIETY, and

Resolved, That this act be construed to take effect as of August 1, 1914.

ROCKS AHEAD!

We had one real jolt at Buffalo. While exulting over the splendid cooperation of consumers of dye-stuffs, as evidenced in the cablegram to President Wilson reproduced in another column, a prominent member stated that he had been told by three professors, representing three state universities, that they would buy from Kahlbaum as soon as trade relations were reestablished, in order to save money.

We would not believe this except for our faith in the good faith of the man who made the statement. It is humiliating to record the fact that there are men among us, receiving their salaries from public funds, and charged with the responsibility of training the

future chemists of America, who are disposed to barter with those who so recently attempted to ravish the world.

How can we have the face to urge public patience and support of our efforts in behalf of economic independence if, in seeking our own supplies, we throw ourselves so willingly into the arms of those who know only too well how to cripple whenever a club is placed in their hands? There are real rocks ahead if our vision is not clear on this point.

At the Council Meeting in December, Congress was urged to abolish the privilege of duty-free importation by educational institutions. This action was supplemented at Buffalo, in the most largely attended meeting of the Council ever held, by a ringing and unanimous affirmative vote on a resolution expressing the conviction that duty-free importation afforded the most subtle means for insidious propaganda. If the Council was right on that vote the three professors are on dangerous ground. In planning their economies we believe that they have not considered this matter in all of its bearings. It cuts deep at the roots of American chemistry.

We do not wish to be misunderstood. Profiteering or continued output of inferior material is not to be condoned. If such practices exist, there are abundant means for correcting them. Friendly and constructive criticism both as to price and quality of material would surely be welcomed by our manufacturers. Cooperation of all interests involved would lead us toward the goal which every true American must have in his heart. If these methods fail, let's try publicity. THIS JOURNAL exists for that purpose, and we shall not hesitate to criticize the manufacturers, if the need ever should arise, just as severely as we now do those who wittingly or unwittingly would undermine their efforts in behalf of our independence.

This matter came up in another form at the Buffalo meeting in connection with the paper read by Dr. H. T. Clarke, of the Eastman Kodak Company, giving an account of the efforts made to supply pure organic chemicals in small quantities for universities and research laboratories. In the ensuing discussion there was criticism of prices. The gratifying outcome was the prompt offer by representatives of three large manufacturers to help by furnishing free to Dr. Clarke raw or technical materials in small amounts, and a further offer by a representative of the U. S. Tariff Commission to furnish a list of all the organic chemicals now being manufactured in this country. At the request of a large number of organic chemists we take pleasure in urging all manufacturers of organic chemicals to cooperate in this work by supplying Dr. Clarke with a complete list of those of their products and intermediates which can be furnished at once.

The American spirit is not on the decline. On the contrary, it is very much alive at the present time. Shall we be the ones to mar it? A thousand times no! Let us pull together, and keep a sharp lookout for the rocks ahead.

CONTRIBUTIONS FROM THE CHEMICAL WARFARE SERVICE, U. S. A.

GAS MASK ABSORBENTS¹

By ARTHUR R. LAMB, ROBERT E. WILSON AND N. K. CHANEY

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INTRODUCTION

The development of absorbents for gases has naturally taken an enormous stride forward during the recent war. The present gas mask absorbents are unquestionably several times as efficient in every way as any materials which were used for like purposes before the war. Such an advance has, of course, been made possible only by intensive study of all the factors which combine to make an efficient absorbent, and by the trial of many thousands of mixtures of different absorbent materials. The development of these absorbents has been further complicated by the fact that the goal aimed at has not been a fixed one, but instead has gradually passed through many different stages, as new gases came into use, as new field conditions arose, and as the relative importance of the different factors had to be re-balanced in the light of new information coming from the front.

The absorbent used in both the British and American gas mask canisters, which afforded a degree of protection far superior to that of any other allied or enemy nation, consisted of a mixture of charcoal and soda-lime. The mixture used in the American canisters for the last 9 months of the war contained 60 per cent 6 to 14 mesh coconut shell charcoal (or other shell charcoal) and 40 per cent 8 to 14 mesh soda-lime-permanganate granules. This absorbent, commonly referred to as the "war gas mixture," has been generally recognized to be distinctly more stable and efficient than that used by any foreign country. Even better than this, however, was a new combination which was to have been put into production very shortly, a mixture of 75 per cent specially impregnated coconut charcoal and 25 per cent of soda-lime containing no permanganate. This mixture would have had a distinctly greater all-round efficiency than the one which was actually used.

In order to make clear the reasons underlying the choice and composition of the above two absorbents, it is necessary to discuss the general requirements which must be met by a gas mask absorbent. Each of these requirements will accordingly be taken up in turn.

GENERAL REQUIREMENTS FOR GAS MASK ABSORBENTS

ABSORPTIVE ACTIVITY

Absorptive activity, or a very high rate of absorption, is one of the most important properties of a satisfactory gas mask absorbent. A normal man when exercising

violently breathes about 60 liters of air per minute and, since inhalation occupies but slightly more than half a breathing cycle, the actual rate at which gas passes through the canister during inhalation is about 100 liters per minute. Calculated on the basis of the regular army canister, this corresponds to an average linear air velocity of about 80 cm. per sec. On the average, therefore, a given small portion of the air remains in contact with the gas absorbent for only about 0.1 sec. This is obviously a very brief interval in which to remove toxic materials from the air.

Furthermore, this removal of the toxic materials must be surprisingly complete. Though the concentration entering the canister may occasionally (though very seldom) be as high as one-half or one per cent, even the momentary leakage of 0.001 per cent (10 parts of gas per million of air) would cause serious discomfort, while the prolonged leakage of as much as 0.0001 per cent (one part per million) would have serious results in the case of many of the extraordinarily toxic gases used in modern warfare.

It is evident, therefore, that an absorbent or combination of absorbents for use in a gas mask must be capable of reducing the concentration of gas from say 1000 p. p. m. to 1 p. p. m. or less, within the 0.1 sec. This is, however, accomplished with a safe margin by the present gas mask materials. In fact, it has been shown that charcoal will reduce a concentration of 7000 parts of chlorpicrin (CCl_3NO_2) per million of air in a rapidly moving current to less than 0.5 part per million in less than 0.03 sec. Nevertheless, a great many other absorbents, which give excellent results under normal conditions of low concentrations and ordinary rates of breathing, must be rejected on account of insufficient activity to meet high concentrations or high rates of breathing. It is essential, therefore, that any absorbent, to be finally adopted for use in a gas mask, must have a very high rate of absorption or, as it is commonly termed, a high degree of adsorptive activity.

ABSORPTIVE CAPACITY

Of almost equal importance, from a military point of view, is the absorptive capacity of an absorbent. The difficulty of transporting large numbers of fresh canisters to the front-line trenches makes it imperative that an absorbent shall have a long life—indeed, one measured in months against ordinary concentrations of gas—and in addition, be able to survive occasional exposure for shorter lengths of time to very high concentrations. The absorbent must, therefore, be able to absorb and hold large amounts of gas per unit weight of absorbent. It is, of course, possible to obtain almost any desired capacity by using very large containers, but the need for conserving every cubic inch of space and every ounce of weight in a soldier's equipment makes it imperative to secure this large capacity with the smallest possible weight of absorbent

¹ This article, one of a series of three on the army gas mask, is published by permission of the Director of Chemical Warfare Service, U. S. A. It is based on investigations conducted by the Research Division of that Service, to which many different individuals have contributed. No attempt has been made to describe the details of the large-scale manufacturing processes, which will be fully covered in another article in this Journal, by Major J. C. Woodruff, of the Gas Defense Division, C. W. S.

material. The American canister, as a matter of fact, contained considerably less than a pound of war gas mixture.

Furthermore, in view of the fact that even extremely small amounts of the war gases are dangerously toxic, it is necessary that the gases be held firmly, and not in any loose combination which might give up even the minutest traces of gas when air is for long periods of time breathed in through a canister which has previously been exposed to gas. This requirement rules out many absorbents which seem to have very good capacity on high concentrations of gas, but which do not hold these gases with sufficient tenacity. This applies particularly to the type of absorbents which hold the gas partly by *adsorption* and partly by *condensation* in extremely small capillaries, the latter form of absorption being practically valueless for field use, although it appears to give very good results on high concentration tests.

VERSATILITY

It is obviously impracticable to have more than one type of canister filling for general military use. Any other arrangement would not only introduce complications and increase transport difficulties, but would also require a more rapid and certain identification of toxic gases than is now available, or than is reasonably to be hoped for. Furthermore, there is always the possibility of meeting some new, and perhaps entirely unknown gas. It follows, therefore, that a single type of canister filling must not only present very high activity and capacity for the ordinary toxic gases now in general use, but it must be of a type which can be relied upon to give protection against practically any kind of toxic gas. It is fortunately true, however, that all gases which are highly toxic, and therefore, adapted for use in warfare, are either very reactive chemically, or else have relatively high boiling points and can therefore be adsorbed in large amounts by a material such as charcoal.

MECHANICAL STRENGTH

A canister during transport over rough roads in motor trucks and in actual field use is subjected to extremely rough handling and jolting. Gas mask absorbents must, therefore, be mechanically strong, in order to retain their structure and porosity under such conditions. Not only must they be not easily crushed or deformed by continuous pressure, but neither must they be subject to abrasion, with the production of any considerable amount of fines. The size of the granules, which, on account of other conditions, must be used in the gas mask, is such that the production of a relatively small amount of fines would tend to plug up the canister or cause serious channeling.

CHEMICAL STABILITY

An absorbent canister is ordinarily filled several months before it is first used in the trenches. Furthermore, air containing more or less gas is breathed through the canister for long periods of time, frequently extending over several months, before the canister is discarded or withdrawn from service.

Obviously, therefore, it is not the *initial* efficiency of an absorbent which determines its value under actual service conditions, but rather the *ultimate* amount of activity and capacity for the absorption of poison gases, which will be retained after this long period of storage and exposure to air of varying humidity, and temperature.

To give satisfactory service, therefore, an absorbent must possess a very considerable degree of chemical stability. In the first place, it must not be subject to any considerable chemical deterioration or slow reaction proceeding within the absorbent itself. The two absorbents used in any mixture must, furthermore, have no tendency to react with one another. In order to withstand the exposure to air of varying and sometimes very high humidity, it is essential that the absorbent contain no hygroscopic or efflorescent material, nor one which is easily oxidized. The absorbent must not be seriously deteriorated by taking up carbon dioxide (which means, in general, that it should not absorb very large amounts of this gas). It must not disintegrate or become deliquescent even after gassing with any of the ordinary war gases. It must also have no tendency to corrode its metal container. It is obvious that the above-mentioned requirements place very serious limitations on the materials which can be used with satisfaction in any gas mask absorbent.

LOW BREATHING RESISTANCE

In order to obtain a high degree of activity, it is necessary to have the absorbent present the largest possible surface to the gas, and to have the distance through which the gas must diffuse to reach the absorbent as small as possible. A finely granular absorbent gives extremely good results in these respects. On the other hand, troops, particularly those in action, must be able to breathe freely and deeply. The size and arrangement of the absorbent granules must accordingly be such that the resistance to the passage of air is very small, as otherwise the soldier will be forced either to cease active movement or remove his mask.

From the standpoint of breathing resistance, therefore, it is important to use granules of a relatively large size. This again places a fresh burden upon the activity of the chemical absorbent. It also requires that the granules be sufficiently porous to permit the penetration of gas well into the interior so that their capacity may be fairly well utilized. The necessity for having low breathing resistance is also the basic reason for the insistence upon the two previously mentioned requirements, namely, the mechanical strength of the absorbent and its non-deliquescent properties, since both of these would tend to cause a marked increase in the breathing resistance.

Very elaborate investigations have been made to determine the most desirable size of granules, depth of layer, and area of cross section in order to strike the best possible balance between low breathing resistance and good all-round absorptive efficiency. These investigations have tended to show, in general, that the use of large cross-sectional areas of relatively fine

granules gives the best all-round results. Such investigations have also indicated that where two absorbents, such as charcoal and soda-lime, are used, as in the present war gas mixture, it is better to mix the components rather than to place them in separate layers. This obviously simplifies the problem of canister filling.

EASE OF MANUFACTURE, CHEAPNESS AND AVAILABILITY OF RAW MATERIALS

The need for adequate protection against war gases is so transcendent that no difficulty would be too great nor any price too dear to provide such protection. On the other hand, the scale of military requirements in our modern armies is so colossal that an expensive absorbent would represent a severe economic strain. Furthermore, the setting up of a very complicated plant with a great deal of special machinery, under the stress of a war emergency, is a difficult and time-consuming task. Cheapness and ease of manufacture are therefore important considerations which must be given due weight in deciding upon an absorbent for war gases. The availability of the raw materials, without putting too much drain on any other essential war industry, is naturally an absolutely essential prerequisite to the choice of any absorbent.

PROPER BALANCE

While a single type of canister filling is essential for military use, it is impossible to combine in any single absorbent or combination of absorbents the best solution of each of the above requirements. For example, it is only possible to obtain adequate mechanical strength in the soda-lime absorbent by the use of certain binding agents which militate markedly against both the activity and the capacity of the resulting absorbent. The most active absorbents are also in general too unstable, or have a tendency to take up carbon dioxide or to deliquesce in the presence of moisture. Certain desirable components for use in absorbents are also too expensive or too difficult to obtain to be recommended for such purposes. It is obvious, therefore, that in a good general absorbent there must be the proper balance between its various essential qualities. Accordingly, the present war gas mixture is at best a compromise. It nevertheless fulfills these requirements to a much greater degree than would previously have been considered possible. It should be emphasized, however, that the best balance of these factors for military purposes is obviously not the one which will give the best results for industrial uses.

CHARCOAL

ADVANTAGES AS AN ABSORBENT

The only single substance which even approximately fulfills all the above requirements is charcoal. This absorbent, when properly prepared, has almost unique qualifications for this purpose as will appear from the following summary of its characteristics.

Its absorptive activity is extremely high. Active charcoal at the temperature of liquid air will bring a hundred times its own volume of air at atmospheric pressure down to a pressure of a few millimeters of

mercury in a few seconds. Similarly, when air containing an easily absorbed gas is passed over the charcoal, the velocity of adsorption is apparently limited only by the velocity of the diffusion of the gas.

Its absorptive capacity is very great. Charcoal has been made on a large scale, which will absorb about half of its own weight of certain toxic gases, while samples have been prepared in the laboratory which will absorb more than their own weight.

Its mechanical strength, at least when prepared by proper treatment from suitable raw materials, is very great.

Its chemical stability is practically complete. Careful investigations have indeed shown that a very slow oxidation of the charcoal by the air is continually proceeding, but this produces no measurable effect on the absorptive value or apparent density of the charcoal over a period of several months. Very small amounts of carbon dioxide are taken up from the air, but produce no harmful effect. The adsorption of water from moist air causes a considerable decrease in its absorptive capacity for many other gases, but even this cannot be said to be due to any chemical instability.

Charcoal is reasonably cheap and not particularly difficult to manufacture after the development stage has been passed. Its raw materials are cheap and accessible, though the quantities required and the scarcity of shipping caused some difficulty during the war.

Its versatilitv is pronounced; indeed, since all gases and vapors are somewhat adsorbed by charcoal, it is a universal absorbent. Permanent gases, to be sure, are only slightly adsorbed, but none of them is highly toxic. A majority of the so-called war gases are really liquids boiling above ordinary temperatures, and all these are very firmly held by charcoal. Only in the case of a relatively few, very volatile, toxic gases, such as arsine and cyanogen chloride, does charcoal possess inadequate adsorptive capacity.

ADSORPTION BY CHARCOAL

METHODS OF DETERMINING ADSORPTION—In discussing the properties of charcoal, it is necessary to distinguish carefully between charcoals of different degrees of "activation." In determining the adsorptive capacity of a sample of charcoal, it is necessary to choose a gas which is rather inactive chemically, and which is therefore held by adsorption only. The standard test used for rating charcoals was known as the accelerated chlorpicrin test, and consisted essentially in passing a stream of dry air, containing 7000 p. p. m. of chlorpicrin, at the rate of 1000 cc. per sq. cm. through a 10 cm. layer of charcoal until the first trace began to come through. The minutes to breakdown measured the value of the charcoal, and was customarily referred to as the *service time* of the charcoal. No pre-war material in the country lasted over 15 sec. on this test. The regular plant product during 1918 averaged about 18 min.; the last 2 months' operation gave material averaging 35 min. Large-scale units have frequently produced 50-min. material, and the Research Division has made material in

the laboratory running as long as 70 min. on the foregoing test.

Tests against other gases are generally conducted at a rate of flow of 500 cc. per sq. cm. cross section, 10 cm. layer, and concentrations varying widely so as to give a reasonable length of test time.

The foregoing type of tests is very valuable and practical, in that it is rapid, reasonably accurate, and approximates fairly closely (except for the high concentrations) actual field conditions. Such tests do not, however, separate the factors of activity and capacity, or represent any very definite physical constant of the material, since equilibrium is by no means obtained. This is especially true if the charcoal contains moisture. In such accelerated tests, the first or upper portion of the absorbent is generally more than saturated, the middle portion partially saturated, and the lower portion contains very little gas when the breakdown occurs. The length of these various portions depends, of course, on the activity or rate of adsorption of the absorbent. The test does, however, weight activity and capacity in about the proper ratio for actual service conditions.

Where investigations are made of the effect of pressure or other factors on adsorption, the test is usually conducted in an evacuated chamber where only the gas being studied is present, and pressures and weights absorbed are carefully determined.

VARIATION WITH KIND OF GAS—As indicated previously, the adsorption of gases on charcoal, and indeed on all substances, is roughly parallel to the case with which they are condensed to the liquid state. In other words, their adsorption decreases with their boiling points, or probably more vigorously with their critical temperatures. This is shown by the figures in the following table:

TABLE 1—ADSORPTION OF GASES AT 0° ON CHARCOAL

Gas	Boiling Point Deg. C.	Critical Temperature Deg. C.	Gas Adsorbed Cc. per G. Charcoal	
			Wood Char- coal at 10 cm.	Coconut Charcoal at 76 cm.
Helium.....	-268	-267	...	2
Hydrogen.....	-253	-241	0.3	4
Nitrogen.....	-196	-149	1.5	15
Carbon monoxide.....	-190	-136	..	21
Oxygen.....	-183	-119	2	18
Argon.....	-186	-117	...	12
Carbon dioxide.....	-78	+131	20	..
Ammonia.....	-33.5	+130	50	..

Carbon monoxide with a critical temperature about 100° higher than hydrogen is adsorbed about 5 times as much on the same charcoal; ammonia with its critical temperature 270° higher still is adsorbed about 200 times as much. This parallelism is not, however, perfect; argon, for example, is adsorbed much less than would be expected from its boiling point and critical temperature. This divergence is unquestionably due to the extreme weakness of its stray fields of force. Also, substances with a relatively high critical temperature and which are highly adsorbed, when compared among themselves, show great irregularities in this respect, the more reactive gases generally being held the more firmly. These facts indicate that although variation in the forces of attraction between the gas molecules themselves is the main factor in causing differences in the adsorption of different gases, regard-

less of the adsorbing agent, nevertheless specific chemical forces between the charcoal and the gas play no small part in the action of the adsorbent.

The service time of a variety of different charcoals against all the commoner war gases is shown later in Table 5.

VARIATION WITH THE CONCENTRATION OF THE GAS—Adsorption represents a balanced condition between the free gas space and the surface film. The higher the concentration of the free gas, that is, the higher the gas pressure, the greater will be the amount adsorbed. The amount of adsorption is not, however, strictly proportional to the pressure; the relationship is shown clearly by means of the typical Curve (a), Fig. 1, for the adsorption of a gas by charcoal at constant temperature.

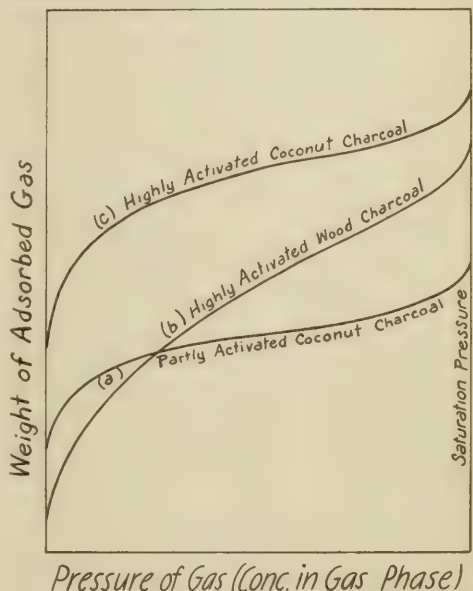


FIG. 1—VARIATION OF ADSORPTION OF A GAS WITH ITS CONCENTRATION AT CONSTANT TEMPERATURE

Each part of the foregoing curve may unquestionably be referred back to certain physical relationships which occur as larger and larger amounts of gas are absorbed. Thus the lower part of the curve, where a considerable amount of gas is absorbed with practically zero vapor pressure, very probably represents the amount of gas adsorbed in a layer one molecule deep covering the active surface of the carbon. This part of the gas is held extremely firm and is unquestionably the most valuable part of the absorption curve. A great difference between charcoal and metallic oxide and gel-like absorbents lies in the fact that this first layer of molecules is held with such extraordinary tenacity, whereas in the case of most other absorbents, even the first layer of molecules exerts appreciable vapor tension.

That part of the curve which begins to round off

away from the zero pressure axis very probably represents the amount of gas which is held by the less firm and more variable adsorption of molecules in the second and third layers. The tenacity of this adsorption depends to a considerable extent upon the curvature of the carbon surface of the capillaries. Thus, if the curvature is very sharp, a molecule might be held rather firmly even on a second-layer film, being partially held by the attraction of the carbon and gas molecules on either side. This second and third layer adsorption, however, passes indistinguishably into a third kind of absorption, which, in general, exerts still higher vapor pressures. This more loosely held gas is not really adsorbed but held merely by condensation in the fine capillaries, where, due to a surface tension effect, it exerts a very much lower vapor pressure than does the free surface of the liquid. As the capillaries become larger and larger, the vapor pressure also increases. If the absorption curve shows an even upward slope free from points of inflection with increasing pressure, it indicates the progressive filling up of larger and larger capillaries. On the other hand, a sharp upward slope followed by a horizontal one indicates that most of the capillary pores have a fairly uniform definite size and that condensation in them proceeds with scarcely any rise in pressure until all of this particular size of pore has been filled. The majority of charcoals exhibit the former type of curve, which can be explained only by the assumption of gradation in the sizes of the capillaries.

As the curve approaches the value of the vapor pressure representing saturation, it invariably shows another sharp rise which is unquestionably due to filling up the larger capillaries which have a very considerable volume, but whose effect in lowering vapor pressure is so small that they do not condense any gas until saturation is practically reached. Such absorption has, of course, absolutely no practical value in the field, where the concentrations are low.

VARIATION WITH THE TEMPERATURE—Adsorption invariably decreases with rising temperature. This temperature effect is slight at higher pressures where the adsorption is nearly independent of the pressure, but much more pronounced at lower pressures. The variation of adsorption with temperature also increases as the boiling point of the gas is approached.

The effect of temperature on the efficiency of charcoal in gas masks, where low pressures are of special concern is, therefore, decidedly important. This is illustrated by the results in Table 2 and Fig. II which show the service time of sample of charcoal against chlorpicrin and cyanogen chloride at different temperatures.

TABLE 2—EFFECT OF TEMPERATURE ON ADSORPTION

TEMPERATURE DEG. C.	SERVICE TIME, MINUTES	
	Chlorpicrin 7000 p. p. m.	Cyanogen Chloride 1000 p. p. m.
0	65	
15	39	87
25	53	55
40	47	38

It is evident that against chlorpicrin the same charcoal is nearly 50 per cent more efficient at 0°

than at 40°. In the case of cyanogen chloride, which boils much lower (15° instead of 112° C.), the effect of temperature is very much more marked, the service time more than doubling in going from 40° to 15°. It is, therefore, apparent that, other things being equal, offensive gas warfare can be more effectively waged in summer. Also gas concentrations are on the average higher during the summer, due to their greater rate of vaporization.

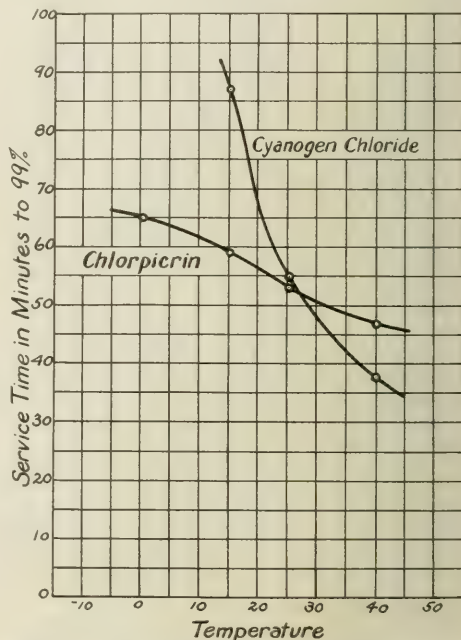


FIG. II—EFFECT OF TEMPERATURE ON SERVICE TIME TO 99 PER CENT EFFICIENCY OF CHLORPICRIN AT 0.7 PER CENT CONCENTRATION OF DRY AIR AND 0.1 PER CENT CONCENTRATION OF CYANOGEN CHLORIDE. AIR-GAS WITH 50 PER CENT RELATIVE HUMIDITY

ADSORPTION OF MIXTURES OF GASES—A gas or vapor, when passed over charcoal on which another gas or vapor is adsorbed, will displace a portion of it; a gas which, by itself, is strongly adsorbed on charcoal, will in time displace a less strongly adsorbed gas almost completely. In general, then, a high boiling gas will displace a lower boiling gas which has previously been adsorbed. If a mixture of gases is passed over charcoal, a final equilibrium condition is established, depending upon the partial pressures of the two gases which are maintained. Substantially the same equilibrium is obtained under the same conditions, no matter which gas was the first adsorbed.

It follows from these considerations that the adsorption of a gaseous mixture will, in general, be less complete than that of either constituent of the mixture by itself. In other words, charcoal would have a certain approximately fixed adsorptive capacity, and if part of this were utilized for one gas, less would be available for another.

Another factor, however, certainly comes into play. If either or both the vapors is soluble in the liquid phase of the other, charcoal will adsorb more of the solution than it will of either component separately. If either or both of the vapors is very soluble in the liquid phase of the other, then an adsorbed film of one vapor may adsorb the vapor of the other even more extensively than the fresh charcoal surface would adsorb it; in other words, the vapor pressure of one or both substances may be lower from the film of adsorbed solution than from an adsorbed film containing the same fractional amount per square centimeter of the pure solute or solvent.

Tests of the service time of charcoal confirm the above conclusions. Thus, stannic chloride, for instance, if mixed in equivalent amounts with chlorpicrin, will decrease the service time against chlorpicrin by about 50 per cent; chlorine and also water similarly hasten the breakdown of charcoal toward chlorpicrin. These substances all show only a moderate or small mutual solubility.

Admixture of $\frac{1}{2}$ an equivalent amount of cyanogen chloride with an air-chlorpicrin mixture has but little effect on the breakdown of charcoal against chlorpicrin, though it shortens decidedly the life of the charcoal to the 90 per cent point. This illustrates the fact that it is the capacity rather than the activity of the charcoal which is affected by this treatment.

On the other hand, the presence of small amounts of water in charcoal actually increases its absorptive power for ammonia or for hydrogen chloride, while small amounts of ammonia will similarly increase the service time of charcoal against arsine. In these cases we have great mutual solubility, and, therefore, enhanced adsorption.

EFFECT OF MOISTURE ON ADSORPTION—Moisture is more highly adsorbed at ordinary temperatures by charcoal than is any other of the normal constituents of the air. On the other hand, it is much less adsorbed than such toxic gases as chlorpicrin for instance. Thus an active charcoal which will adsorb and retain 25 per cent of its own weight of chlorpicrin at 20° , will adsorb an approximately equal amount of water if it is exposed to saturated water vapor at the same temperature, but it holds this water very feebly, losing all but a per cent or two of it when it is exposed to dry air for some time. Charcoal in the canister will, when in use, evidently adjust itself to the humidity of the air drawn through it. As this humidity is usually high under the climatic conditions prevailing in northern France, it will, after prolonged exposure, contain perhaps 10 per cent of water, the exact amount, of course, depending upon its own degree of activation, as well as upon the prevailing humidity.

In accordance with what was stated in a previous section regarding adsorption from mixtures, this adsorbed moisture will diminish somewhat the adsorptive efficiency of charcoal against other gases, except those gases which are very soluble in water, and gases such as phosgene, which react with water in the presence of charcoal. This decrease, however, is not in general serious, for water, compared with most of the

toxic gases, is relatively but slightly adsorbed, and is easily displaced by gases of higher boiling point. This is illustrated by the curve in Fig. III, showing the effect of humidity on the adsorption of chlorpicrin by a rather poor sample of charcoal at 20° .

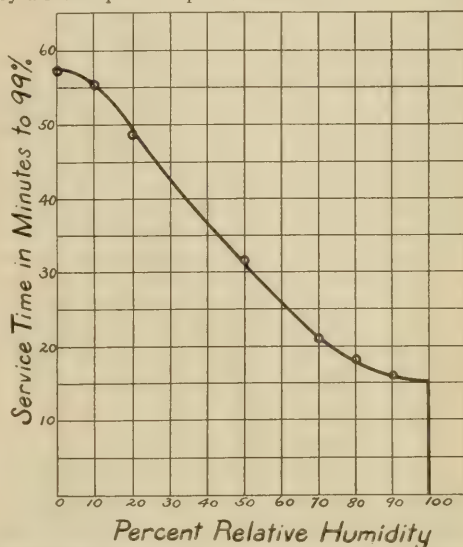


FIG. III.—EFFECT OF HUMIDITY OF GAS-AIR ON SERVICE TIME OF EQUILIBRATED CHARCOAL AGAINST CHLORPICRIN. CONCENTRATION, 0.7 PER CENT. DEPTH OF LAYER, 10 CM.

The results shown in this diagram were obtained by conducting the standard 0.1 per cent chlorpicrin test with an air of varying humidities against charcoal which had previously been equilibrated with pure air of the same humidity as that used in the test. The water content of the charcoal, therefore, increased roughly in proportion to the humidity. The line is brought down to zero service at 100 per cent humidity, because any charcoal which is actually wet with more water than it will take up from saturated air shows an immediate break on this test. In this case, the large as well as the small capillaries are filled with moisture, and the chlorpicrin cannot get in to displace the water, except very slowly.

Adsorbed moisture has a similar and even more pronounced effect upon the adsorption of cyanogen chloride. A sample of charcoal which, when dry, ran 120 min. to the break against this gas, lasted but 69 min. after equilibration with air of 70 per cent relative humidity. This is what would be expected, for cyanogen chloride, being less firmly adsorbed than chlorpicrin, would less readily displace the water film.

The effect of moisture on the adsorption of phosgene by charcoal is more complicated. Dry charcoal adsorbs phosgene freely and constitutes a satisfactory absorbent for it, provided the air-phosgene mixture to be purified is also dry. If, however, the mixture is partially humidified, the apparent service time of the dry charcoal drops to one-third of its former value. Careful tests indicate, however, that the gas which

comes through under such circumstances is hydrogen chloride and that the decrease in service time is due primarily not to any decreased adsorption of phosgene, but to the catalytic action of charcoal on the hydrolysis of phosgene. This and similar special cases are, therefore, discussed under the later heading, "Chemical Action of Charcoal."

VARIATION WITH THE KIND OF CHARCOAL—The same charcoal activated to different degrees will show similar but somewhat displaced adsorption curves. Curve (b), Fig. I, for instance, represents a less highly activated sample of the same coconut charcoal as was used in obtaining Curve (a). With a charcoal of different origin and composition, the form of the adsorption curve may be quite different, as is illustrated by Curve (c), which represents the adsorption curve of wood charcoal. The wood charcoal used for Curve (c) was evidently a better adsorbent at high pressures than the coconut charcoal, but for use under war conditions would be inferior to it, for at low pressures, which are then of primary importance, it is a distinctly poorer adsorbent. The effect of the kind of charcoal is further discussed in connection with the structure of active charcoal.

CHEMICAL ACTION OF CHARCOAL

In addition to its adsorptive action, charcoal acts catalytically upon a number of reactions to which certain war gases are subject. The most conspicuous instance of this effect is its catalytic action upon the hydrolysis of phosgene into hydrogen chloride and carbon dioxide. Superpalite (trichloromethylchlor-formate) behaves in almost identically the same way as phosgene with regard to its hydrolysis into hydrogen chloride and carbon dioxide. Certain other hydrolyzable gases also show evidence of an accelerated hydrolysis. Some similar reaction appears during the absorption of chlorine by moist charcoal, in which case hydrogen chloride is formed and oxygen is evolved. Arsine is to some extent catalytically oxidized by the charcoal, although this suffices to take care of only a fraction of the gas. In fact, charcoal has such a pronounced chemical action on most of the active toxic gases that there are relatively few of the war gases with regard to which it can be stated with certainty that they are held by adsorption alone, and that accelerated chemical reactions play no part in their absorption.

The importance and characteristics of the chemical action of charcoal can best be brought out by the detailed discussion of a specific case—the hydrolysis of phosgene. As previously pointed out, in the entire absence of moisture phosgene is fairly well absorbed. When, however, any moisture is present, either in the air or in the charcoal, the break point comes much sooner, though hydrogen chloride rather than phosgene comes through at first, indicating that the hydrolysis of the phosgene has been greatly accelerated by the charcoal. The catalysis undoubtedly proceeds by the simultaneous absorption of phosgene and water vapor on the charcoal surfaces. The hydrogen chloride gas thus formed is only very slightly adsorbed by dry charcoal and, therefore, comes through very rapidly.

Charcoal containing moisture lasts somewhat longer than dry charcoal against moist air-phosgene mixtures (but is still far inferior to dry charcoal against dry air-phosgene mixtures). The reason for this increase is that the hydrogen chloride gas is very soluble in the water held in the charcoal. The same effect would have been produced in the above-mentioned case of dry charcoal against moist air-phosgene mixtures had the test lasted long enough to permit the absorption of considerable amounts of the water vapor by the charcoal.

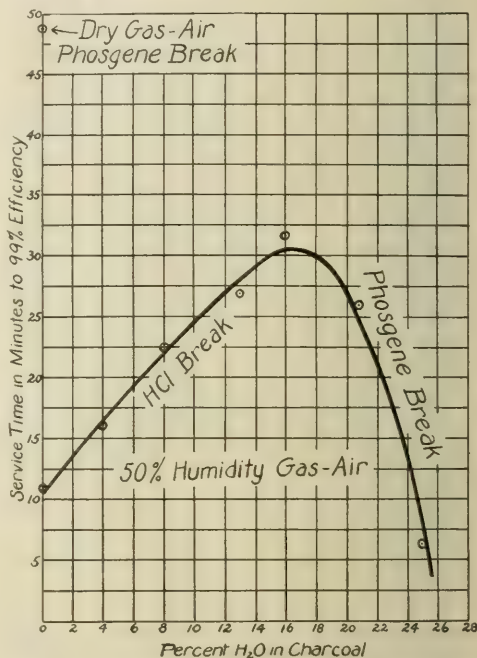


FIG. IV.—EFFECT OF MOISTURE CONTENT OF CHARCOAL ON SERVICE TIME AGAINST PHOSGENE 1 PER CENT CONCENTRATION, 10 CM. LAYER

The behavior of a typical sample of charcoal against phosgene is shown in Fig. IV. The point on the ordinate axis indicates the very high service time of dry charcoal against dry air mixtures. The points on the curve indicate the service time of charcoal with varying percentages of moisture on phosgene-air mixtures of 50 per cent humidity. It will be noted that these conditions are somewhat different from those prevailing in the above-mentioned chlorpicrin tests. In this case, the humidity is constant during the test, while the original water content varies. The general effect is the same, however, since the test time is much too short to reach equilibrium.

As would be expected from the foregoing explanation, the service time for the moist air mixture against perfectly dry charcoal is very low, but increases rapidly with increasing water content, due to the tendency of the water to hold the hydrogen chloride formed by the hydrolysis of the phosgene. In the case of all the

foregoing points on the curve, the gas which comes through at the breakpoint and for some time thereafter is hydrogen chloride only.

When very high water contents are reached, however, another striking change takes place in the service time curve, in that it rapidly drops off and soon reaches zero. Furthermore, beyond the maximum of the curve the gas which comes through first is always found to be phosgene. The effect is unquestionably due to the fact that by the time these high water contents are reached practically all the capillaries are filled up with water, and the simultaneous absorption of phosgene and water vapor on carbon surfaces, which causes the hydrolysis, is thereby very greatly slowed up. Part of the phosgene is unquestionably still hydrolyzed. The hydrogen chloride thus produced is easily held by the large amount of water present. A considerable amount of unhydrolyzed phosgene comes through, however, and gives the earlier break. As the water content goes still higher, the charcoal becomes, in effect, merely an inert material covered entirely with a film of water and in this case phosgene comes through from almost the first moment, since it is impossible to hydrolyze it rapidly enough on any such relatively small amount of water surface.

It should be stated that the higher water contents (those beyond the maximum part of the curve) cannot be obtained by passing even 98 per cent saturated air through the charcoal, but only by adding water as such to the charcoal. This part of the curve is, therefore, of theoretical rather than practical interest as affecting field service conditions.

The behavior of charcoal against chlorine and superpalite is very similar to that described for phosgene.

In the case of gases where chemical reactions play a large part in their absorption, two charcoals which differ very greatly in their true adsorptive capacity (as measured by their chorpiprin service time) show much less difference in their service time against these gases. In general, however, the charcoals which are best against chlorpicrin are at least slightly better against practically all gases.

BEHAVIOR OF CHARCOAL IN THE CANISTER

In the light of the foregoing discussion, the behavior of charcoal in a gas mask canister can be readily explained. The air entering at the bottom may be assumed to contain, under average battlefield conditions, perhaps one part of toxic gas per 1000 parts of air. When the wearer is moderately active, his inhalation will be at the rate of about 30 liters per min., or with a canister of normal dimensions about 500 cc. per sq. cm. of cross section. Under these conditions, ordinarily active charcoal will adsorb practically all the war gases very rapidly and very completely, so that only the lower layers are at first operative. If the supply of the toxic gas continues, the zone of adsorption moves upward, and, of course, the toxic gas will finally begin to escape from the upper layers in detectable quantities. In the case of most gases the amount leaking through the canister increases very slowly from the time the first trace appears until 1 or 2 per cent of the affluent gas concentration begins

to pass through. Just when the apparent breakdown occurs will depend on the sensitiveness of the tests used for the toxic gas. Tests are available however, sufficiently sensitive to detect amounts considerably below the toxic or harmful limit of practically every gas.

The layer of charcoal in the bottom of the canister becomes highly saturated with toxic gas before the breakdown occurs. There is, however, no great advantage in having a charcoal which holds a great deal of gas loosely in this way (that is, at a high equilibrium pressure), because as was pointed out previously, even if the breakdown during exposure to toxic gas is delayed on this account, this gas will be rapidly passed along in the canister even when pure air alone is breathed through it.

STRUCTURE OF ACTIVE CHARCOAL

Since the functioning of charcoal depends primarily upon its adsorptive power, the greater the ratio of its surface to its mass, that is, the more highly developed and fine-grained its porosity, the greater its value. Since increase in porosity involves the removal of material from the interior of the charcoal, the activation of charcoal is necessarily accompanied by a decrease in its apparent density; and starting with any given inactive charcoal, the increase in adsorptive capacity is approximately parallel to this decrease.

The porosity of the most active charcoals is very great. By a comparison of their true and apparent densities, it has been found that about one-half the volume of such charcoal consists of capillary pores. This does not, however, include the grosser pores which must be relatively inactive in adsorption, though they are necessary to serve as passages to the interior of the charcoal grains.

Most of the pores are extremely minute. From a study of the slope of the vapor pressure curves of liquids adsorbed upon such charcoal, the indications are that the pores have, if a cylindrical form be assumed, an average diameter of about 5×10^{-7} cm. On this basis, 1 cc. of active charcoal would contain about 1000 sq. m. of surface.

The amount of surface exposed by charcoal does not, however, appear to be the only determining factor, for it has been found that active charcoal can be obtained only from amorphous carbon formed or deposited at relatively low temperatures by thermal or chemical decomposition. Carbon deposited at high temperatures, presumably more graphite in nature, will not become activated. This fact might conceivably be explained by assuming that the graphitic carbon does not become so pitted and porous during the activation process as does the low temperature amorphous carbon. It seems much more reasonable, however, to assume that the amorphous carbon has a greater specific adsorptive power than the graphitic carbon. In strong support of this latter explanation is the fact that an active amorphous carbon can be ruined for adsorptive purposes by the deposition of a thin film of graphitic carbon on its surface.

The carbon formed or deposited by the destructive

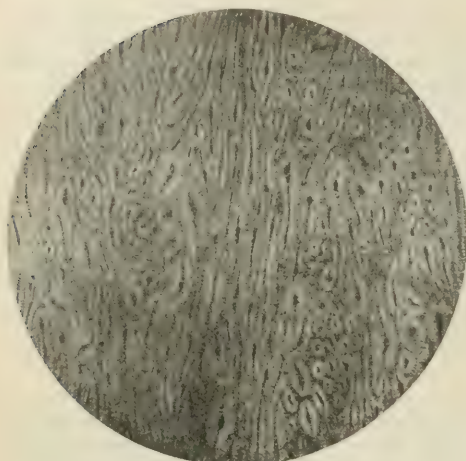


FIG. V.—SECTION OF RAW COCONUT SHELL. MAGNIFIED
146 $\frac{1}{2}$ DIAMETERS

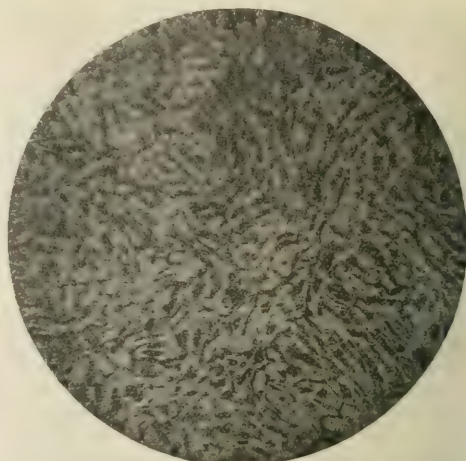


FIG. VI.—SECTION OF CARBONIZED COCONUT SHELL. MAGNIFIED
146 $\frac{1}{2}$ DIAMETERS

distillation and cracking of hydrocarbons, etc., at low temperatures (as in the charring of woods, or the distillation of coal-tar, pitches, etc.), is spoken of as "primary carbon." This primary carbon has little or no apparent adsorptive power. It is evidently a complex material consisting of hydrocarbons adsorbed on a base of active carbon. These hydrocarbons, being difficultly volatile, prevent the adsorption of other gases or vapors upon the active material. They can be driven off by heating, and particularly by the application of a high vacuum at elevated temperatures, but, like any adsorbed material, they require temperatures well above their boiling points to accomplish this. In other words, these adsorbed hydrocarbons are very greatly stabilized by their adsorption, and so resist volatilization and decomposition up to a very high temperature. Some of them, for instance, become so stable under these conditions, that they will survive exposure for some time to temperatures as high as 1000°.

The essential characteristics of active charcoal then are:

- 1—It must have high and fine-grained porosity.
- 2—It must consist of amorphous base carbon.
- 3—It must be free from adsorbed hydrocarbons.

PREPARATION OF ACTIVE CHARCOAL

On the basis of the above discussion, the preparation of active charcoal will evidently involve two steps:

First—The formation of a porous, amorphous base carbon at a relatively low temperature.

Second—The removal of the adsorbed hydrocarbons from the primary carbon, and the increase of its porosity.

The first step presents no very serious difficulties. It involves, in the case of woods and similar materials, a process of destructive distillation at relatively low temperatures. The deposition of inactive carbon, resulting from the cracking of hydrocarbons at high temperatures, must be avoided for reasons described

more fully elsewhere. The material is therefore charged into the retorts in thin layers, so that the contact of the hydrocarbon vapors with hot charcoal is avoided as much as possible. Furthermore, most of the hydrocarbon is removed before dangerous temperatures are reached. A slight suction is maintained to prevent outward leaks, but no activation by oxidation is attempted, as this can be carried on under better control and with less loss of material in a separate treatment.

The second step, that is, the removal of the adsorbed hydrocarbons from the primary carbon, is a much more difficult matter. Prolonged heating, at sufficiently high temperatures, is required to remove or break up the hydrocarbon residues. On the other hand, volatilization and cracking of the hydrocarbons at high temperatures is certain to produce an inactive form of carbon more or less like graphite in its visible characteristics, which is not only inert and non-adsorbent, but is also highly resistant to oxidation. The general method of procedure which has yielded the best results, is to remove the adsorbed hydrocarbons by various processes of combined oxidation and distillation, whereby the hydrocarbons of high boiling points are broken down into more volatile substances and removed at lower temperatures, or under conditions less likely to result in subsequent deposition of inactive carbon. Thin layers of charcoal and rapid gas currents are used so that contact between the volatilized hydrocarbons and the hot active charcoal may be as brief as possible. In this way cracking of the hydrocarbons at high temperature, with consequent deposition of inactive carbon, is largely avoided.

While the removal of the hydrocarbons by oxidation and distillation is the main object of the activation process, another important action goes on at the same time, namely, the oxidation of the primary carbon itself. This oxidation is doubtless advantageous,

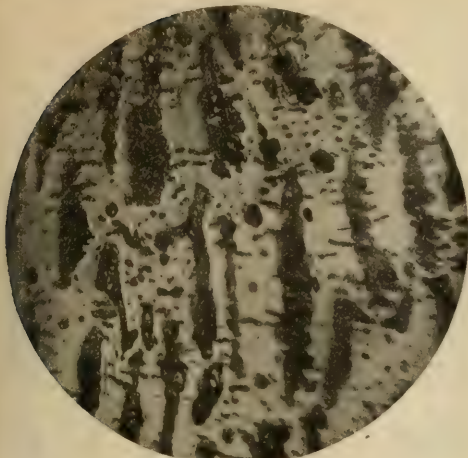


FIG. VII—TWO-MINUTE CHARCOAL NOT ACTIVATED. MAGNIFIED 732 DIAMETERS

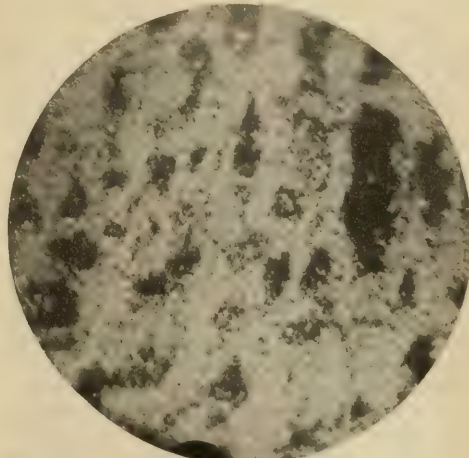


FIG. VIII—31-MINUTE STEAM ACTIVATED CHARCOAL. MAGNIFIED 732 DIAMETERS

up to a certain point, for it probably at first enlarges, at the expense of the walls of solid carbon, cavities already present in the charcoal, thus increasing the total surface exposed. Moreover, the outer ends of the capillary pores and fissures must be somewhat enlarged by this action and a readier access thus provided to the inner portions of the charcoal. However, as soon as the eating away of the carbon wall begins to unite cavities, it decreases, rather than increases, the surface of the charcoal, and a consequent drop in volume activity, that is in the service time, of the charcoal, is found to result.

It is obvious, therefore, that conditions of activation must be so chosen and regulated as to oxidize the hydrocarbons rapidly and the primary carbon slowly. Such a differential oxidation is not easy to secure since the hydrocarbons involved have a very low hydrogen content, and are not much more easily oxidized than the primary carbon itself. Furthermore, most of the hydrocarbons to be removed are shut up in the interior of the granule. On the one hand, a high enough temperature must be maintained to oxidize the hydrocarbons with reasonable speed; on the other hand, too high a temperature must not be employed, else the primary carbon will be unduly consumed. The permissible range is a relatively narrow one, only about 50 to 75°. The location of the optimum activating temperature depends upon the oxidizing agent employed and upon other variables as well; for air, it has been found to lie somewhere between 350 and 450°, and for steam between 800 and 1000°.

The air activation process has the advantage of operating at a conveniently low temperature. It has the disadvantage, since the oxidation of the hydrocarbons and the primary carbon by oxygen is an exothermic process, that local heating and an excessive consumption of primary carbon occur, so that a drop in volume activity results from that cause before the hydrocarbons have been completely eliminated. As

a consequence, charcoal of the highest activity cannot be obtained by the air activation process.

The steam activation process has the disadvantage that it operates at so high a temperature that the regulation of temperature becomes difficult and other technical difficulties are introduced. It has the advantage that since the reaction between carbon and steam is endothermic, local heating, due to this cause, is eliminated, and a stable thermal equilibrium is possible. The hydrocarbons can, therefore, be largely removed without a disproportionate consumption of primary carbon. This permits the production of a very active charcoal.

The fact that some carbon is always oxidized at the same time as the hydrocarbon, puts an additional premium upon high initial density. High initial density of a primary carbon is apparently caused by a preponderance of very fine pores, and hence a relatively large amount of primary carbon. In addition, this denser material will permit a more extensive consumption of carbon before a pronounced decrease in surface begins to take place, and consequently will admit of a more complete removal of the hydrocarbons.

The air, steam, and also carbon dioxide-steam activation processes have all been employed on a large scale by the Chemical Warfare Service for the manufacture of gas mask carbon.

The above considerations are illustrated fairly well by the photomicrographs shown in Figs. V to VIII. Fig. V shows a section of the original untreated coconut shell crosswise to the long axis of the shell. In it can be seen the closely packed, thick-walled so-called "stone-cells" characteristic of all hard and dense nut shells. Fig. VI is a photograph of a similar section through the same coconut shell after it has been carbonized. As these photographs are all taken with vertical illumination against a dark background, the cavities, or voids, and depressions all appear

black, while the charcoal itself appears white. It is clear from this photograph that much of the original grosser structure of the shell persists in the carbonized products. Figs. VII and VIII are more highly magnified photographs of a carbonized charcoal before and after activation, respectively. As before, all the dark areas represent voids of little or no importance in the adsorptive activity of the charcoal, while the white areas represent the charcoal itself. In Fig. VII (unactivated) the charcoal itself between the voids is seen to be relatively compact, while in Fig. VIII (activated) it is decidedly granular. This granular structure, just visible at this high magnification (1000 diameters), probably represents the grosser porous structure on which the adsorption really depends. These photographs, therefore, show how the porosity is increased by activation.

Another more recently developed method of activation should be mentioned as having distinct promise. The original wood or nut cellulose structure consists essentially of carbon, oxygen, and hydrogen, the latter two being in the proportion to form water. The distillation method of making a primary carbon has the disadvantage of driving off carbon along with both the hydrogen and oxygen (as carbon monoxide, carbon dioxide, hydrocarbons, etc.), thus greatly reducing the density of the product. Furthermore, a considerable amount of nonvolatile hydrocarbon remains which must be removed by one of the high temperature activation processes.

It has been found, however, that by certain chemical processes, such as heating the wood up with strong sulfuric acid, hydrochloric acid and zinc chloride, etc., it is possible to remove practically all of the hydrogen and oxygen as water, leaving behind a very dense carbon which, since there is practically no hydrocarbon present, needs relatively little treatment (except washing out the chemicals) to make a satisfactory charcoal. The sulfuric acid method has been successfully used in England, the hydrochloric acid and zinc chloride in Germany, both employing wood as a raw material. The resulting product is distinctly better than charcoals made from similar woods by the regular activation process, but by no means as good as coconut charcoal made by the regular process. The application of the chemical treatment to coconuts, etc., has not as yet been developed to give entirely satisfactory results, and all American production charcoal has, therefore, been made by the other methods.

COMPARISON OF CHARCOALS FROM DIFFERENT SOURCES

A great number of charcoals have been prepared in the laboratory from the most varied raw materials. The results obtained with representative samples of a few typical materials are collected in Table 3.

In all cases, the method of activation has been identical and the times of treatment have been approximately those giving the highest service time. The results against chlorpicrin, therefore, represent roughly the relative excellence of the charcoals ob-

tained from these various raw materials, using this method of activation. Too much significance must not, however, be attached to the precise figures or the exact order of excellence thus established, as a more careful regulation and adjustment of the activation treatment might easily have altered the service times by perhaps 15 per cent.

TABLE 3—COMPARISON OF VARIOUS ACTIVE CHARCOALS ACTIVATED IN LABORATORY

BASE MATERIAL	APPARENT DENSITY		STEAM TREATMENT AT 900°		ACCELERATED CHLORPICRIN TEST RESULTS	
	Primary Carbon	Activated Carbon	Time Min.	Weight Loss Per cent	Weight Absorbed Per cent	Service Time Min.
Sycamore.....	0.158	0.080	18	53	41	7.3
Cedar.....	0.223	0.097	60	88	78	16.0
Mountain mahogany.....	0.420	0.236	60	44	32	16.3
Ironwood.....	0.465	0.331	60	44	31	20.8
Brazil nut.....	0.520	0.316	120	71	46	32.2
Ivory nut.....	0.700	0.460	120	70	48	47.0
Cohune nut.....	0.659	0.502	120	48	51	53.4
Babassu nut.....	0.540	0.322	210	68	85	58.7
Coconut.....	0.710	0.445	120	60	61	58.4
Coconut.....	0.710	0.417	180	73	72	64.4
BRIQUETTED MATERIALS						
Sawdust.....	0.542	0.365	120	66	53	40.0
Carbon black.....	0.769	0.444	240	64.3	53	50.5
Bituminous coal.....	0.789	0.430	165	61	58.3	46.8
Anthracite coal.....	0.830	0.371	480	81	53	40.7

These figures illustrate clearly the points brought out in the above discussion of the method of preparation of active charcoal. The dense primary carbons permit of a more extensive activation treatment before their carbon is too extensively eaten away, as would be disclosed by the figure for the apparent density. The hydrocarbons can, therefore, be more completely removed. The results indicate clearly that the higher the original density of the wood, the longer the time required for proper activation, but the latter the final adsorptive capacity, especially on a volume basis (service time.)

Anthracite and bituminous coals contain considerable amounts of refractory hydrocarbons, and very few large pores to permit access of the oxidizing agent. They require very long activation treatment, with at least some consequent deposition of inactive carbon, and, hence, a lessened final activity. Nuts, with their high initial density and relatively easy activation, give the highest service time.

Artificially dense primary carbons may be made by briquetting almost any carbonaceous material with a suitable hydrocarbon binder. Sawdust, charcoal fines, powdered anthracite and bituminous coal, and petroleum black have all been converted into reasonably good absorptive charcoal by this means. These charcoals are more difficult to activate than woods or nuts but easier than plain anthracite or bituminous coals, as the burning away of the hydrocarbon binder provides an adequate amount of the larger voids, which afford ready access for the oxidizing agent to the interior of the granules.

None of the briquetted materials has yielded as high maximum capacity as is possessed by charcoal made from the denser nuts.

In conclusion, it will be of interest to compare the charcoals manufactured and used by the principal belligerent nations, both with one another and with the above-mentioned laboratory preparations. Data on these charcoals are given in the following table:

TABLE 4—COMPARISON OF TYPICAL PRODUCTION CHARCOALS OF THE PRINCIPAL BELLIGERENT NATIONS

Country	Date	Raw Material	Apparatus	Service Time	Remarks
United States	Nov. 1917	Coconut	0.60	10	Air activated
United States	Nov. 1918	Mixed nuts, etc.	0.58	18	Steam activated
United States	Nov. 1918	Coconut	0.51	34	Steam activated
England	1917	Wood	0.27	6	Long distillation
England	Aug. 1918	Peach stones, etc.	0.54	16	.....
France	1917-18	Wood	0.23	2	.....
Germany	Early	Wood	?	3	.....
Germany	June 1917	Wood	0.25	33	Chemical and steam treatment
Germany	June 1918	Wood	0.24	42	Chemical and steam treatment

It is at once evident that the service time of most of these charcoals is very much less than was obtained with the laboratory samples. However, in the emergency production of this material on a large scale, quantity and speed were far more important than the absolute excellence of the product. It will be noted, for instance, that the coconut charcoal manufactured by the United States, even in November 1918, was still very much inferior to the laboratory samples made from the same raw material. This was not because a very active charcoal could not be produced on a large scale, for even in May 1918 the possibility of manufacturing a 50-min. charcoal on a large scale had been conclusively demonstrated, but this activation would have required two or three times as much raw material and five times as much apparatus as was then available, due to the much longer time of heating, and the greater losses of carbon occasioned thereby.

It should furthermore be pointed out that the increase in the chlorpicrin service time of charcoal from 18 to 50 min. does not represent anything like a proportionate increase in its value under field service conditions. This is partly due to the fact that the increased absorption on the high concentration tests is in reality due to condensation in the capillaries, which, as has been pointed out, is not of much real value. More important than this, however, is the fact that most of the important gases used in warfare are not held by adsorption only, but by combined adsorption and chemical reaction, for which purpose an 18-min. charcoal is, in general, almost as good as a 50-min. charcoal.

It will be noted that the American charcoals, produced at any given time, show up better than either the French or British absorbents of similar periods, in spite of the fact that the work on this problem was started here much later. On the other hand, German charcoals, since the middle of 1917, have shown up better on the accelerated chlorpicrin test than the American production charcoals. This advantage is entirely illusory, however, because it is produced by capillary condensation in a wood charcoal and is held but very loosely. In fact, experiment has shown that drawing a stream of air through such charcoal which has been subjected to the accelerated test removes over 70 per cent of the adsorbed gas, whereas, in the case of the 35-min. American coconut charcoal, it displaces less than 10 per cent. The American charcoal is, therefore, very much superior for field use, where the concentrations are low and air is drawn through the mask over long periods of time.

It will also be of interest to compare the behavior of these charcoals against a variety of toxic gases.

This can readily be done by means of the following table where the service times of the various charcoals against a concentration of 0.1 per cent of the more important war gases are given.

TABLE 5—TYPICAL ABSORPTIVE VALUES OF DIFFERENT CHARCOALS AGAINST VARIOUS GASES

No.	Charcoal	Nation	H ₂ O Content, %	Ave. Chlorpicrin Service Time, Min.	Service Time, Minutes—Standard Conditions—					
					Chlorpicrin	Phosgene	Hydrocyanic Acid	Arsine	Cyanogen Chloride	Trichloromethylchloroformate
1	Poor coconut	U. S. A.	0	10	120	175	20	18	55	50
2	Medium coconut	U. S. A.	0	30	350	260	25	25	65	65
3	Good coconut	U. S. A.	0	60	620	310	27	30	75	70
4	Same as No. 2 but wet	U. S. A.	12	18	320	330	35	16	35	95
5	No. 2 impregnated	U. S. A.	0	35	400	700	70	400	70	190
6	Wood	French	0	2	25	75	9	0	1	20
7	Wood	British	0	6	70	90	18	4	5	30
8	Peach stone	British	0	16	190	135	30	25	65	60
9	Treated wood	German	0	42	250	105	20	20	22	25
10	No. 9 impregnated	German	30	9	90	320	16	1	110	120

STANDARD CONDITIONS OF TESTS

Mesh of absorbent	8-14
Depth of absorbent layer	10 cm.
Rate of flow per sq. cm. per min.	500 cc.
Concentration of toxic gas	0.1 per cent
Relative humidity	50 per cent
Temperature	20°

Results expressed in minutes to the 99 per cent efficiency points
Results corrected to uniform concentrations and size of particles

While this concentration is not as high as is occasionally met with in field service, particularly in projector attacks, it is still many times greater than the average. The rate of flow employed in the test was always the same, and corresponds to the breathing rate of a moderately exercising man. It will be seen that the service times of the best American and German productions run into hundreds of minutes in the cases of the gases chlorpicrin and phosgene, even at this high concentration. This means, of course, that under average service conditions, the absorbent will function satisfactorily for months at a time without any necessity for renewal.

In general, the charcoals show the shortest service times toward arsine and hydrocyanic acid, but fortunately both of these gases are fairly well adsorbed by the permanganate soda-lime. Moreover, neither of these gases has been found well-adapted for use in gas warfare.

As a matter of general interest, it may be mentioned that even relatively poor charcoal will furnish indefinite protection against field concentrations of the vapor of high boiling vesicant substances such as "mustard gas."

SODA-LIME

NEED FOR SODA-LIME IN WAR-GAS MIXTURE

While charcoal unquestionably comes surprisingly close to fulfilling all of the requirements which have been outlined, nevertheless, plain charcoal alone cannot be considered a satisfactory all-round absorbent. Its principal deficiencies are as follows:

1—It has too little capacity for certain highly volatile acid gases, such as phosgene, hydrocyanic acid, etc., which are used to a fairly large extent in warfare.

2—Certain other gases are best handled by oxidation and it is impossible to accomplish this with the aid of charcoal alone (although certain impregnated charcoals have been found to be very satisfactory in this respect).

3—While charcoal has a very high activity for all gases and a fairly high capacity for most gases, in general it does not hold the more volatile gases quite as firmly as would be desirable, and there is a tendency for such gases to be slowly given off to a current of air. This is because, as previously pointed out, the gases in charcoal are held almost entirely by physical adsorption, and they, therefore, exert a certain small, but nevertheless, in the case of the more volatile gases, appreciable vapor pressure, when any considerable amount of gas has been taken up.

In order to counterbalance these deficiencies, the use of an alkaline oxidizing agent in combination with the charcoal has been found advisable. The material actually used for this purpose by both the British and the Americans has been granules of soda-lime containing sodium permanganate. Such an absorbent when properly prepared has a remarkably high capacity for the acid gases, and will oxidize easily oxidizable gases. Since the soda-lime in all cases holds the gases in very stable chemical combination, it has no tendency to release even the smallest amounts when air is breathed through the mask. It has, in fact, been shown that after a canister filled with a mixture of charcoal and soda-lime has been exposed to certain gases, such as phosgene, a slow transfer of gas from the charcoal to the soda-lime takes place continually, thus leaving the charcoal free to pick up more gas the next time the canister is used. It may, therefore, be said that the principal function of the soda-lime is to act as a reservoir of large capacity for the permanent fixation of the more volatile acid and oxidizable gases, while the charcoal serves to furnish the required degree of activity for all gases as well as the storage capacity for the more stable and less volatile ones.

In the case of phosgene and superpalite, two widely used war gases, the soda-lime has a special function. Both of these gases, especially the latter, are very well adsorbed by dry charcoal, but, as previously pointed out, in the presence of moisture they are very rapidly hydrolyzed into carbon dioxide and hydrogen chloride, the reaction being catalyzed by the charcoal. While the latter gas is not extremely toxic, it nevertheless causes serious discomfort, and if allowed to pass through, causes the wearer to lose confidence in his mask. Since ordinary charcoal can hold but little of this very volatile gas, there is great need for the presence of the alkaline soda-lime, which very readily adsorbs large amounts of it. In fact, soda-lime is a much better absorbent for hydrogen chloride than for an equivalent amount of phosgene, so while the charcoal holds but little of the phosgene, it nevertheless greatly aids in its absorption by accelerating its hydrolysis.

Another reason for the use of the combination absorbent rather than charcoal alone is its well-balanced

behavior toward variations in temperature and humidity. Thus as the temperature increases, charcoal adsorbs more poorly, while soda-lime reacts more readily. High humidity also tends to decrease the value of the charcoal, but in general favors absorption by the soda-lime. The absorptive efficiency of the combination is, therefore, surprisingly little affected by all ordinary variations in temperature and humidity.

SPECIAL REQUIREMENTS FOR A SATISFACTORY SODA-LIME

Due to the inherent nature of soda-lime, it is obvious that the problem of determining the best balance of the requirements is a very difficult and complicated one. The principal requirements may with profit be reconsidered briefly in this connection.

In the first place, since the alkaline absorbent is mixed with charcoal before use, its activity is not of vital importance, as the charcoal is able to take up the gas with extreme rapidity and then later give it off more slowly to the soda-lime. Absorptive activity is, nevertheless, a very desirable property, especially if high concentrations of phosgene are to be dealt with.

Adsorptive capacity is of the greatest importance since the soda-lime is relied upon to hold in chemical combination a very large amount of toxic gas.

Chemical stability is obviously much more difficult to attain in the case of soda-lime than in that of charcoal, especially when a strong and somewhat unstable oxidizing agent, such as sodium permanganate, is present. The deliquescent tendency of sodium hydroxide is another great source of difficulty.

Mechanical strength combined with absorptive activity and capacity is also difficult to attain, and this problem had never been solved until the war made some solution absolutely imperative. Methods had to be worked out by which the hardness and mechanical strength required to withstand the severe conditions of usage could be secured without any serious sacrifice of activity and capacity.

In order that the following discussion of the various components and their functions shall be clear, it is desirable at this point to outline very briefly the steps in the manufacture of the army soda-lime. Within limits, the method of manufacture is more important than the composition of other variables, and has been the subject of a great deal of research work even on apparently minor details. The process finally adopted consists essentially in making a plastic mass of lime, cement, kieselguhr, caustic soda, and water, spreading in slabs on wire-bottomed trays, allowing to set for 2 or 3 days under carefully controlled conditions, drying, grinding, and screening to 8-14 mesh, and finally spraying with a strong solution of sodium permanganate with a specially designed spray nozzle. The spraying process is a recent development, most of the soda-lime having been made by putting the sodium permanganate into the original wet mix. Many difficulties had to be overcome in developing the spraying process, but it eventually gave a better final product, and resulted in a large saving of permanga-

nate which was formerly lost during drying, in fines, etc.

COMPOSITION OF REGULAR ARMY SODA-LIME

The exact composition of the army soda-lime has undergone considerable modification from time to time as it has been found desirable to change the raw materials or the method of manufacture. A rough average formula which will serve to bring out the interrelation between the different constituents is as follows:

TABLE 6—COMPOSITION OF WET MIX
Per cent

Hydrated lime	45
Cement	14
Kieselguhr	6
Sodium hydroxide	1
Water	33 (approx.)
AFTER DRYING	
Moisture content	8 (approx.)
AFTER SPRAYING	
Moisture content	13 (approx.)
Sodium permanganate content	3 (approx.)

FUNCTIONS OF THE DIFFERENT COMPONENTS

Having previously pointed out in detail the requirements which gas mask absorbents must meet, it is well to show exactly what part is contributed by each of the components in the soda-lime toward making a well-balanced absorbent granule for military purposes.

It must be emphasized at the start of this discussion that the statements hereinafter made with regard to the effect and optimum amount of each of the constituents apply with accuracy only to a soda-lime made essentially according to the method above described. Different methods of preparation may profoundly modify the effect of any of the above-mentioned components.

HYDRATED LIME—This material furnishes the backbone of the absorptive properties of the soda-lime. It constitutes over 50 per cent of the finished dry granule and is responsible in a chemical sense for practically all of the gas absorption.

CEMENT—The sole function of the cement in the soda-lime formula is to furnish a degree of hardness adequate to withstand service conditions. It interferes considerably with the absorption properties of the soda-lime, especially if no kieselguhr is present. On the other hand, a great many other binding agents have been very thoroughly tried out, practically all of which seem to form an impenetrable film over the particles of lime and prevent their functioning satisfactorily as an absorbent. Cement has therefore been chosen as the least objectionable binder which will give satisfactory results. It is, however, still an open question as to whether the gain in hardness produced by its use is valuable enough to compensate for the decreased absorption which results.

KIESELGUHR—As stated above, the introduction of cement into an ordinary soda-lime formula makes a very distinct decrease in the porosity and hence in the absorptive capacity of the soda-lime. It has been found possible, however, to counterbalance this loss in porosity by the simultaneous introduction of a rel-

atively small weight, though considerable bulk, of kieselguhr. It is rather surprising to find that this addition of kieselguhr does not cut down the hardness. In fact, with carefully controlled methods of preparation, a reaction appears to take place between the lime and the kieselguhr, which results in some increase in hardness. The main function of the kieselguhr, however, is to produce increased porosity and hence increased absorptive activity in the finished cement granule. It is interesting to note in this connection that in a cement-free granule the addition of kieselguhr serves to reduce rather than increase the absorptive capacity. This reduction is not serious, however, and the resulting increase in hardness may for some purpose be worth while.

SODIUM HYDROXIDE—This material has two primary functions in the soda-lime granule. In the first place, a small amount of it serves to give the granule considerably more activity. In other words, the sodium hydroxide tends to react with very small traces of toxic gases somewhat more rapidly than does the calcium hydroxide and hence delays the breakdown and gives the latter time to react and take up the bulk of the gas. This greater reactivity produced by the alkali is almost certainly due to the fact that the gas first comes in contact with an aqueous film on the surface of the soda-lime, and the presence of the sodium hydroxide in this solution keeps the hydroxylion concentration of this film high enough to react readily with the gas the instant the two come into contact.

During the process of manufacture and use in the field the small amount of free sodium hydroxide present must certainly become fully carbonated by the carbon dioxide of the air. There is every indication, however, that in soda-lime of the proper moisture content the carbonate thus formed is fairly rapidly re-causticized by the great excess of lime which is present, and that there is actually free sodium hydroxide present even after the soda-lime has taken up several times the sodium hydroxide equivalent of carbon dioxide.

If large amounts of sodium hydroxide are used, the effect is quite the reverse of that observed with small amounts. The activity of the absorbent is greatly decreased, apparently due to the fact that the pores become plugged with a concentrated solution of alkali. The best absorbent seems to be one in which the structure is very porous and yet each particle of lime in the granules is covered with a thin film of a dilute sodium hydroxide solution.

One of the most striking things which has been brought out of the careful investigation of the soda-lime composition is the fact that in practically all cases the optimum content of sodium hydroxide is between 2 and 8 per cent, the remainder being lime, and that a material with 1 per cent caustic in general works much better than a material with 15 per cent or more. This is rather surprising, in view of the fact that practically all industrial soda-limes now on the market contain between 30 and 50 per cent of sodium hydroxide. Such granules are, of course,

very deliquescent, hard to handle, and could never be considered for any gas mask purposes.

The second function of sodium hydroxide in the granule is to maintain roughly the proper moisture content. In most of the absorbents of the soda-lime type, the water content is the most important single factor in their composition. If only a very little caustic soda is used in the granules they dry out very rapidly and become more friable when air of ordinary humidity is passed through them. If, on the other hand, too much caustic soda is used, the material will tend to take up water rapidly from air of average humidity and form a deliquescent product, increasing the resistance through the canister and greatly cutting down the porosity and value of the absorbent. For the majority of gases the optimum water content is in the general neighborhood of 11 per cent. The proportions of caustic and any other material tending to take up water must, therefore, be adjusted in such a way as to keep the water content between say 9 and 13 per cent under the humidity conditions prevailing where the box respirator is likely to be used. This adjustment cannot, of course, be very precise even under the best conditions.

If there were no need for sodium permanganate in the finished granule, the recommended alkali content would be 4 per cent. On the other hand, when sodium permanganate is to be sprayed on the dry, finished granules there are several other factors which must be considered, and which finally fix the alkali content at the rather low figure of 1 per cent.

In the first place, the low alkali content in the original white granule greatly increases the ease of drying the granule down to the low moisture content which is necessary before spraying. This easy dehydration would, of course, be a serious objection if the granules were to be used without further treatment. Fortunately, however, the sodium permanganate, which is later added, is in itself deliquescent and tends to replace almost an equivalent amount of sodium hydroxide in holding the proper moisture content at ordinary humidities.

A third reason for the use of the low alkali content is that in the presence of more alkali there is a very marked tendency to reduce the sodium permanganate to sodium manganate, which latter is of more or less value as an oxidizing agent.

Furthermore, there is no question but that the sodium permanganate, when introduced into the granule, has an activating action resembling that of caustic. This may be partially due to the small amount of sodium carbonate which is always present in the sodium permanganate solution. Again, as the permanganate is decomposed into manganese dioxide, either spontaneously or by oxidizing other substances, more caustic is automatically liberated. At any rate, the sodium permanganate tends to replace an equivalent amount of sodium hydroxide in its activating as well as its moisture-retaining action.

WATER—The water content of absorbents is very frequently overlooked in studying their behavior, but as a matter of fact, not only is the final water

content of great importance, as pointed out above, but it is also one of the most important variables at practically every stage in the manufacture of soda-lime, and must be kept under very careful control.

A soda-lime-kieselguhr "wet mix" changes its properties very markedly as the water content changes from about 25 or 30 per cent to about 35 or 40 per cent, the exact limits depending upon the raw materials. At the lower limit it is moist but will not form a coherent plastic mass which can be thoroughly mixed in a kneading type of mixer. At the upper limit it becomes a thick but fluid cream. In order to get a satisfactory product, especially from the standpoint of the hardness of the final product, it is absolutely essential that the water content be kept very close to the minimum which can be used and yet make a mass which is plastic and workable. There should be absolutely no tendency toward fluidity or the finished granules will be very soft. The exact description of the proper consistency of this wet mix is very difficult, but experience will soon indicate just what water content is necessary to give the best results. A consistometer has been used with success in keeping this property constant.

The water content of the wet mix should, of course, not be considered to be rigidly fixed at the 33 per cent specified in the table, but should be varied, depending upon the exact qualities of the raw materials.

The water content after drying must be made low enough so that when the permanganate solution is sprayed onto the finished white granules there will be no necessity for further drying to bring the granules to the proper final water content. On the other hand, it is important not to dry the material too far or the hardness will be injured. About 7 or 8 per cent water gives the best results.

The water content of the granules after spraying should be 13 to 14 per cent. This water content is somewhat higher than the precise optimum value at which the soda-lime has the maximum efficiency against most gases, but the specified figure is determined by the fact that when the soda-lime is mixed with the dry charcoal in the canister it is immediately robbed of 3 or 4 per cent of its water. This brings the moisture content down to slightly below the optimum for gas absorption. It is not considered wise to increase the water content after spraying still further, however, as the large amount of water which would then be taken up by the charcoal would considerably injure its adsorptive properties.

Careful determinations have been made of the vapor pressure-water content equilibria of the army soda-lime. The curves in Fig. IX show these vapor pressure curves at 4 different temperatures. Rather surprisingly, the logarithms of these vapor pressures when plotted against the reciprocals of the absolute temperatures give the perfectly straight line characteristic of pure substances, and with a slope very nearly that for pure water.

The relationships prevailing are brought out even more clearly in Fig. X, in which the per cent of the saturation pressure at each temperature is plotted

against the water content. It will be noted that the curves for the different temperatures agree very closely with one another, although the higher temperatures consistently give slightly higher relative humidity.

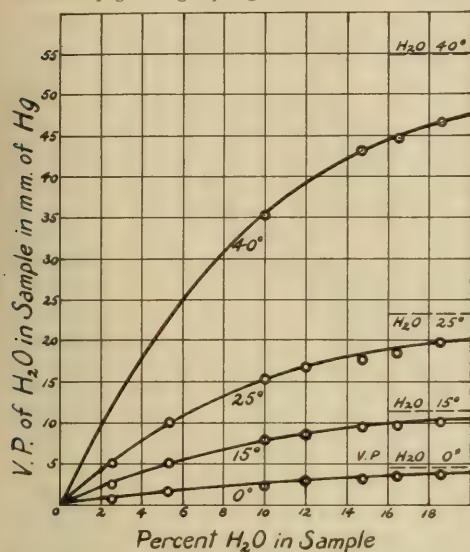


FIG. IX—VAPOR PRESSURE OF WATER IN ARMY SODA-LIME WITH VARYING WATER CONTENT

The relationships indicated by the above figure are of considerable value in determining the proper conditions in the setting room and drying tunnel where definite moisture contents are to be produced. By controlling the wet and dry bulb temperatures, it is possible to dry to any given point and then stop. The figure also shows very clearly that the sodium hydroxide and sodium permanganate contents are correctly adjusted to give almost exactly the optimum water content (11 to 12 per cent) under the humidity conditions prevailing in France (about 70 per cent relative) regardless of the temperature. The exact shape of the curve does not accord exactly with what would be expected if the vapor pressure lowering were entirely due to the dissolved sodium hydroxide and the sodium permanganate.

SODIUM PERMANGANATE—The function of the sodium permanganate is to oxidize certain gases, such as arsine, this gas being especially difficult to absorb with charcoal or plain soda-lime. When the permanganate was first introduced it was the only satisfactory absorbent which had been found for this gas. Later several impregnated charcoals were perfected which would handle arsine even better than permanganate soda-lime, but the value of an active alkaline oxidizing agent as an assurance of protection against possible new gases was deemed sufficient to justify the very considerable expense of its continued use in the war-gas absorbent.

Of the five permanganates tried out (including all those which would be commercially available) potas-

sium and barium, the two most stable and easily manufactured, were found to be insufficiently active as oxidizing agents, and so slightly soluble that they crystallized on drying, thus clogging the pores. Magnesium and calcium permanganates both gave slightly better results than sodium, but the former was too unstable, and both of them were too difficult to manufacture on a large scale to permit their use. Sodium permanganate was therefore used and when its impurities had been eliminated, it gave very satisfactory results.

The exact amount of sodium permanganate to be used in the granule depends upon the degree of protection deemed desirable, taking into account the great cost of the permanganate. It is possible to use up to 5 or 6 per cent without interfering seriously with the physical properties of the granule. Careful consideration of the amounts of oxidizable gases likely to be met with in the field led to fixing the sodium permanganate content of the granules for the Army at about 3 per cent.

SELECTION OF RAW MATERIALS

The selection of the various raw materials for the soda-lime must be very carefully made in order to obtain a satisfactory product. The most important requirements for each material will be briefly discussed.

HYDRATED LIME—It has been definitely shown that to make a highly absorbent soda-lime it is necessary to have a completely hydrated, high calcium lime with a low per cent of carbon dioxide. An incompletely hydrated lime tends to give a rather soft, final product,

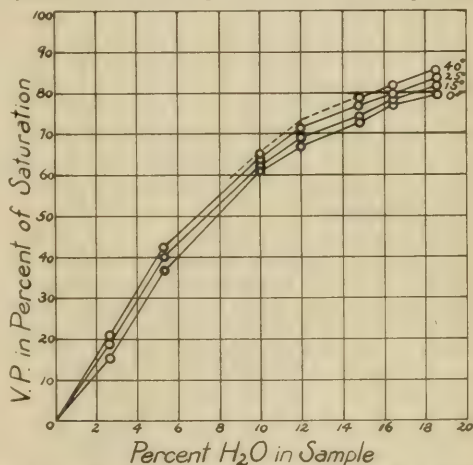


FIG. X—VAPOR PRESSURE OF WATER IN ARMY SODA-LIME WITH VARYING WATER CONTENT PLOTTED AS PER CENT OF SATURATION PRESSURE AT CORRESPONDING TEMPERATURES

although it is entirely satisfactory from a chemical standpoint. The Bureau of Standards "soundness test" for hydrated lime has not been found to be a reliable indication of the completeness of hydration, at least for these purposes. The presence of magnesium makes the resulting soda-lime considerably harder,

but very inefficient chemically; carbon dioxide has a similar harmful effect. Altogether about 15 different brands of lime have been tried out, and no sample which contained over 5 per cent magnesium oxide or which was incompletely hydrated has given good results.

It is apparent, however, that not all the factors which go to make a satisfactory lime have been fully determined. While the three above-mentioned variables are unquestionably the most important, nevertheless four brands of lime, all of which meet the above specifications very satisfactorily, have been thoroughly tested out, and only two have been found to give consistently good results when used in soda-lime. It is quite possible that the difference between the high-calcium, completely hydrated brands may lie in the size of the ultimate lime particles. No adequate study has been made of the effect of this property, except that it has been found that pure precipitated calcium hydroxide does not give as satisfactory results as some of the commercial brands of lime, and that especially fine, air-separated lime and cement give poor results on absorption tests. It may well be, therefore, that within certain limits the larger the ultimate particles of lime the better the results.

The following set of specifications for the lime would serve to eliminate most of the unsatisfactory grades. It should not contain over 4 per cent carbon dioxide and not over 5 per cent combined magnesium oxide, aluminum oxide and ferric oxide. There should be enough combined water present to hydrate at least 98 per cent of the calcium oxide present. Not over 4 per cent should be held on a 100-mesh sieve.

CEMENT—Practically all the standard grades of Portland cement seem to give satisfactory results and to be much better than any of the special cements (natural, quick-setting, etc.) which have been tried. A slow-setting cement is preferable in order to decrease the difficulty of handling the product during the slabbing stage. The cement should pass the standard cement specifications of the American Society for Testing Materials.

KIESELGUHR—A very careful study has been made of the different brands of kieselguhr available on the market, and there is no question but that the lightest grades are the best. There are only two commercial brands which give satisfactory results. The apparent density of the kieselguhr after packing in a wooden box, tapping and refilling until it does not settle any further, should in no case exceed 0.3. It should not contain appreciable amounts of organic matter.

SODIUM HYDROXIDE—Any grade of material reasonably free from sodium chloride will give satisfactory results.

SODIUM PERMANGANATE—The purity of the sodium permanganate solution used has been found to be one of the most important factors in making stable soda-lime. Apparently any considerable amount of soluble salts greatly increases the rate of decomposition of the sodium permanganate. It is therefore necessary to carry on the method of manufacture in such a way that the amount of chloride, chlorate,

and sulfate shall be a minimum. In no case should the total amount of these three salts exceed 25 per cent of the amount of sodium permanganate in the solution.

The production of such a solution on a commercial scale has necessitated the working out of a new process for its manufacture. Material of a satisfactory purity containing about 30 per cent sodium permanganate is now being produced on a large scale by a process involving the customary fusion of sodium hydroxide and manganese dioxide, leaching, and chlorination of the sodium manganate in the presence of a catalyst which decomposes all excess sodium hypochlorite into sodium chloride and oxygen and prevents the formation of sodium chlorate. Further purification is then effected by evaporation, during which most of the sodium chloride crystallizes out and is removed. The resulting 30 per cent solution contains about 6 per cent sodium chloride and practically no other impurities. This is far superior to any similar material previously obtainable on the market. An electrolytic method for producing sodium permanganate has also been worked out by the Research Division and found to be entirely practicable, reasonably cheap, and to yield a very pure product.

THE STRUCTURE OF SODA-LIME

The structure of army soda-lime is probably the most important single cause of its great superiority over the types used before the war. This structure depends, of course, to a considerable extent, upon the raw materials and the proportions in which they are used. Even more important than these factors, however, are three details in the method of preparation.

In the first place the plasticity of the wet mix before slabbing has a marked influence on the final structure. This has already been discussed in connection with the water content of the wet mix.

In the second place, in order to get a product with a satisfactory degree of hardness and resistance to abrasion, it is necessary to allow the material to take a sort of preliminary set by allowing it to stand several days and lose water very slowly, in a room where the temperature and humidity conditions are carefully controlled. Thus if the material is dried out within a day after it has been mixed, a very soft, crumbly product invariably results, but, allowing it to stand 2 or 3 days and slowly lose 8 or 10 per cent of water before the final drying, gives a hard and yet porous material.

The exact mechanism by which the material thus gains hardness during the time of setting is not definitely understood. Several hypotheses have been advanced to explain it. Unquestionably the slow setting of the cement cannot be realized if the soda-lime is dried too soon after mixing. On the other hand, however, much the same effects are observed with soda-limes containing no cement. It may be that the rapid drying of material which contains a large amount of water serves to disrupt the structure which would otherwise be produced. Again, the setting effect might conceivably depend on the slow deposition of a small amount of calcium hydroxide

which was dissolved in the excess water. Another plausible explanation is that the very slow but steady decrease in the volume and water content of the slab gives the cohesive force of surface tension full opportunity to pack together the individual particles into a very dense, strong material which is, nevertheless, porous after the water has been still further evaporated.

At any rate, the fact remains that a better material can be made with no binding agents by the slow-setting process than by using considerable amounts of kieselguhr and cement and drying shortly after mixing. Furthermore, no matter what binding agent is used, the slow-setting process seems to be of great advantage in developing the maximum hardness for any given formula.

The third very important factor in the structure of soda-lime influences the efficiency of the material rather than its mechanical strength. This is the necessity of having the outer surface of a granule composed entirely of freshly broken surfaces. A great variety of experiments in which granules were made from soda-lime molded in pill machines, rolled into pellets, squirted through macaroni machines, etc., have shown that such surfaces produced before drying, or which have been smeared over while the material was still plastic, have very little value for absorptive purposes. Material made in this way seems to be coated with a sort of skin through which the gas can penetrate but very slowly. This effect is not difficult to understand because an examination shows that such outer surfaces of such material are more dense and of distinctly different texture from the interior of the granule, which is porous and highly absorptive.

It is obvious, therefore, that the material must be dried in relatively large, thick slabs and then ground up in such a way as to produce the maximum amount of freshly broken surface. The slabs must not be made too thick or the drying process will be greatly impeded. A slab $1\frac{1}{2}$ in. thick has been found to yield very good material, and can be dried without serious difficulty.

SUGGESTED MODIFICATIONS OF SODA-LIME FOR INDUSTRIAL USE

The conditions which the soda-lime must meet when used for industrial purposes are very markedly different from those prevailing in gas warfare. It is therefore necessary to strike a new balance between the various factors, and specify a different formula if the new conditions are to be adequately met.

In general, a soda-lime for industrial use will meet higher concentrations of gas and be subjected to much less severe handling than under field service conditions. It is advisable therefore to increase the capacity and especially the activity of the soda-lime and it is entirely justifiable to decrease its hardness markedly. It is furthermore almost certainly unnecessary to use sodium permanganate as it is of value only against a limited number of gases, and these are not ordinarily met with in the industries. Furthermore, if these gases must be provided for in special cases, a special

absorbent can be used which will handle them much more efficiently than sodium permanganate granules.

A thoroughgoing investigation as to the extent to which hardness of the soda-lime might be sacrificed and its chemical efficiency increased for use in industrial masks was started by the Chemical Warfare Service, but not completed before the experimental work had to be stopped. An investigation was also partially completed covering the effect of variations in composition on the absorption of certain gases, such as sulfur dioxide, which are met with in industries but not on the battlefield. While these investigations are not complete nor entirely conclusive, the indications are that a soda-lime containing 4 per cent sodium hydroxide, 4 per cent kieselguhr, and the remainder lime, with a final water content of about 12 per cent, would be an adequately hard and very efficient all-round absorbent for practically all industrial gases. The use of more kieselguhr and less caustic would give a harder product, while the use of less kieselguhr and slightly more caustic would give softer but somewhat more absorptive material. The method of preparation would be similar to the above-described process now used by the Army.

As a special case of the industrial use of soda-lime may be mentioned the need for a satisfactory carbon dioxide absorbent. Such absorbents are very much used in self-contained oxygen respirator apparatus where the air is circulated in a closed circuit, carbon dioxide being absorbed and oxygen led in from a tank as needed. A special investigation of carbon dioxide absorbents has therefore been made by the Research Division. It has been found that the great difference between a good absorbent for carbon dioxide and absorbents for the more strongly acid gases lies in the need for a very high moisture content to give complete carbon dioxide absorption. A formula which has been found to give very satisfactory results contains about 4 per cent alkali, and should have a moisture content between 16 and 18 per cent. The reason this high moisture content gives so much better results is not entirely clear, but it may be necessary in order to facilitate the rapid recausticization of the sodium hydroxide by the lime, which unquestionably plays a considerable part in the rapid and complete absorption of carbon dioxide by soda-lime.

The simplest way to obtain material with this moisture content is to dry to 10 or 12 per cent water preferably in vacuum (to prevent the absorption of carbon dioxide as in air drying), grind and screen, and then increase the water content to 16 or 18 per cent by spraying the granules with a specially designed atomizing nozzle, which gives an extremely fine, uniform mist. This spraying must, of course, be very carefully controlled so as to make it quite uniform. The reason for adopting this method is the great difficulty of grinding and screening material containing 16 or 18 per cent water. At best, the grinding yields are rather low.

The use of even a small amount of any binding agent has been found to decrease very markedly the efficiency of the carbon dioxide absorption. The

methods of handling the product throughout are of the greatest importance. If properly prepared, the soda-lime should absorb in the neighborhood of 0.3 g. of carbon dioxide per gram of soda-lime at high rates of flow before its efficiency drops off seriously. It is reasonably hard, granular, and non-deliquescent. The material possesses a further great advantage over the ordinary high caustic-absorbing materials for respirators in that it gives off much less heat due to the fact that it evaporates off rather than absorbs moisture.

The suggestions made in this section as to the modifications of the army soda-lime for industrial purposes are based on investigations which are as yet incomplete. That the recommended procedure will produce an absorbent several times as efficient as any soda-lime now on the market has been verified by thoroughgoing tests on all available commercial soda-limes. It should have considerable value for use in steel analyses, where present types of soda-lime do not give satisfactory service, and for other industrial purposes.

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EFFECT OF EXPOSURE TO WEATHER ON RUBBER GAS MASK FABRICS¹

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The purpose of this investigation was to determine the relative desirability for gas mask use of a number of rubber coated fabrics submitted by different manufacturers, particularly with regard to their resistance to the deteriorating effect of exposure to the elements. The desirable qualities in a rubber fabric for gas mask use are:

- 1—Resistivity to war gases
- 2—Flexibility and comparative lightness
- 3—Resistance to deterioration by weather
- 4—Resistance to deterioration due to exposure to gas

MATERIALS USED

Gas mask fabrics consisting of a finely woven cotton sheeting covered with a rubber layer varying from 0.010 to 0.025 in. in thickness were used for the tests.

Fabric No.	Manufacturer	Weight Oz./Sq. Yd.	Thickness of Rubber Layer Inch	Date Received
P-190	Plymouth Co.	29.06	0.025	Jan. 16, 1918
P-196	U. S. Rubber Co.	18.9	0.015	Jan. 21, 1918
P-197	Kenyon Co.	15.0	0.012	Jan. 21, 1918
P-198	Kenyon Co.	13.9	0.011	Jan. 21, 1918
P-298	Kenyon Co.	15.4	0.011	April 19, 1918
P-199	Goodrich Co.	19.1	0.018	Jan. 21, 1918
P-200	Goodrich Co.	15.9	0.016	Jan. 21, 1918
P-299	Goodrich Co.	15.5	0.012	April 19, 1918
P-205	Goodyear Co.	16.0	0.019	Feb. 14, 1918
P-366	Goodyear Co.	13.8	0.012	May 13, 1918
P-297	Plymouth Co.	15.9	0.010	April 19, 1918

METHOD OF EXPOSURE

The effect of exposure to weather (sun and rain) and the effect of exposure to heat alone have been investigated.

For exposure to weather, the samples were loosely stretched on wooden frames placed on a slightly slop-

¹ Approved for publication by the Director of the Chemical Warfare Service.

ing roof with southern exposure. At successive periods samples were cut to be examined for permeability, acetone extract, and general physical properties.

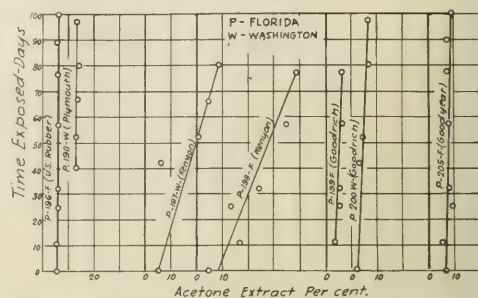


FIG. 1.—FABRICS EXPOSED TO WEATHER, FEBRUARY TO JUNE, 1918.
ACETONE EXTRACT

At the time when the investigation was started (early in February) it was thought that exposing samples in Florida would give quicker deterioration due to greater amount of heat, sunshine, and moisture. Accordingly, Samples P-198, P-199, P-197, and P-205 were exposed in Florida. Later other samples were exposed in Washington, of which P-197 and P-200 are duplicates of P-198 and P-199, respectively.

In order to determine the effect of ultraviolet light in the sun's rays on the rate of deterioration, a portion of each fabric exposed was covered with a sheet of glass $\frac{1}{8}$ in. thick. This shielded the fabric underneath from that portion of the sunlight which is of short wave length.

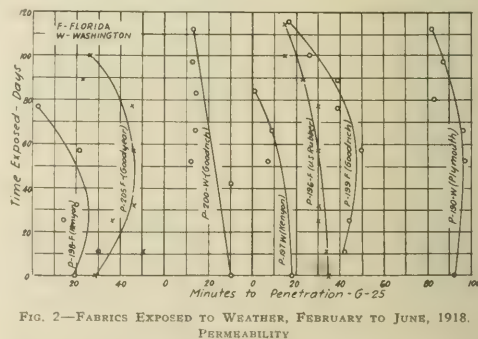


FIG. 2.—FABRICS EXPOSED TO WEATHER, FEBRUARY TO JUNE, 1918.
PERMEABILITY

The early samples were exposed rubber side up. Surface cracking occurred so quickly that later tests conducted in Washington were run with samples both rubber up and cloth up.

The accelerated aging tests were made in a Freas electric drying oven, heated to 130° C., well ventilated by an electric fan. Temperature did not vary more than a few degrees in any part of the oven. No attempt was made to control humidity. Samples were cut at successive intervals over a period of 18 hrs.

FABRICS EXPOSED IN FLORIDA, FEBRUARY-JUNE, 1918

Days Aged	Per cent Acetone Extract			Minutes to Penetration against Chlorpircin (Saturated Vapor at 20° C.)		
	P. 196	P. 198	P. 199	P. 196	P. 198	P. 199
0	5.8	4.4	7.3	35	19	28
11	5.4	16.6	3.5	34	30	42
25	5.5	13.4	5.3	30	25	44
32	5.8	23.9	5.7	30	20	46
57	6.0	34.7	6.5	30	21	50
77	5.7	38.5	6.4	30	2	39
89	5.6	Dis-	7.7	23	Dis-	39
100	6.2	con-	9.0	15	con-	26
114	timed			15	timed	17

TABLE I

FABRICS EXPOSED IN WASHINGTON, FEBRUARY-JUNE, 1918

Days Aged	Per cent Acetone Extract			Minutes to Penetration against Chlorpircin (Saturated Vapor at 20° C.)		
	P. 190	P. 197	P. 200	P. 190	P. 197	P. 200
0	4.7	4.7	2.5	92	18	30
42	12.7	6.3	3.1	97	25	30
52	12.8	20.5	4.5	97	7	12
66	13.4	24.4	0	96	9	14
80	14.0	28.6	6.7	83	1/2	14
97	13.4	Discon-	7.1	87	Discon-	13
112	timed			82	timed	13

TABLE II—FABRICS EXPOSED IN WASHINGTON, MAY 25, 1918 AUGUST 2, 1918, SHOWING EFFECT OF EXPOSING RUBBER SIDE AND CLOTH SIDE OF FABRICS TO SUN AND OF SHIELDING FABRIC FROM ULTRAVIOLET LIGHT

Days Aged	P-297			P-298			P-299			P-366		
	Rubber Exposed	Cloth Exposed	Under Glass	Rubber Exposed	Cloth Exposed	Under Glass	Rubber Exposed	Cloth Exposed	Under Glass	Rubber Exposed	Cloth Exposed	Under Glass
0	1.7	7.7	1.7	3.9	9.9	3.9	5.3	5.3	5.3	5.3	5.3	5.3
7	2.8	2.5	2.1	5.7	5.8	4.1	4.4	4.4	4.4	5.2	5.3	4.4
14	3.8	3.8	3.4	5.8	5.0	5.3	7.0	5.9	5.1	6.2	6.5	6.9
21	3.7	2.2	4.4	10.1	5.7	9.4	6.7	4.9	7.2	6.2	4.9	6.4
28	4.4	2.2	4.2	12.7	6.2	11.0	6.5	6.9	7.2	6.8	5.8	6.6
42	5.5	2.2	2	18.2	7.1		7.7	4.8		6.6	5.5	
57	7.5	2.5		22.2	8.1		9.2	4.7		7.2	5.6	
70	10.1	3.5		27.2	8.7		11.7	6.0		8.2	6.4	

It is important that a rubber fabric for gas mask use should not deteriorate from exposure to gas. To determine the amount of deterioration, several fabrics were exposed in the man-house chamber to varying concentrations of chlorpircin and phosgene for several days, the fabrics being examined at intervals.

TESTS MADE

PERMEABILITY—Permeability of the fabric was determined in a specially designed apparatus.¹ A 4-in. square of the fabric is clamped in a horizontal position in a cell which it divides into two compartments. The lower compartment contains a cotton pad saturated with chlorpircin. The apparatus is immersed in a bath at 20° C. A current of air is drawn over the top of the fabric, through a silica tube heated to about 400° C., into a starch-potassium iodide solution. The first trace of chlorpircin diffusing through the fabric is indicated by the appearance of a blue color. The time from the beginning of the tests to the appearance of the blue color is called the time to penetration.

After exposure tests had proceeded for a few weeks, an increase in the hardness and brittleness of the rubber layer which rendered it susceptible to cracking was noticed. In order to detect this brittleness, a folding test was devised. The ends of a strip of fabric were gripped by two wide clamps. A lead weight was suspended from one of these, and with the other clamp the fabric was drawn over a steel straight edge at an angle of 90° back and forth 10 times under a tension of 1 lb. per linear in. The permeability was determined after the fabric had been folded in this manner. This precaution obviated misleading results due to stiffening of the fabric.

ACETONE EXTRACT—Rubber, both crude and vulcanized, is insoluble in acetone. When rubber breaks down through aging, oxidation, etc., the decomposition products are soluble in acetone. This test is therefore one indication of the life of rubber goods; a

¹ A more detailed description of methods of testing permeability of fabrics will be given in an article by one of us in a future number of This JOURNAL.

slight increase in acetone extract from time to time would show normal aging, while a rapid increase would indicate that the life of the material was at an end.

Acetone extractions were made on 2-g. samples in a battery of 9 Wyley extractors for a period of 8 hrs. The solution was then transferred to a weighed, 150-cc. flask, the solvent evaporated on a steam bath, using a gentle current of air, dried to constant weight in a drying oven at 95° C., and weighed. The extract was corrected for free sulfur.

Free sulfur was determined by adding 40 to 60 cc. of water and 2 or 3 cc. of bromine. These were allowed to digest on the water bath until the solution was nearly colorless, then filtered and washed. The sulfur was precipitated as barium sulfate and calculated to sulfur.

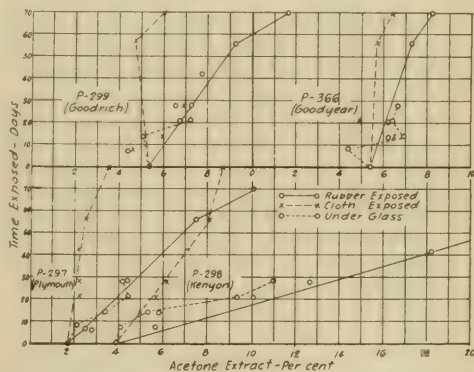


FIG. 3—FABRICS EXPOSED TO WEATHER, WASHINGTON, MAY 25 TO AUGUST 2, 1918. ACETONE EXTRACT

DISCUSSION

Consideration of curves shows that, with the exception of fabrics from the Kenyon Company, all samples deteriorated at about the same rate. Fabrics aged in Florida and Washington this winter showed no marked increase in acetone extract over a period

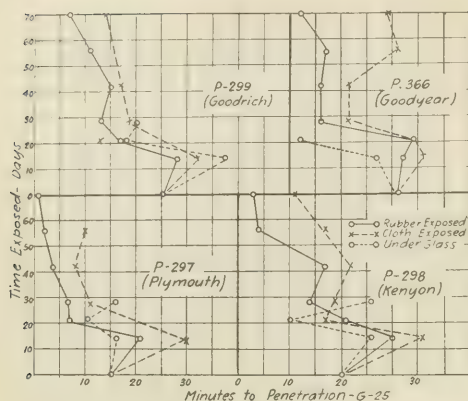


FIG. 4—FABRICS EXPOSED TO WEATHER, WASHINGTON, MAY 25 TO AUGUST 2, 1918. PERMEABILITY

of 100 days. The difference in temperature between Florida and Washington did not prove to be sufficient to markedly change the rate of deterioration. Deterioration in physical appearance had noticeably taken place on all the fabrics after one month. The surface became covered with minute cracks which, as time went on, deepened. The Kenyon fabrics (P-197 and P-198) were covered with deep cracks after 6 weeks, and became gummy and quite useless. Of the other fabrics, P-196 retained its original flexibility through the entire 100 days.

From inspection of Fig. 2 it is apparent that resistance to penetration by chlorpicrin increased for the first month and then declined. This is evidently due to the increased resinification of the rubber (as indicated by increase of acetone extract), making a harder surface less easily penetrated by chlorpicrin. Later, although the amount of resin still increased, brittleness and checking of the rubber film reduced the thickness of rubber effective as a buffer to the gas.

Four samples last received (P-297, P-298, P-299, and P-266) were exposed in Washington for a period of 10 weeks, May 25 to August 2. One-half of each sample was exposed with the rubber side up and one-half with cloth side up. A small part of each sample was covered with glass to exclude ultraviolet light. The samples in which the rubber was exposed to the sunlight deteriorated much more rapidly than the samples shielded by the cloth backing of the fabric. Acetone extracts and cracking of the surface increased much more rapidly than for the sample exposed during the winter months. At the end of 10 weeks, increase in permeability, in acetone extract, and in poor appearance, was very marked. In contrast, the samples aged rubber side down were well preserved. The fabric weathered under glass did not differ markedly in properties from that exposed to the full rays of the sun.

Fabrics have been arranged in Table III according to their efficiency, which is based on permeability to chlorpicrin, acetone extract, and appearance. The

general trend of each curve was considered, and percentage increase or decrease calculated. The fourth column, based on the other three, is to some extent a question of judgment. It is apparent, however, that P-196 and P-200 are best, and P-197 and P-198 poorest.

TABLE III—RELATIVE DESIRABILITY

Time to Penetration	Acetone Extract	Appearance	Average
P-205	P-196	P-196	P-196
P-196	P-205	P-205	P-205
P-190	P-190	P-190	P-190
P-298	P-366	P-199	P-299
P-200	P-299	P-200	P-200
P-196	P-199	P-366	P-199
P-190	P-200	P-299	P-366
P-299	P-297	P-298	P-297
P-366	P-298	P-297	P-298
P-197	P-197	P-197	P-197
P-197	P-198	P-198	P-198

There is apparently a fairly close relationship between increase in permeability and increase in acetone extract. Such a relationship is logical, since increasing acetone extract is an evidence of the decomposition of the rubber.

ACCELERATED AGING

Rubber manufacturers in determining the best composition of a mix make use of an accelerated test to determine the relative aging properties of different samples. In this test the sample is heated in an oven and the change in properties noted at the end of several hours.

Our experiments showed no relation whatever between results of actual weather exposure and accelerated aging.

Fabrics heated in an oven at 70° C. for 200 hrs. showed no perceptible deterioration.

A series of fabrics was run at 130° C. and results compared with those obtained by weather aging. Acetone extracts and permeability were determined every 3 hrs. for 18 hrs. Figs. 5 and 6 show the results. Acetone extract increased for 9 hrs. and then remained stationary. Resistance to gas increased for 9 hrs. and then decreased, due to cracking of the rubber when creased. There is, however, no relation between these values and those obtained by exposure to weather. P-299 stood up best against weather aging, P-298 poorest. In the accelerated test, P-298 was as good as ever after 12 hrs. heating; P-299 was hard and brittle. The method might have some value

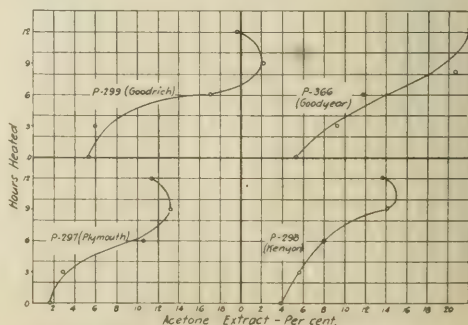


FIG. 5—ACCELERATED AGING AT 130° C. ACETONE EXTRACT

as a check on successive mixes of the same composition, but is apparently not dependable where a number of different samples of varying compositions and treatments are being tested.

TABLE IV—ACCELERATED AGING AT 130° C. IN ELECTRIC DRYING OVEN

Hours	Per cent Acetone Extract				Minutes to Penetration against Chlorpicrin Vapor (Saturated at 25° C.)			
	P-297	P-298	P-299	P-366	P-297	P-298	P-299	P-366
0	1.7	3.9	5.3	5.3	15	20	25	21
3	2.8	5.6	7.9	9.3	22	40	56	29
6	10.7	8.0	17.0	11.7	48	36	89	41
9	13.3	14.0	22.1	20.9	35	42	69	23
12	11.3	13.5	19.7	22.3	42	43	81	36
15	..	..	..	..	39	47	120	57
18	..	..	..	..	24	27	26	31

EXPOSURE TO GAS

It is important that a gas mask fabric should not deteriorate from exposure to gas. To determine to what extent the fabrics under consideration were affected by such exposures, they were left in a gas chamber containing a concentration of phosgene of 10,000 p. p. m. for 15 hrs. Other samples of the fabrics were exposed for 15 hrs. to a concentration of 2,000 p. p. m. of chlorpicrin.

The cloth backing of all the fabrics was rotted by both gases. The rubber of P-196 was unaffected by either gas. Phosgene deteriorated the rubber of the other fabrics. Chlorpicrin caused deterioration of the rubber of P-298, but not to so great an extent as phosgene. Apparently the high percentage of carbon in P-196 protected it against the action of the gas (see Table V).

ANALYSIS

In order to obtain, if possible, an idea of why certain fabrics deteriorated more rapidly than others, a chemical analysis was made of the samples under consideration.

SPECIFIC GRAVITY was determined by weighing a sample of stripped fabric in air and in water, using an analytical balance and a beaker of water set on a bridge over the balance pan. The sample was suspended from the beam by a hair.

THICKNESS was determined by an Ashcraft micro-gauge reading to thousandths of an inch. Thickness as here given is the thickness of the rubber coating of the fabric.

ASH was found by igniting a one-gram sample at the lowest possible heat and weighing. The ash was then used for the inorganic analysis.

MATTER INSOLUBLE IN HCl was found by boiling with 1:1 hydrochloric acid, filtering, washing, and weighing.

LEAD, IRON, ALUMINUM, CALCIUM, AND MAGNESIUM were determined gravimetrically. Zinc was titrated with standard potassium ferrocyanide (22 g. per l.), using uranyl nitrate indicator.

ACETONE EXTRACTS were made as already described. Following this, a chloroform extraction was made on the same 2 g. sample for bitumen, asphalt, coal tar, pitch, etc.

BITUMEN was calculated empirically from the per cent of chloroform extract by subtracting 0.5 and multiplying by 5.

PETROLEUM WAX was determined by charring an acetone extraction with 2 or 3 cc. of concentrated sulfuric acid, neutralizing with alcoholic potash, extracting with petroleum ether, evaporating in a weighed flask, and weighing.

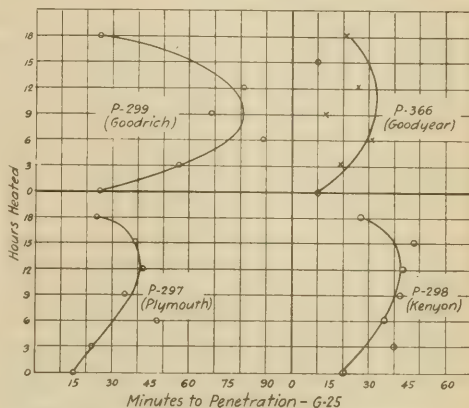


FIG. 6—ACCELERATED AGING AT 130° C. PERMEABILITY

CARBON was determined by digesting 1 g. of a fresh sample successively with concentrated nitric acid, dilute ammonia containing ammonium chloride, and finally dilute hydrochloric acid. It was filtered through the same tared filter paper each time and thoroughly washed with hot water. The paper was dried in an oven at about 100° C., desiccated, and weighed. The difference between this weight and the filter paper tare gives the weight of carbon plus the mineral. By igniting this in a porcelain crucible the carbon is burnt off, leaving the mineral. The loss in weight is the carbon.

TOTAL SULFUR was found by continuously fusing a fresh 1/2-g. sample with a mixture of sodium carbonate and potassium nitrate, lixiviating with water, filtering, precipitating as sulfate, and calculating to sulfur.

"GUM" is found by difference, as there is no satisfactory method for determining it directly. It is therefore subject to the accumulation of errors in the balance of the analysis, which may at times be considerable. For instance, in the calculation of bitumen from chloroform extract, the result is only a very rough approximation.

Therefore, the extra table of analytical data giving the compounded materials in round numbers based, as closely as possible, on the actual analysis, and on manufacturers' custom in compounding, is helpful in comparing the composition of fabrics.

The methods of analysis of the rubber part of the fabric are exact except in three instances. The percentage of bitumen is very approximate because it is calculated on the per cent of chloroform extract, which represents an amount ranging from 10 to 30 per cent of the bitumen present in the compound. Crude gum is determined by difference and may vary by several per cent, since the percentage is affected by

TABLE V—CHEMICAL COMPOSITION

SAMPLE NO.	No.	Sp	Gr.	Thick-ness, Inch	TABLE V—CHEMICAL COMPOSITION										Total of 6 Cols. Preceding	Ash Per cent	Acetone Extract Unrecr. Per cent	Free S Per cent	Acetone Extract Corr. Per cent	Chloro- form Extract Per cent	Bitu- men Per cent	Car- bon Per cent	Petro- leum Wax Per cent	Total Per cent	Gum Per cent
					Insol. in HCl, Per cent	Fe+Al+O Per cent	Pb Sulfate, Per cent	ZnO Per cent	Ca(OH) ₂ Per cent	MgO Per cent															
P-196	1.50	0.015		0.015	Barytes	31.7	0.7	5.2	...	1.5	Trace	39.1	38.1	6.1	0.8	5.3	2.4	9.5	21.7	1.0	3.1	25.6			
P-197	1.25	0.012		0.012	Talc	13.5	0.9	10.2	3.1	1.9	3.5	33.2	34.9	4.6	0.3	4.3	7.4	34.5	6.4	...	0.5	25.4			
P-198	1.30	0.011		0.011	Talc	12.5	1.2	10.2	3.9	2.1	3.4	33.3	35.4	4.6	0.3	4.3	8.3	39.0	4.7	...	0.6	22.4			
P-298	1.29	0.011		0.011	Talc	12.2	0.6	9.6	3.0	0.7	3.3	33.8	33.6	4.7	0.8	3.9	2.4	9.5	5.0	2.7	1.6	47.4			
P-199	1.01	0.018		0.018	Talc	0.7	0.5	2.8	0.5	2.5	0.6	7.6	7.9	5.4	...	...	...	...	3.3	...	2.5	86.6
P-200	(1.01)	0.016		0.016	Talc	0.7	0.8	2.9	...	2.7	1.0	8.1	7.9	5.4	...	...	...	...	1.6	...	2.4	87.9
P-299	(1.01)	0.012		0.012	Talc	0.7	0.3	3.2	0.5	...	0.3	5.0	4.9	7.2	1.9	5.3	...	...	3.1	...	5.0	86.9	
P-297	1.51	0.010		0.010	China clay	36.9	...	10.2	...	0.6	...	47.7	49.1	2.7	1.0	1.7	...	...	...	...	4.8	47.5
P-205	1.04	0.019		0.019	Trace	1.2	...	10.2	...	4.0	0.7	7.1	6.8	8.6	1.8	6.8	1.4	4.5	5.5	1.8	2.0	79.1			
P-366	1.03	0.018		0.018	Trace	2.3	2.4	2.3	1.0	1.4	7.9	7.5	7.3	2.0	5.3	0.9	2.0	6.0	...	3.0	81.1				

the total analytical error. It is also difficult to determine whether lead is present as basic lead sulfate or litharge.

But few generalizations can be made from the results of chemical analysis of the several fabrics.

It will be observed that the six best fabrics, with the exception of P-196, are mostly gum. From this it appears that fabrics without considerable filler are perhaps best. P-196, however, contains 32 per cent inorganic

TABLE VI—PROBABLE COMPOSITION OF MIX

SAMPLE No.	Filler Per cent	Basic Sul- fide Per cent	Lith-arge Per cent	Zinc Oxide Per cent	Hy- drated Lime Per cent	Mag- nesia Per cent	Car- bon Per cent	Bitu- men Per cent	Petro- leum Wax Per cent	Sul- fur Per cent	Gum Per cent
P-196	30.0	5.0	...	...	1.0	...	20.0	10.0	1.0	3.0	30.0
P-197	15.0	...	10.0	3.0	2.0	3.5	5.0	36.0	...	0.5	25.0
P-198	15.0	...	10.0	3.0	2.0	3.5	5.0	36.0	...	0.5	25.0
P-298	18.0	...	10.0	3.0	1.0	4.0	5.0	10.0	2.5	1.5	45.0
P-199	1.0	...	3.0	4.5	2.0	...	...	...	...	2.5	88.0
P-200	1.0	...	3.0	0.5	2.0	...	...	...	...	2.5	88.0
P-299	1.0	...	3.0	0.5	...	...	3.0	...	...	4.5	88.0
P-297	35.0	10.0	...	...	1.0	...	5.0	5.0	1.5	4.0	50.0
P-205	1.0	...	1.5	...	4.0	...	5.0	2.0	80.0	...	...
P-366	1.0	...	2.0	2.0	...	...	5.0	2.0	...	3.0	85.0

filler and 20 per cent carbon, and has by far the best appearance. Whether or not its excellence is due to the large amount of carbon it contains is a question. There are not sufficient data to conclude that a large amount of carbon preserves the efficiency of rubber, but it is not unlikely, inasmuch as it would protect the rubber from the action of sunlight.

An analysis for carbon alone on P-190, an earlier sample from the Plymouth Company, supports this view, as it contains about 20 per cent carbon and is one of the three best fabrics investigated.

TABLE VII—DETERIORATION IN TENSILE STRENGTH
Fabrics set out in Pensacola, February 18, 1918, rubber side up

FABRIC No.	Original—			April 21, 1918—			May 20, 1918—			June 5, 1918—			July 15, 1918—		
	Wt.	W	F	Wt.	W	F	Wt.	W	F	Wt.	W	F	Wt.	W	F
P-196	18.9	60	52	19.2	54	61	18.0	61.5	42	17.5	58	51.3	18.7	51	49.5
P-198	14.0	55	53	14.2	49	48	13.5	55.3	39.7	13.0	47	36	...	...	...
P-199	17.1	60	54	16.5	51	51	16.4	50.5	45.7	16.2	46	39.3	...	...	...
P-205	16.7	41	57	16.0	50	49	15.4	53.8	47.8	15.4	53.8	47.8	14.6	46	36.5

¹ Wt. = Oz. per sq. yd.; W = Warp; F = Filling.

It appears that, up to 10 per cent, bitumen is not harmful, and probably desirable as far as weathering is concerned. Whether the poor quality of the Kenyon fabrics, P-197 and P-198, is due to too much bitumen or insufficient gum, or both, cannot be said with certainty.

Magnesia and zinc oxide should be left out, and probably petroleum wax might better be omitted.

Litharge and basic lead sulfate should not be present in too great amounts.

It is desirable that fabrics be under-vulcanized when manufactured with enough excess sulfur to allow a slow after-vulcanization on exposure, thus insuring that the fabric remain soft and flexible for a longer time.

The poor quality of P-197 and P-198, Kenyon samples may be due to insufficient sulfur as well as too large a percentage of bitumen and too small a percentage of rubber. Likewise the poor elastic properties of P-199 and P-200, Goodrich, may be due to insufficient sulfur (see Table VI).

TENSILE STRENGTH

Tensile strength of the fabrics weathered in Pensacola was tested by the Bureau of Standards at various times. Tests were made by the strip method, using a strip 1 in. by 5 in. with a 3 in. separation of the jaws.

The data set forth in Table VII show P-196 to be as strong as ever after exposure to weather for 4 mo. The other fabrics have lost from 15 per cent to 30 per cent of their original tensile strength. This loss in tensile strength is due to weakening of the fabric which determines the tensile strength of the combination. P-196 probably resisted weathering better because the rubber film was still unimpaired after 4 mo., while the other samples were more or less cracked and allowed light to penetrate to the fabric. Deterioration in tensile strength is apparently not sufficiently rapid to impair the usefulness of the fabric over a period of 6 mo.

EFFECT OF WEATHER CONDITIONS

Fabrics exposed in Washington during the period from May to August (average temperature, 73° F.) deteriorated much more rapidly than those exposed during the winter months (average temperature, 58° F.). This was due undoubtedly to the increased temperature and increased total radiation. Data on weather conditions are given in Tables VIII and IX.

TABLE VIII—DATA ON WEATHER CONDITIONS, WASHINGTON

DATES	No. Days	Average Precipitation which It Rained	Days on which It Rained	Average Relative Humidity	Average Temperature, Deg. F.	Total Radiation Cals. per Sq. Cm.
Feb. 14-Mar. 27.....	42	0.136	18	64	45	16,588
Mar. 28-Apr. 6.....	10	0.006	1	86	52	4,856
Apr. 7-Apr. 20.....	14	0.331	7	75	50	4,183
Apr. 21-May 4.....	14	0.137	6	60	58	6,758
May 5-May 21.....	17	0.086	5	66	69	9,061
May 22-June 5.....	15	0.085	5	73	75	7,514
TOTAL.....	112	..	..	..	..	48,960
DAILY AVERAGE.....	..	0.134	..	66	55	437
May 25-May 31.....	7	0.084	4	81	75	3,111
June 1-June 7.....	7	0.087	4	68	76	3,622
June 8-June 14.....	7	0.061	4	60	71	4,085
June 15-June 21.....	7	0.010	2	61	69	3,627
June 22-July 5.....	14	0.080	5	67	69	6,465
July 6-July 19.....	14	0.128	6	63	72	6,935
July 20-Aug. 2.....	14	0.130	7	74	78	6,941
TOTAL.....	70	..	..	..	..	34,786
DAILY AVERAGE.....	..	0.092	..	69	73	497

TABLE IX—DATA ON WEATHER CONDITIONS, PENSACOLA, FLORIDA

DATES	No. Days	Average Precipitation Inch	Days on which It Rained	Average Relative Humidity	Average Mean Temperature, Deg. F.
Feb. 18-Feb. 28.....	11	0.050	2	84	61
Mar. 1-Mar. 14.....	14	0.004	1	90	67
Mar. 15-Mar. 21.....	7	0.011	1	70	61
Mar. 22-Apr. 15.....	25	0.231	6	79	62
Apr. 16-May 5.....	20	0.415	6	85	66
May 6-May 17.....	12	0.095	1	87	72
May 18-May 28.....	11	0.001	1	80	75
May 29-June 11.....	14	0.058	3	79	79
DAILY AVERAGE.....	114	0.147	..	82	67

SUMMARY

With the exception of Kenyon Company fabrics, P-298, P-197, and P-198, the different fabrics deteriorate only very slowly over a period of 100 days; there is a general relation between increase in acetone extract and increase in permeability; the

fabrics exposed from February to June (average temperature 58° F.) deteriorate more slowly than those exposed in the warmer weather from June to August (average temperature 73° F.); fabrics exposed with rubber side down showed no appreciable deterioration over the whole period; fabrics exposed rubber up, but shielded from ultraviolet light, deteriorated at about the same rate as those exposed to the direct rays of the sun; and there is no apparent relation between the results of weather aging and an accelerated aging test at 130° C.

Tensile strength of all fabrics is decreased about 15 per cent by the exposure. Exposure to high concentrations of phosgene for 15 hrs. rots the fabric and rubber.

Chemical analysis of the fabrics appears to indicate that over 10 per cent bitumen is undesirable and that as high as 20 per cent of carbon tends to preserve the fabric, especially when exposed to sunlight. Fabrics with a high percentage of gum are, in general, more resistant to the effects of weather than those containing a large amount of filler.

Results indicate that any of the fabrics tested, with the exception of the Kenyon Company fabrics, are satisfactory from the point of view of resistance to weather.

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ORIGINAL PAPERS

THE DETERMINATION OF THE FREEZING-POINT CURVES AND DENSITIES OF DENATURED ALCOHOL-WATER MIXTURES

By CLARKE E. DAVIS AND MORTIMER T. HARVEY

Received December 27, 1918

INTRODUCTION

The great importance of denatured alcohol as a means of protecting the radiator and cooling system of automobiles, air planes, and trucks from freezing has prompted the authors to undertake an investigation of the freezing-point curve of mixtures of completely denatured alcohol and water. This information is necessary in order to determine how much denatured alcohol should be added in order to secure protection to a particular temperature.

While the curve for mixtures of ethyl alcohol and water has been previously investigated, we have found no record of any work on completely denatured alcohol-water mixtures.

The object of this investigation has been to determine the temperatures at which equilibrium exists in systems in which the liquid phase is composed of completely denatured alcohol and water and in which the solid phase is ice.

HISTORICAL

Raoult¹ states that mixtures of alcohol and water when subjected to low temperatures congeal but never completely solidify. That which solidifies con-

sists of plates of pure ice and can be freed from alcohol by simple mechanical means.

Volume Alcohol Per cent	Alcohol in 100 g. Water Grams	Temperature of Congelation Deg. C.	Volume Alcohol Per cent	Alcohol in 100 g. Water Grams	Temperature of Congelation Deg. C.
0.0	0.0	-0.0	21.9	21.90	-9.0
1.6	1.32	-0.5	25.3	25.60	-10.0
3.2	2.65	-1.0	26.4	27.60	-12.0
4.8	3.97	-1.5	29.1	31.30	-14.0
6.3	5.30	-2.0	31.3	35.10	-16.0
7.8	6.62	-2.5	33.8	39.00	-18.0
9.2	7.95	-3.0	36.1	42.80	-20.0
10.6	9.27	-3.5	38.3	46.60	-22.0
11.8	10.60	-4.0	40.0	50.60	-24.0
13.1	11.90	-4.5	41.6	54.80	-26.0
14.2	13.00	-5.0	43.7	59.20	-28.0
16.4	15.30	-6.0	46.2	64.40	-30.0
18.7	17.80	-7.0	47.9	70.00	-32.0
20.4	19.80	-8.0			

These results are graphically represented by the curve of Fig. 1.

Pictet¹ gives the following results of the determination of the freezing points of mixtures of ethyl alcohol and water.

Alcohol Per cent by Weight	Point of Crystallization Deg. C.	Alcohol Per cent by Weight	Point of Crystallization Deg. C.
2.5	-1.0	22.1	-12.2
4.8	-2.0	24.2	-14.0
6.8	-3.0	26.7	-16.0
11.3	-5.0	29.9	-18.9
13.8	-6.1	33.8	-23.6
16.4	-7.5	39.0	-28.7
17.5	-8.7	46.3	-33.9
18.8	-9.4	56.1	-41.0
20.3	-10.6	71.9	-51.3

The author noted the temperature at the appearance of crystals while the mixture was being cooled.

¹ *Compt. rend.*, 90 (1880), 865.¹ *Compt. rend.*, 119 (1894) 678

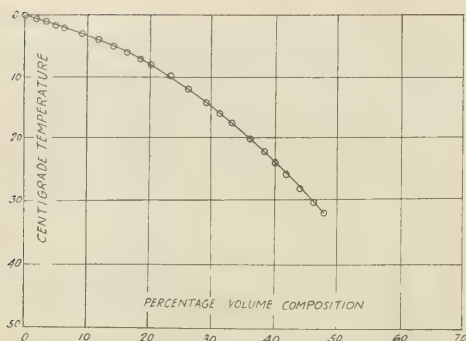


FIG. 1—FREEZING-POINT CURVE, ALCOHOL AND WATER, DETERMINED BY RAOULT IN 1880

These results are graphically represented by the curve of Fig. 2.

Guttmann¹ used a constantan-copper junction. The constantan wire was $\frac{1}{2}$ mm. in diameter, while the copper wire was No. 32 (o. 27 mm.). A d'Arsonval galvanometer with a resistance of 800 ohms was placed in series with a manganin resistance of about 700 ohms. For calibration of the couple he determined the melting and boiling points of (1) ice, (2) chloroform, (3) stiff paste of solid carbon dioxide and absolute alcohol, (4) ether, (5) liquid air.

Kendall and Booge² determined the freezing points of ester-acid systems. With monobasic acids a temperature of -90° and with dibasic acids a temperature of -70° was reached. In all cases the melting point was determined by warming the partially frozen mixtures very slowly and observing the temperature at which the last traces of crystals were just in equilibrium, i. e., the true temperature of incipient freezing.

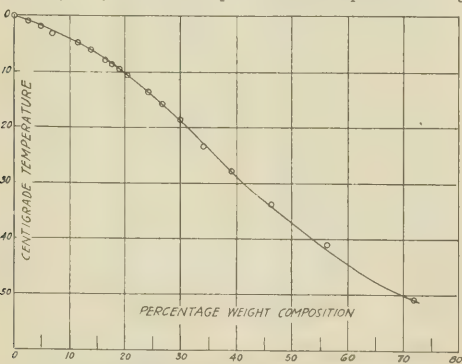


FIG. 2—FREEZING-POINT CURVE, ALCOHOL AND WATER, DETERMINED BY PICTET IN 1895

Above -35° mercury thermometers and below -35° toluene thermometers were used. The former were calibrated in the usual way and the latter by checking against carbon dioxide-alcohol paste (-78.2°) and pure ethyl acetate (-82.8°).

¹ J. Chem. Soc., 87 (1905), 1037.

² J. Am. Chem. Soc., 38 (1916), 1712.

It is impossible to see with accuracy the exact temperature at which the solid phase appears or disappears. It is more accurate to determine the melting point than the freezing point. It is still more accurate to determine the melting point by measuring the resistance and determining, by a series of readings at slowly increasing temperatures, the break in the curve which indicates the change from the solid to the liquid phase.

EXPERIMENTAL PROCEDURE—A

The temperature changes were all detected by means of a nickel resistance thermometer, T, with three leads. The amount of inflection or increase in resistance due to the melting was measured by the

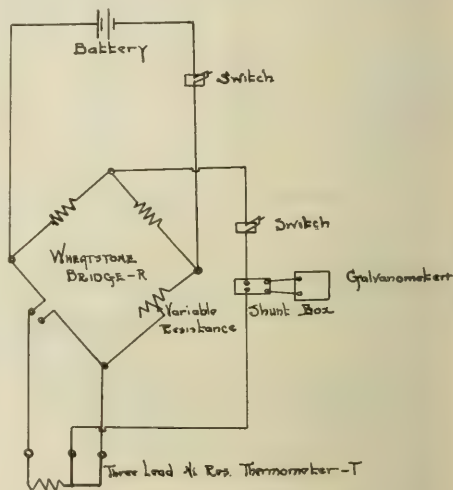


FIG. 3—ARRANGEMENT OF APPARATUS

standard Leeds and Northrup Wheatstone bridge, R. T and R, a d'Arsonval, two dry cells, and a shunt box are connected, as shown in Figs. 3 and 4.

The melting points of water and various concentrations of denatured alcohol by $2\frac{1}{2}$ or 5 per cent increments up to 90 per cent alcohol were determined. The freezing mixture was a paste of carbon dioxide-alcohol which, after resting for a time, shows a definite temperature of -78.2° .¹ This was contained in a quart thermos bottle. The mixture of alcohol and water, made up volumetrically from calibrated burettes, was contained in a test tube 6 in. \times 1 in. This was frozen by immersion in the carbon dioxide-alcohol paste. For the melting the test tube containing the frozen mixture was placed in a Janus bottle as shown in Fig. 5.

In order to make the rate of heating very slow, the neckless bottle, B, was made to hold the loaded test-tube. This allows the presence of a film of cold air between the melting solid and the cold bath, keeping

¹ Travers, Proc. Roy. Soc., 74 (1905), 534.

the temperature gradient as low as possible. The change of temperature was about 0.05° per min.¹

The whole magma was kept constantly in motion by a stirrer made of brass, 8 in. long and $\frac{3}{16}$ in. in diameter, the end of which was flattened out in paddle form. The stem was covered with a strip of jagged sheet copper which gave an up and down circulation. The stirrer was belt-driven by a small motor.

The three-lead nickel resistance thermometer was calibrated against known temperatures in order that interpolation might be practiced between these working limits to get the exact temperature corresponding to any resistance (see Fig. 6).

The points used were the melting points of ice, melting point of mercury, and the constant temperature of carbon dioxide-alcohol paste.

Ice.....	0° C.
Mercury.....	-38.8° C.
Carbon dioxide-alcohol paste.....	-78.2° C.

The results are given in Table I.

The mercury used was first washed with nitric acid according to the method of Hildebrand,² filtered through a dry cloth, then distilled under reduced pressure in a current of air according to Hulett.³

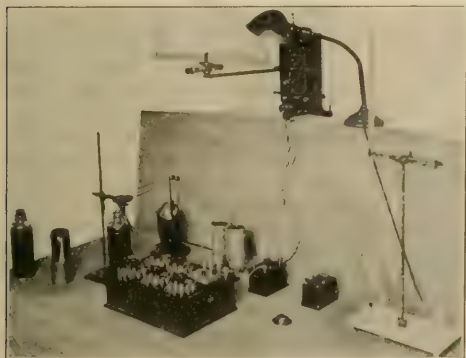


FIG. 4

The denatured alcohol was made in the following proportion:⁴

100 parts ethyl alcohol
10 part. methyl alcohol
$\frac{1}{2}$ part benzolene

This is known commercially as Pyro. The actual amounts used were 2 liters of ethyl alcohol, 200 cc. of methyl alcohol, and 10 cc. of benzolene.

EXPERIMENTAL DATA

SPECIFICATIONS ON MATERIALS⁵—(I) The specific gravity of the ethyl alcohol was 0.811 at 20° C.

¹ Up to 14 per cent of alcohol the rate of heating varied from 0.0° to 0.05° per min. From 14 per cent to 30 per cent it varied from 0.05° to 0.10° per min. For high percentages it was about 0.8° per min.

² J. Am. Chem. Soc., **31** (1909), 933.

³ Z. physik. Chem., **33** (1900), 611.

⁴ U. S. Internal Revenue specifications for completely denatured alcohol.

⁵ See U. S. Internal Revenue Regulations No. 30, revised, for specifications required.

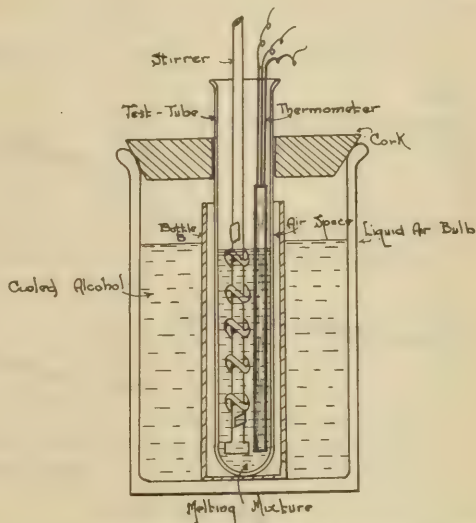


FIG. 5—METHOD FOR MELTING SOLID SOLUTION

(II) The methyl alcohol possessed the following properties:

(a) Color—extremely clear.

(b) Boiling point—out of 100 cc., 98 cc. were recovered as condensate before the temperature reached 75° C. at 30 in. pressure. Not less than 90 cc. should distill over.

(c) It gave a very clear mixture with two volumes of distilled water.

(d) The acetone number was 5 g. per 100 cc. of spirit by Messinger's method. It should run 10 g. per 100 cc.

(e) The ester number was 3.5 g. methyl acetate per 100 cc. of spirit. The limits are 2–5 g. per 100 cc.

(f) The bromine absorption was 19.2 cc., meaning that it took 19.2 cc. of methyl alcohol to decolorize a standard solution containing 0.5 g. of bromine. The limits are 15 to 25 cc.

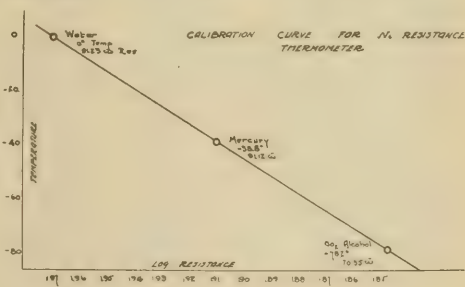


FIG. 6

(g) The specific gravity was 0.817 at 20° C. It should not be more than 0.830 at 60° F. (15.6° C.).

(III) The specific gravity of the benzolene was 0.798 at 20° C. It should be 0.800 at 20° C. The boiling

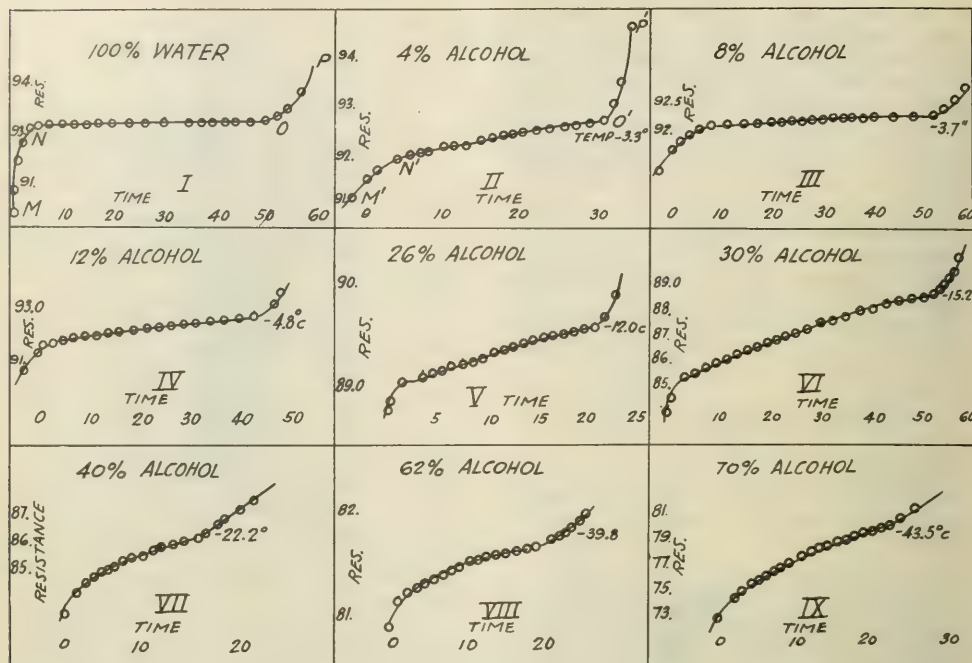


FIG. 7

point varied from 150° to 265° C. at a pressure of 30.05 in. It should range from 150° to 200° C. at 30 in.

A series of measurements of the melting curves was made at 35 different concentrations. See Table II and the individual melting curves in Fig. 7.

TABLE I—DATA ON CALIBRATION OF NICKEL RESISTANCE THERMOMETER

—Mercury Resistance—		—Water Resistance—	
Time	Ohms	Time	Ohms
11.20	75.0	12 58 1/2	85.00
11.21	78.7	12 59 1/2	86.80
11.22	78.6	1.01	88.40
11 22 1/2	79.1	1.02	90.00
11.23	79.7	1.03	91.10
11 23 1/2		1.04	91.97
11.24	80.60	1.05	92.50
11 24 1/2	80.90	1.06	92.90
11.25	81.08	1.07	93.20
11 25 1/2	81.10	1.08	93.22
11.26	81.12	1.09	93.22
11.27	81.12	1.10	93.22
11 27 1/2	81.12	1.11	93.22
11 28 1/2	81.12	1.12	93.22
11.29	81.12	1.13	93.22
11 29 1/2	81.12	1.14	93.22
11.30	81.12	1.15	93.22
11.31	81.12	1.16	93.22
11.32	81.12	+ 1.17	93.22
11.33	81.12	-1.27	93.22
11.34	81.20	1.33	93.23
11.35	81.28	1.43	93.23
11.36	81.40	1.47	93.23
11.38	81.70	1.50	93.24
11 39 1/2	81.90	1.56	93.25
11.41	82.60	2.00	93.25
11.42	83.20	2.03	93.29
.....	.....	2.05	93.36
.....	.....	2.08	93.47
.....	.....	2.10	93.90
.....	.....	.....	95.20

A second series was made independently with such accuracy that one curve coincides with the other (see Fig. 8).

Fig. 8 shows the results of plotting the resistance in ohms at the time of complete melting against the per cent composition.

Above 70 per cent of completely denatured alcohol the degree of accuracy of the melting points is somewhat less as it is impossible to get the m. p. from the resistance, there being no break in the curve. Observation of the point of disappearance of crystals, however, enabled us to get the melting point. That they fall directly on the curve, Fig. 9, is evidence that they are reasonably correct.

Table III gives the per cent of denatured alcohol in water and the corresponding point of crystalliza-

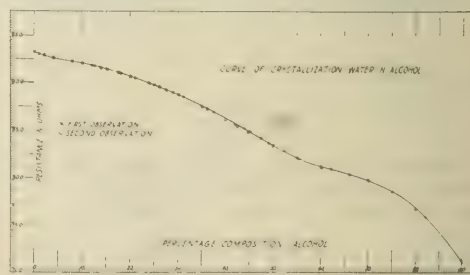


FIG. 8

tion, this temperature in degrees Centigrade being taken from the curve (see Fig. 6).

Fig. 9 shows the curve obtained by plotting the melting point in degrees Centigrade against percent composition.

TABLE II—DATA

Water or 0 per cent Alcohol Resistance			4 Per cent Alcohol Resistance			14 Per cent Alcohol Resistance			40 Per cent Alcohol Resistance			50 Per cent Alcohol Resistance			70 Per cent Alcohol Resistance		
Time	Ohms		Time	Ohms		Time	Ohms		Time	Ohms		Time	Ohms		Time	Ohms	
8.01	91.02		9.33	91.68		3.24	90.50		2.14	83.10		10.01	81.06		4.09	72.80	
8.02 1/2	92.80		9.34	91.78		3.25	90.68		2.15	...		10.02	81.25		4.11	74.45	
8.03	93.10		9.37	91.95		3.27	90.68		2.16	83.99		10.03	81.48		4.12	74.90	
8.03 1/2	93.18		9.38	92.03		3.28	90.68		2.17	84.30		10.04	81.72		4.13	75.46	
8.04	93.20		9.39	92.07		3.29	90.70		2.18	84.47		10.05	81.93		4.14	75.80	
8.04 1/2	93.23		9.40	92.10		3.30	90.72		2.19	84.67		10.06	82.10		4.15	76.20	
8.05	93.23		9.41	92.14		3.33	90.74		2.20	84.83		10.07	82.25		4.16	76.60	
8.05 1/2	93.23		9.42	92.18		3.35	90.79		2.21	84.99		10.08	82.38		4.17	76.89	
8.06	93.23		9.43	92.21		3.37	90.98		2.22	85.13		10.09	82.50		4.18	77.14	
8.06 1/2	93.23		9.44	92.22		3.40	91.01		2.23	85.24		10.10	82.64		4.19	77.39	
8.07	93.23		9.45	92.25		3.41	90.89		2.24	85.35		10.11	82.77		4.20	77.69	
8.07 1/2	93.23		9.46	92.28		3.43	90.92		2.25	85.49		10.12	82.87		4.21	77.93	
8.08	93.23		9.47	92.30		3.45	90.94		2.26	85.61		10.13	82.99		4.22	78.18	
8.08 1/2	93.23		9.48	92.35		3.47	90.98		2.27	85.70		10.14	83.12		4.23	78.38	
8.09	93.23		9.49	92.38		3.49	91.01		2.28	85.81		10.15	83.25		4.24	78.56	
8.10 1/2	93.23		9.50	92.40		3.51	91.10		2.29	85.90		10.16	83.35		4.25	78.73	
8.14	93.23		9.51	92.44		3.53	91.07		2.30	86.00		10.17	83.50		4.26	78.90	
8.15	93.23		9.52	92.48		3.55	91.10		2.31	86.18		10.18	83.65		4.27	79.02	
8.16	93.23		9.53	92.50		3.57	91.19		2.32	86.35		10.19	83.80		4.28	79.16	
8.18	93.24		9.54	92.52		3.59	91.15		2.33	86.54		10.20	83.99		4.29 1/2	79.40	
8.19	93.24		9.55	92.54		3.61	91.22		2.34	86.72		10.21	84.19		4.30 1/2	79.56	
8.20	93.25		9.56	92.56		3.63	91.27		2.35	86.85		10.22	84.38		4.31	79.67	
8.21	93.25		9.57	92.58		3.65	91.32		2.36	87.07		10.23	84.57		4.32	79.84	
8.22	93.26		9.58	92.60		3.67	91.36		2.37	87.20		10.24	84.76		4.33	80.09	
8.24	93.26		9.59	92.62		3.69	91.41		2.38	87.35		10.25	84.95		4.34	80.38	
8.25 1/2	93.28		9.60	92.64		3.71	91.45										
8.29	93.30		9.61	92.66		3.73	91.48										
8.31	93.34		9.62	92.70		3.75	91.52										
8.32 1/2	93.37		9.63	92.74		3.77	91.56										
8.33 1/2	94.24		9.64	92.78		3.79	91.60										

EXPERIMENTAL PROCEDURE—B

The specific gravity of mixtures of completely denatured alcohol and water at concentrations varying from 0-100 per cent was determined. The ordinary form of Ostwald pycnometer was used.

TABLE III

Percentage of Alcohol by Volume	Temp. Deg. C.	Temp. Deg. F.	Percentage of Alcohol by Volume	Temp. Deg. C.	Temp. Deg. F.
0.0	0.0	+32.0	47.5	-28.8	-19.8
2.5	-2.0	+28.4	50.0	-31.1	-24.0
5.0	-2.8	+27.8	52.5	-34.3	-29.7
7.5	-3.2	+26.2	55.0	-35.7	-32.3
10.0	-4.0	+24.8	57.5	-37.6	-35.7
12.5	-4.7	+23.6	60.0	-38.9	-38.0
15.0	-6.0	+21.2	62.5	-40.0	-40.0
17.5	-7.1	+19.2	65.0	-41.0	-42.0
20.0	-8.5	+16.7	67.5	-41.9	-43.4
22.5	-9.5	+14.9	70.0	-43.6	-46.5
25.0	-11.5	+11.3	72.5	-45.0	-49.0
27.5	-12.9	+8.8	75.0	-48.0	-54.4
30.0	-14.8	+5.4	77.5	-50.5	-58.9
32.5	-16.0	+3.2	80.0	-53.7	-64.7
35.0	-18.3	-0.9	82.5	-57.7	-70.9
37.5	-20.0	-4.0	85.0	-62.0	-79.6
40.0	-22.1	-7.8	87.5	-67.8	-90.0
42.5	-24.0	-11.2	90.0	-73.7	-100.7
45.0	-26.9	-16.4			

The measurements were all made at 20° C.,¹ as this temperature most closely approximates the average of our laboratories. It is also much more easily reproducible than lower temperatures. The temperature at 20° was obtained in a thermostat equipped with a toluene regulator and sensitive to 0.1°.

TABLE IV—SPECIFIC GRAVITY OF DENATURED ALCOHOL-WATER MIXTURES

Per cent Alcohol by Volume	Sp. Gr. at 20° C. Water at 20° C. = 1	Per cent Alcohol by Volume	Sp. Gr. at 20° C. Water at 20° C. = 1
0.0	1.0000	55.0	0.9264
5.0	0.9935	60.0	0.9138
10.0	0.9873	65.0	0.9037
15.0	0.9816	70.0	0.8926
20.0	0.9763	75.0	0.8802
25.0	0.9715	80.0	0.8677
30.0	0.9656	85.0	0.8529
35.0	0.9592	90.0	0.8413
40.0	0.9515	95.0	0.8268
45.0	0.9442	100.0	0.8117
50.0	0.9345		

As the change in density of water is only 2 parts in 10,000 per degree at this temperature, the change of

¹ "The Testing of Glass Volumetric Apparatus," U. S. Bureau of Standards, Reprint 92 (1908), 566.

0.1° is without effect on the values as given in Table IV.

Fig. 10 shows specific gravity at 20° C. plotted against percentage composition.

DISCUSSION OF RESULTS

When a pure substance is frozen and allowed to warm gradually the continuous curve MN, Curve I in Fig. 7, is obtained, depending upon the specific heat of the solid. At the melting point N, the solid begins to melt and melting continues along the line NO without increase of temperature until the solid phase entirely disappears. A break in the curve now occurs and the temperature increases along OP as uniformly as the rate of heating. Curve I shows this phenomenon with pure water. If the solution

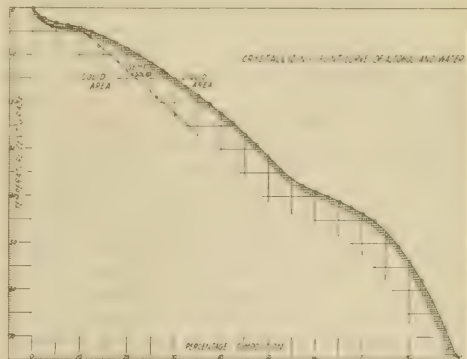


FIG. 9

of denatured alcohol in water, Curve II, is frozen and heated gradually, a continuous curve M'N' obtains until the melting point is reached. Continued addition of heat to the system changes the solid phase

to the liquid along the line N'O', which constantly dilutes the mixture with a consequent rise of the melting point. At O' the solid phase has entirely disappeared, a break occurs, heat is again uniformly absorbed and the temperature rises, dependent upon the specific heat of the resulting mixture and the supply of heat. By observing the curve for pure water, I, and for 4 per cent denatured alcohol in water, it is evident that the addition of the latter has changed the slope of the curve slightly. It is still comparatively flat but there is a retrogression from the curve of pure water. The slope of the curve has increased between the eutectic point and the point of disappearance of the last trace of the solid phase. As the concentration is still further increased, the deviation becomes more marked until at the maximum concentration the once flat portion of the curve has been made to approach a point. As the solid phase disappears the solution becomes more dilute, or richer in A and poorer in B, and the melting point is accordingly raised. The concentration of the liquid phase is the determining factor in controlling the melting point of the solid which is disappearing.

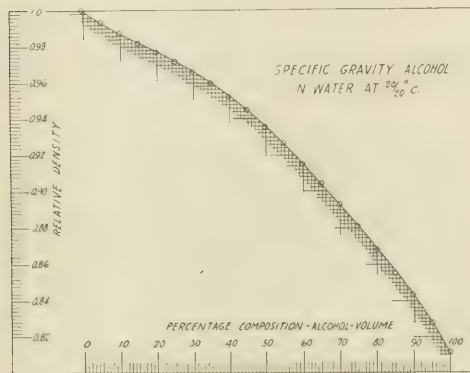


FIG. 10

In Curve I it is obvious that the change from liquid to solid, or *vice versa*, is very rapid, *i. e.*, is an isothermal function.

In the increased concentrations, Curves III, IV, V, VI, VII, etc., it is equally obvious that the change from liquid to solid, or *vice versa*, is rather slow, the degree of slowness depending upon the concentration. This is an important point, for the change from one phase to the other gives a safety margin for utilization of these mixtures where mobility is desired. The surface included between the two curves on Fig. 9 represents the "zone of safety," where solid and liquid phases co-exist. That point on the upper curve at any concentration represents the point at which crystallization starts and similarly on the lower curve the point at which liquid and solid cease to co-exist. In other words, below the lower curve mobility is no longer obtainable. It is evident from the aforementioned curves that the "zone of safety" is very narrow in low concentrations and tends to increase very ma-

terially with increasing concentration. In high concentrations it is absolutely impossible to freeze the mixture rigidly under any conditions imposed by nature herself. In the melting-point curve for 70 per cent denatured alcohol note the absence of the break in the lower part of the curve where solidification ordinarily takes place.

SUMMARY

I—The details for the accurate measurement of low temperatures have been set forth.

II—The temperature at the point of crystallization has been determined for various concentrations of denatured alcohol-water mixtures.

III—Likewise the temperatures at the point of solidification have been determined for a number of concentrations. A "zone of safety" has been proclaimed for several concentrations.

IV—It is possible to determine the exact concentration of denatured alcohol in water which will resist freezing at any temperature.

V—The specific gravities of 20 different concentrations of denatured alcohol in water have been determined at 20°C.

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DISINFECTION WITH FORMALDEHYDE THE PRACTICAL EFFICIENCY OF SOME SUBSTITUTES FOR THE PERMANGANATE-FORMALIN METHOD

By M. A. POZEN AND L. V. DIETER

Received September 24, 1918

Since the outbreak of the war with the resulting increase in the cost of permanganate several substitutes have been suggested to replace it for generating formaldehyde and water vapor from formalin in disinfection after contagious and infectious diseases. Among the substitutes proposed are sodium dichromate,¹ barium peroxide,² chlorinated lime,³ sodium chlorate,⁴ and lime.⁵

The purpose of this investigation was to determine on a practical scale the relative efficiencies of the proposed methods and to consider also their comparative economy.

Attention was also directed to the degree of manipulation required by the different methods, as this is a factor to be considered in routine disinfection.

Following are the quantities of reagents recommended for each 1000 cu. ft. of space:

DICHROMATE METHOD

Sodium dichromate.....	10 oz. avoirdupois (283.5 g.)
Formalin.....	1 pt. (480 mls)
Sulfuric acid (commercial).....	1½ fluid oz. (45 mls)
Glycerin.....	1½ fluid oz. (45 mls)

BARIUM PEROXIDE METHOD

Barium peroxide (technical, not less than 78 per cent BaO).....	1½ lbs. (680 g.)
Formalin.....	1 pt. (480 mls)

¹ S. G. Dixon, *J. Am. Med. Assoc.*, **64** (1915), 459.

² R. P. Crandall, *U. S. Naval Med. Bull.*, **11** (1917), 519-20.

³ D. W. Horn, *Am. J. Pub. Health*, **8** (1918), 161. Horn states he devised method in 1915.

⁴ C. G. Storm, *This Journal*, **10** (1918), 123.

⁵ Suggested by Dr. J. J. Kinyoun.

CHLORINATED LIME METHOD¹

Chlorinated lime.....	1 1/2 lbs. (620 g.)
Formalin.....	17 1/2 pts. (800 mls)

CHLORINATED LIME METHOD²

Chlorinated lime.....	5 1/2 lb. (378 g.)
Formalin.....	1 pt. (480 mls)

SODIUM CHLORATE METHOD

Sodium chlorate (technical).....	6 oz. avoirdupois (170 g.)
Formalin.....	1 pt. (480 mls)

LIME METHOD

Crushed lime.....	1 1/2 lbs. (680 g.)
Formalin.....	1 1/2 pts. (605 mls)
Sulfuric acid (commercial).....	2 fluid oz. (60 mls)
Magnesium sulfate.....	1 1/4 oz. avoirdupois (50 g.)

Enough permanganate was available for one test, using for each 1000 cu. ft.

PERMANGANATE METHOD

Potassium permanganate.....	1/2 lb. (240 g.)
Formalin.....	1 pt. (480 mls)

LABORATORY EXPERIMENTS

Before using the methods in practice, they were tried on a laboratory scale. The reagents were brought together in 1000 mil beakers in the proportions recommended and the character of the reaction was noted.

The results of the observations appear in Table I.

TABLE I

METHOD	PERMANGANATE	DICHROMATE	BARIUM PEROXIDE	CHLORINATED LIME	SODIUM CHLORATE	LIME
Reaction begins....	At once	At once	At once	At once	At temperature of 60-65° C.	At once
Character of reaction.....	Violent	Violent	Very violent	Very violent	Very violent	Brisk
Reaction completed.....	In about 5 min.	In about 5 min	In 2-3 min.	In about 3 min.	In 30-45 sec.	In 3-8 min.
Maximum temperature noted.....	97.5° C.	97.5° C.	97° C.	102° C.	110° C.	96° C.
Condition of residue.....	Practically dry in 24 hrs.	Practically dry in 3 hrs.	Practically dry in 1 1/2 hr.	Moist after 24 hrs.	Practically dry in 3 min	Moist after 24 hrs.
Odor of residue.....	H.CO.H odor after 24 hrs.	H.CO.H odor after 24 hrs.	No odor after 3 hrs.	No H.CO.H odor after 3 hrs.	Practically no odor after 1/2 hr.	H.CO.H odor after 24 hrs.

TESTS ON PRACTICAL SCALE

For this purpose two rooms were used having capacities of 1740 cu. ft. (Room 1) and 1680 cu. ft. (Room 2), respectively. Each room had a window, 3 doors, the usual woodwork, papered walls, and a glass transom through which a view into the room could be had at all times. Articles of clothing and books were placed in various parts of each room. Cultures were placed in a manner to be described later. Before beginning a test all windows, doors, keyholes, cracks, and transoms were carefully sealed with adhesive strips, only the exit door being left unsealed. The reagents were brought together in a 2 gal. bucket placed in a shallow pan in the center of the room, exit was made, and the exit door sealed from without. The room was unsealed the following morning and ventilated for at least 24 hrs. between tests. Condensation was noted on the glass transoms in about 3 min. after the reaction had begun in each case.

CHEMICAL EXAMINATION OF THE AIR—For the chemical examination of the air 10 liter samples were drawn, using an apparatus similar to that employed by Base³ for the determination of formaldehyde in air. Base used potassium cyanide solution to absorb the gas, whereas ammonia-free distilled water was used in these experiments. The air was drawn through a

glass tube 3 1/2 ft. long to the end of which was attached a funnel. The tube was fitted by means of a rubber stopper into a specially bored hole in one door of each room. A tight joint was made and the protruding end of the tube was connected to the first of a series of 5 absorption tubes. After drawing a sample, the tubes were disconnected and the formaldehyde determined by the cyanide method.¹ The tube entering the room was sealed by means of a screw clamp. All joints were tested for leaks.

An interval of 10 min. was allowed between the completion of the reaction, as determined by laboratory trials, and the beginning of the drawing of the samples.

The formalin used in all these experiments was from the same lot and assayed 39.91 per cent by weight formaldehyde, by the Pharmacopoeial method.

The results of these analyses appear in Table II.²

BACTERIOLOGICAL—Envelopes containing mixed cultures of *B. coli*, *Staphylococcus aureus*, and *B. pyocyaneus* were placed in various parts of the rooms during each test and were permitted to remain in the sealed rooms over night. The cultures were placed between the leaves of books, in the pockets of articles of clothing, at or near the ceiling at opposite sides

of the room, on the floor in corners of the room, over transoms, in center of the rooms near the ceiling, and on window sills.

TABLE II

METHOD	Room No	Volume of Sample Liters	Time to Draw Sample	Temperature of Room ° F.	H.CO.H in 10 Liters Gram	H.CO.H per Cu. Ft. Gram
Permanganate.....	1	10	1 hr. 30 min.	74.3	0.0078	0.0221
Dichromate.....	1	10	1 hr. 11 min	83.3	0.0036	0.0102
	2	10	1 hr. 3 min.	81.5	0.0036	0.0102
Barium Peroxide.....	1	10	1 hr. 15 min.	82.4	0.0060	0.0170
	2	5	35 min	81.5	0.0048	0.0136
Chlorinated Lime.....	1	10	1 hr. 4 min	79.7	0.0054(a)	0.0153
	2	10	1 hr. 8 min	75.2	0.0072(b)	0.0204
Sodium Chlorate.....	1	10	1 hr. 7 min	77.9	0.0048	0.0136
	2	10	1 hr. 3 min.	74.3	0.0048	0.0136
Lime.....	1	10	1 hr. 2 min	73.4	0.0024	0.0068
	2	10	1 hr. 9 min	75.2	0.0024	0.0068

(a) Modified formula

(b) Horn's formula.

After unsealing the rooms the culture envelopes were removed to the laboratory, the cultures contained therein were inoculated into tubes of sterile bouillon and incubated for 24 hrs. at 37° C. Control cultures were similarly inoculated and incubated. At the end of 24 hrs. an examination was made to determine whether growth had taken place. The results are summarized in Table III, growth being indicated by + and no growth by —.

¹ Sutton, "Volumetric Analysis," 10th Ed., pp. 391-392

² These figures represent, of course, the excess of formaldehyde in the air of the room over that which had condensed on the walls and objects. in the room and that lost by leakage.

³ As recommended by Horn.

⁴ Modified formula.

⁵ J. Am. Chem. Soc., 28 (1906), 964-96.

TABLE III

LOCATION OF CULTURE	Potassiumate Method	Dichromate Method	Barium Peroxide Method	Chlorinated Lime Method	Sodium Chlorate Method	Lime Method
Room 1						
On window sill	—	—	—	—	—	—
Transom	—	—	—	—	—	—
Ceiling, center of room	—	—	—	—	—	—
Corner on floor	—	—	—	—	—	—
Corner on floor	—	—	—	—	—	—
Corner on floor	—	—	—	—	—	—
Trouser pocket, in closet	—	—	—	—	—	—
In book, corner on floor	—	—	—	—	—	—
Room 2						
On window sill	—	—	—	—	—	—
Near ceiling, over door	—	—	—	—	—	—
Near ceiling, over door	—	—	—	—	—	—
Ceiling, center of room	—	—	—	—	—	—
Corner on floor	—	—	—	—	—	—
Corner on floor	—	—	—	—	—	—
Corner on floor	—	—	—	—	—	—
Trouser pocket, on door	—	—	—	—	—	—
Coat pocket, in closet	—	—	—	—	—	—
Book, corner on floor	—	—	—	—	—	—

1 Room 1 disinfected by modified formula; Room 2 by Horn's formula.

Too much significance should not be attached to the fact that in some instances cultures placed between the leaves of books were not killed, as the disinfection of books by this method presents certain difficulties which must be considered. The presence of living organisms in any of the envelopes otherwise placed is significant, as it indicates that the method is not efficient for practical disinfection.

RELATIVE EFFICIENCY—This is based not on the germicidal activity of the formaldehyde generated by each method from an equal volume of formalin, but on the practical bactericidal efficiency of each method as recommended by the originators or proponents thereof.

Horn¹ states that 250 g. permanganate with 500 mls formalin yield about 75 g. formaldehyde gas and that in order to get this same weight of formaldehyde gas about 3 times as much sodium dichromate, sulfuric acid, glycerin, and formalin as recommended for 1000 cu. ft. by the Pennsylvania Department of Health must be used. He recommends his original formula to liberate 75 g. formaldehyde gas. In one of our experiments we reduced Horn's formula to the basis of 1 pt. (480 mls) formalin to each 1000 cu. ft., and in spite of the reduction in the amount of formaldehyde gas generated it was efficient as a germicidal agent.

It is interesting to note that while by no other method is the excess of formaldehyde in the air of the room quite as great as that yielded by the permanganate method, yet from a bactericidal standpoint, the barium peroxide, chlorinated lime (either formula), and the sodium chlorate methods are all equally as efficient and as reliable as the permanganate method. The dichromate method is probably as effective, while the lime method is decidedly inefficient and unreliable.²

MANIPULATION—This factor must be considered because the laborers who do the practical disinfecting may not take the requisite care to insure efficient

¹ Loc. cit.

² Bolten, *Pharm. Weekblad*, 55 (1918), 60-1; *Chem. Abs.*, 13 (1918), 1225, states that the lime method is not only as efficient, but has the advantage of not oxidizing H₂COH in 20 per cent solution as does KMnO₄. The formula recommended to us, however, gave decidedly unsatisfactory results.

disinfection. For that reason the simplest efficient method should be chosen. From the standpoint of simplicity of manipulation the permanganate, barium peroxide, and chlorinated lime methods are ideal. In either case all that is necessary is to add the measured volume of formalin to the weighed solid reagent contained in a bucket or jar. The only error possible here is in weighing, measuring, or calculating the amounts of reagents to be used. The dichromate method requires the mixing of the formalin with sulfuric acid and glycerin, while the lime method requires that the magnesium sulfate be dissolved in the mixture of formalin and sulfuric acid. Carelessness, haste, or indifference in the preparation of the solution may affect the results. The relatively large bulk of lime used in the lime method is so great that unless the contents of the bucket are thoroughly stirred before sealing the room there is danger that the formalin will not come in contact with all of the lime and the reaction will not run to completion in 24 hrs.

The sodium chlorate-formalin mixture must be placed in a weighted bucket and immersed in a pan or basin of boiling water. The danger here is that the water will not be heated to a high enough temperature or that not enough water will be used to heat the mixture up to the reaction temperature (60-65° C.). In either case the room would be sealed and the reaction would not take place.

RELATIVE ECONOMY—According to current prices (July 1, 1918) the relative economy of the different methods is as follows:

METHOD	Cost to disinfect 1000 cu. ft.
Permanganate	\$2.41
Barium Peroxide	0.88
Dichromate	0.48
Chlorinated Lime (Horn's formula)	0.43
Sodium Chlorate	0.29
Chlorinated Lime (modified formula)	0.28
Lime	0.24

POSSIBLE OBJECTIONS TO THE BLEACH-FORMALIN METHOD—Hamilton,¹ referring to various methods for generating formaldehyde gas from formalin, says: "When lime is used * * * the lime water slowly but almost completely destroys the aldehyde, forming inert decomposition compounds. The same is true of caustic soda * * *. It is also essentially true if calcium hypochlorite is so employed.

"A prompt and more or less violent reaction occurs when a 40 per cent aqueous solution of formaldehyde is mixed with any one of the above named reagents, but careful experiments failed to reveal effective quantities of formaldehyde among the evolved gases.

"The method employed to determine the amount evolved was essentially that described by Frankforter.²

* * * Chlorinated lime * * * appeared to evolve only chlorine compounds, no formaldehyde gas being detected in the aqueous solution collected."

The portions of Hamilton's statements referring to chlorinated lime are not at all in accord with our observations. Even in experiments on the laboratory scale when the concentrations of formalin and chloro-

¹ "Facts and Fallacies in Disinfection," *Am. J. Pub. Health*, 7 (1917), 283.

² *J. Am. Chem. Soc.*, 28 (1906), 1234.

rated lime used were about 1/300 of those used in the room tests, the amount of formaldehyde gas evolved was so great that it was impossible to remain in the laboratory until it had been thoroughly ventilated. Qualitative tests for formaldehyde in the aqueous absorbing liquid from laboratory tests gave positive reactions for formaldehyde with Leach's, Hehner's, the resorcinol, and the phenylhydrazine hydrochloride tests. The bacterial results also indicate that Hamilton's statement is not correct. Horn states¹ that "Hamilton's experiments were faulty in that the expelled formaldehyde gas was redissolved in the water condensed on the upper, cool walls of the Frankforter and West apparatus, and, thus dissolved, was returned to the now hot oxidizing agent. Naturally, under these conditions, an aldehyde would be destroyed."

Another objection investigated was the possible bleaching or fading of colored fabrics and the tarnishing of metals exposed in rooms disinfected by this method. Horn¹ states that no bleaching action on moist litmus paper and no tarnishing of metals or bleaching of colored fabrics have been reported by health officers who have used this method without complaint. In our experiments wool, cotton, silk, velvet, and cheap printed calico were exposed in the rooms disinfected over 24-hr. periods. The colors included blues, yellow, pinks, greens, orange, gold, black, etc. No general bleaching or fading effect was noted except in one test in which all the fabrics were moistened with water. In the tests conducted under practical conditions only the cheap cotton fabrics showed signs of fading. It was found, however, that such fading occurred when other oxidizing agents were used to liberate the formaldehyde gas.

Gold, silver, copper, brass, and nickel-plated ware were found to be slightly tarnished on exposure to bleach-formalin disinfection over 24-hr. periods. The tarnishing is entirely superficial and we do not consider this a valid objection to the use of this method as the thin film may easily be removed by polishing the metallic surface with a soft cloth. The extent of the tarnishing is apparently no greater than that which occurs in homes under ordinary conditions.

SUMMARY

I—The relative practical efficiencies of several substitutes for the permanganate-formalin method of disinfection have been studied in comparison with the permanganate method.

II—The barium peroxide, sodium chlorate, and chlorinated lime methods are all as efficient as the permanganate method.

III—The barium peroxide and the chlorinated lime methods involve the simplest manipulation.

IV—The relative economy of the different methods is given.

V—Possible objections to the chlorinated lime method are considered.

VI—The chlorinated lime method is recommended for routine disinfection as combining germicidal efficiency, economy, and simplicity of manipulation.

¹ Personal communication to the senior author.

CONCLUSION

As a result of this brief study we are inclined to recommend the chlorinated lime-formalin method (either formula) as the most practical method, of those studied, for routine disinfection of rooms.

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THE PHOSPHORUS, POTASSIUM, AND NITROGEN CONTENT OF THE WATERS OF THE INTER- MOUNTAIN REGION

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In a preceding paper¹ we have shown that the irrigation waters of the intermountain regions vary greatly, both qualitatively and quantitatively, in their content of injurious soluble salts, many of them carrying sufficient toxic salts to the soil to render it in a few years sterile. Little, however, has been done to determine the influence of irrigation waters on the fertility of the soil. It is certain that irrigation waters may either increase or decrease the plant food of the soil, depending upon the composition of the water and the quantity used. The fact that many western irrigated soils are extremely fertile even after long periods of continuous cropping raises the question: is it not at least occasionally the case that the quantity of plant nutrients carried to a soil by water greatly exceeds that removed by the drainage waters? This work was planned with the hope that it would throw some light on this subject.

During the years 1916-17 the chemical department of the Utah Agricultural College collected several hundred samples of water representing 58 streams, the majority of which are extensively used for irrigation purposes. From the majority of the streams monthly samples were taken during the irrigation season. These were collected according to standard methods in carefully cleaned containers and shipped to the laboratory where composite samples were made and these analyzed by standard methods for total phosphorus, potassium, and nitrogen.

POTASSIUM

The water from 67 streams, 4 drains, and 3 wells was analyzed for total potassium. Although these do not represent all the irrigation systems of the state of Utah, the distribution of the streams is such that we are fairly safe in taking them as representative. Hence the results indicate fairly accurately the potassium content of the water of the intermountain regions. The results as reported in Table I represent the total potassium in parts per million and pounds per acre-foot of water. Each reported result is the average of two or more closely agreeing determinations.

These waters vary in potassium content from 49 p. p. m. in the case of the drain at St. George to 0.79 p. p. m. in Mill Creek. Only 14 out of the 71 samples

¹ THIS JOURNAL, 10 (1918), 1001.

TABLE I—TOTAL POTASSIUM IN WATERS FROM THE FOLLOWING STREAMS

STREAM	Sampled at	Parts per Million	Pounds per Acre-Foot
Green River.....	S. George.....	49.00	133.3
White River.....	Green River.....	28.30	68.3
White River.....	Stage Road Crossing.....	21.62	58.7
Blue Creek.....	Howell.....	19.82	53.9
Heaver.....	W. Milford.....	17.36	47.2
Beaver.....	Milford.....	17.24	46.9
Drain (Logan Land & Drainage Co.).....		16.18	44.0
Jordan.....	Narrows.....	16.00	43.3
Uinta.....		14.81	40.3
Utah Lake.....	Pumping Plant.....	14.81	40.3
Ray's well.....	West Meadows.....	14.32	38.9
Spring River.....	Corinne.....	12.48	32.0
Spanish Fork.....		11.78	32.0
U. S. Reclamation Service Canal.....		10.29	28.0
Lake Fork.....		9.23	25.1
Cedar Creek.....		8.59	23.4
Drain.....	June Ogden's farm.....	7.66	20.8
Sevier.....	Sigurd Bridge.....	7.27	19.8
Little Bear.....	Mendon (Logan Road).....	7.17	19.3
Sevier.....	Delta.....	7.16	19.3
Bingham Creek.....	Grace Ranch.....	7.14	19.4
Beaver.....	Minersville.....	7.01	19.1
Indian Creek.....	Richfield City.....	6.48	18.4
Red Creek.....		6.76	18.4
Indian Creek.....		6.71	18.2
Price River.....	Price.....	6.37	17.3
Seepage water.....		6.24	17.0
Duchesne.....	Cedar City.....	6.24	17.0
Rock Creek.....	Randlett.....	6.08	16.5
Summit.....		5.86	15.9
Strawberry.....	N. Summit.....	5.69	15.3
Weber River.....		5.02	13.7
Drain.....	Riverdale.....	4.94	13.4
Perron.....	F. B. Stevens.....	4.75	12.9
Herriman Tr. Ditch.....		4.74	12.9
Cottonwood.....		4.50	12.2
Spring Creek.....	Orangeville.....	4.46	12.1
Ogden.....	Mendon (Logan Road).....	3.99	10.9
Clear Creek.....	Mouth of Canyon.....	3.99	10.9
Santa Clara.....	Sevier Station.....	3.76	10.2
Hobble Creek.....		3.60	9.8
A. Robinson's well.....		3.42	9.3
Paragonah.....	S. W. Filmore.....	3.32	9.3
Beaver.....	East of town.....	3.40	9.2
Santa Clara Creek.....	City power plant.....	3.25	8.8
Ashley Creek.....	Santa Clara (Road).....	3.23	8.8
Salt Creek.....	Vernal.....	3.20	8.7
Duchesne.....	Nephi.....	3.06	8.3
Parawan Creek.....	Tabby.....	2.96	8.1
Emigration Creek.....		2.80	8.0
B. Tompkins's well.....	W. Filmore.....	2.84	7.7
Spanish Fork.....	Thistle.....	2.74	7.5
North Creek.....	N. of Wm. Twitchell's.....	2.71	7.4
Provo.....	Olinstead.....	2.64	7.2
Irrigation ditch.....	Buhl.....	2.52	6.9
Duchesne.....	Duchesne.....	2.51	6.9
Huntington Creek.....		2.49	6.8
Haw's Bush well.....	Huntington.....	2.22	6.0
Cottonwood.....	N. W. Filmore.....	2.12	5.8
Cub River.....		1.93	5.4
Parley's Creek.....	Franklin.....	1.93	5.3
Boxelder.....	Brigham.....	1.64	4.5
Dray Creek Co.....		1.61	4.4
American Fork.....	Crescent Ditch.....	1.37	3.8
Emery Canal.....	American Fork.....	1.29	3.5
Rasmussen well.....		1.25	3.4
North Creek.....	Santaquin.....	1.13	3.1
Logan River.....	W. Filmore.....	1.08	3.0
Mill Creek.....	Stamp mill.....	0.92	2.5
	State dam.....	0.80	2.2
		0.79	2.2

TABLE II—TOTAL PHOSPHORUS IN WATERS FROM THE FOLLOWING STREAMS

STREAM	Sampled at	Parts per Million	Pounds per Acre-Foot
Green River.....	Green River.....	5.47	14.9
White River.....	Stage Road.....	4.24	11.5
U. S. Reclamation Service		3.97	10.8
Spanish Fork.....		3.20	8.7
Rasmussen well.....	W. Filmore.....	2.04	5.5
Beaver River.....	Milford.....	1.22	3.3
Uinta River.....		1.07	2.9
Cedar Creek.....		0.90	2.5
Duchesne.....	Randlett.....	0.83	2.3
Drain (Logan Land & Drainage Co.).....		0.76	2.1
Summit Creek.....	N. Summit.....	0.72	2.0
Lake Fork.....		0.72	2.0
Price River.....		0.60	1.6
Strawberry.....		0.60	1.6
Sevier.....	Delta.....	0.59	1.6
Ferron.....	Ferron.....	0.58	1.6
Cottonwood.....		0.54	1.5
Beaver.....	W. Milford.....	0.48	1.3
Duchesne.....	Tabby.....	0.46	1.3
Beaver.....	City power plant.....	0.40	1.1
Santa Clara.....	W. Town.....	0.38	1.0
Drain.....	Graysville Reservoir.....	0.32	0.9
Drain (June Ogden's farm s. w. Cedar City).....		0.28	0.8
Hobble Creek.....	Clear Creek.....	0.26	0.7
Bear River.....	Sevier Station.....	0.26	0.7
Spring Creek.....	Santa Clara.....	0.26	0.7
Drain.....	St. George.....	0.25	0.7
Indian Creek.....		0.25	0.7
North Creek.....		0.24	0.7
Blue Creek.....	Corinne.....	0.24	0.7
Summit.....	F. B. Stevens's farm.....	0.24	0.7
Ashley Creek.....		0.23	0.60
Paragonah Creek.....	Stamp mill.....	0.22	0.60
A. Robinson's wells.....	Howell.....	0.22	0.60
American Fork.....	Santaquin.....	0.20	0.54
Salt Creek.....	Vernal.....	0.20	0.54
Spanish Fork.....	East of town.....	0.20	0.54
Strawberry Reservoir.....	W. Filmore.....	0.20	0.54
Red Creek.....	American Fork.....	0.18	0.49
Weber River.....	Nephi.....	0.17	0.46
Riverdale.....	Thistle.....	0.16	0.44
Cub River.....		0.16	0.44
Bingham Creek.....		0.16	0.44
Parawan Creek.....	Grace Ranch.....	0.16	0.44
Beaver.....	Franklin.....	0.16	0.44
Well (Haw's Bush).....	Cedar City.....	0.13	0.35
Drain.....		0.13	0.35
Seepage Water.....	Creek bed 6 mi. s. w. Cedar City.....	0.12	0.33
Dry fork.....	Crescent Ditch.....	0.12	0.33
B. Tompkinson's well.....	Filmore.....	0.12	0.33
North Creek.....	N. of Wm. Twitchell's.....	0.12	0.33
Emery Canal.....	Near Emery.....	0.11	0.30
Little Bear.....	Mendon (Logan Road).....	0.11	0.30
Emigration Creek.....	Canyon.....	0.10	0.27
Rock Creek.....		0.10	0.27
Utah Lake.....	Pumping plant.....	0.10	0.27
Ray's well.....	West Meadow.....	0.10	0.27
Boxelder.....	Brigham.....	0.08	0.22
Maple Creek.....		0.08	0.22
Huntington Creek.....	Huntington.....	0.08	0.22
Provo.....	Olinstead.....	0.07	0.19
Parley's Creek.....	East of town.....	0.06	0.16
Jordan.....	Narrows.....	0.04	0.11
Logan River.....	State dam.....	0.02	0.05
Duchesne.....	Duchesne.....	0.00	0.00
Ogden.....		0.00	0.00
Sevier.....	Mouth of canyon.....	0.00	0.00
	Sigurd Bridge.....	0.00	0.00

analyzed contained over 10 p. p. m.; 31 contained over 5 p. p. m. Hence we find slightly over half of the waters analyzed containing less than 5 p. p. m. of total potassium. The importance of these results becomes more obvious when we examine the pounds of potassium carried to an acre of soil by one acre-foot of water. This varies from 133.3 lbs. to 2.2 lbs. It may be taken from these results that considerably more potassium is being carried from the soil by the drainage water than is being stored by the irrigation water, but this conclusion is not warranted by the facts in the case, for unfortunately we have no analysis of the waters which are being applied to the soils in these drainage areas and all the soils where the drainage is in operation which were analyzed are high in alkali salts. Hence the results cannot be taken to indicate a great loss of potassium from a normal agricultural soil. It is quite likely that where the application of

water does not exceed 2 acre-feet per year the whole of the potassium is left in the soil within reach of the plant roots, for we have found that with the use of this quantity of water there is but little loss of the readily soluble nitrates for the soil.¹

Although the extreme variation in the potassium content makes an average of little value, yet it is interesting to note that the average pounds per acre-foot of water for the streams is 16.7 lbs., for the drains 51.8, and for the wells 15.4 lbs.

Some of these values are not without economic significance, for the potassium in one acre-foot of the water from Green River is sufficient for the production of 362 bu. of corn, 265 bu. of wheat, or 9 tons of sugar beets. That of Logan River, however, is sufficient for the production of only 12 bu. of corn, 9 bu. of wheat, or 15 lbs. of sugar beets. The average potas-

sium content of the streams is sufficient for the production of 98 bushels of corn, 64 bu. of wheat, or 1.2 tons of sugar beets. The actual significance of these results is apparent when we remember that about 2 acre-feet of water must be applied for the production of maximum crops.

PHOSPHORUS

Many of the soils of the intermountain region are rich in potassium, hence this element is not as important as is the phosphorus, which although used by the crop in smaller quantities, is nevertheless at times the limiting factor in crop production.

TABLE III—TOTAL NITROGEN IN WATERS FROM THE FOLLOWING STREAMS

STREAM	Sampled at	Parts per Million	Pounds per Acre-Foot
U. S. Reclamation Service Canal		24.3	66.1
Spanish Fork		15.9	43.2
Paragonah	East of town	14.50	39.4
Green River	Green River	12.46	33.9
Beaver River	Millford	5.67	15.4
Duchesne	Tabby	5.60	15.2
Summit	N. Summit	5.54	15.1
Summit	Santaquin	4.62	12.6
Cedar Creek		4.06	11.0
Red Creek		4.00	10.9
Ferron		3.22	10.7
Strawberry	Duchesne	3.22	8.76
Santa Clara	Santa Clara	3.08	8.38
Lake Fork		3.08	8.38
Beaver	Minersville	2.94	8.00
American Fork		2.80	7.62
Price	Price	2.80	7.62
Cottonwood	Orangville	2.66	7.23
Beaver	City power plant	2.66	7.23
Little Bear	Mendon (Logan Road)	2.58	7.02
Provo	Olinstead	2.40	6.53
Santa Clara	West of town	2.38	6.47
Cub River	Franklin	2.33	6.34
Uinta		2.24	6.09
Bingham Creek		2.24	6.09
Sevier	Siguard Bridge	2.10	5.71
Big Cottonwood		2.04	5.55
Salt Creek	Nephi	1.96	5.33
Indian Creek		1.96	5.33
Rock Creek		1.78	4.84
Emery Canal		1.54	4.19
Clear Creek	Sevier Station	1.40	3.81
Sevier	Delta	1.12	3.05
Weber	Riverdale	0.98	2.61
Duchesne	Duchesne	0.98	2.66
North Creek	N. of Wm. Twitchell's	0.98	2.66
Parley's Creek	Canyon	0.98	2.66
Huntington Creek	Huntington	0.70	1.90
Parawan		0.56	1.52
Jordan	Narrows	0.56	1.52
Emigration		0.56	1.52
Little Cottonwood			
Mill Creek			
Ogden River			
Spring Creek			

The total phosphorus of these waters varies from zero to 5.47 p. p. m. Of all the samples analyzed there were only 4 in which the quantity of phosphorus present was within experimental error. The great majority of them, however, contain less than one p. p. m. There were only 7 in which the quantity exceeded this amount. It is interesting to note that Green River, which is the highest in potassium, is also the highest in phosphorus. The quantity added to the soil by one acre-foot of water by Green River, White River, U. S. Reclamation Service Canal, and Spanish Fork is significant and would be sufficient to increase the phosphorus content of the soil. The average in

one acre-foot of water from the streams is 1.73 lbs., for the wells 1.68 lbs., and for the drains 0.91 lb.

The phosphorus in 2 acre-feet of the water from Green River is sufficient for the production of 175 bu. of corn, 120 bu. of wheat, or 33 tons of sugar beets. In the case of all the other streams, while not as high, it undoubtedly plays a part in maintaining the phosphorus content of irrigated soils.

NITROGEN

Even more important than the phosphorus is the nitrogen content, for nitrogen is the limiting factor of crop production in most of the soil of the intermountain region.

The average results stated as parts per million and pounds per acre-foot of total nitrogen contained in the various waters are given in Table III.

The quantity of total nitrogen in these waters varies greatly, ranging all the way from traces up to 24.3 p. p. m. Four streams, Little Cottonwood, Mill Creek, Ogden River, and Spring Creek contained only traces. Eight others contained less than one p. p. m., whereas 4 contained over 4 p. p. m. The pounds per acre-foot of water in 11 streams is over 10 with a maximum of 66.1 lbs. in the water of the U. S. Reclamation Service Canal. This would be sufficient nitrogen for the production of 66 bu. of corn, 46 bu. of wheat, or 12 tons of sugar beets. The average quantity of total nitrogen in one acre-foot of water from the streams is 11.4 lbs.

TOTAL SALTS

It is not those streams which are high in valuable nitrates which are high in total alkali salts as may be seen from Table IV.

Only three of the streams, Beaver, Jordan, and Bear Rivers, appear both in the column of total soluble salts and of total phosphorus; only two, Beaver and Lake Fork, appear both in the column of total salts and of total potassium; and only one, Beaver River, appears both in the column of total salts and of total nitrogen; whereas seven out of the ten appear both in the column of total potassium and of phosphorus.

SUMMARY

The results herein reported represent determinations made of the potassium, phosphorus, and nitrogen of the main irrigation waters of the intermountain region. The quantity of potassium carried to the soil by one acre-foot of water varies from 2.2 to 133.8 lbs., the phosphorus from zero to 14.9 lbs., and the nitrogen from traces to 66.1 lbs.

Although only a few of the waters analyzed were carrying sufficient phosphorus, potassium, and nitrogen to the soil to supply plants with the necessary

TABLE IV—TOTAL SALTS, POTASSIUM, PHOSPHORUS, AND NITROGEN IN THE TEN BIGGEST STREAMS ANALYZED

TOTAL SALTS		TOTAL POTASSIUM		TOTAL PHOSPHORUS		TOTAL NITROGEN	
P. p. m.		P. p. m.		P. p. m.		P. p. m.	
Emery Creek	1498.6	Green River	25.3	Green River	5.47	U. S. Reclamation Service Canal	24.3
Sevier	1259.8	White River	21.6	White River	4.24	Spanish Fork	15.9
Price River	1210.3	Blue Creek	19.8	U. S. Reclamation Service Canal	3.97	Paragonah	14.5
Bingham Creek	939.7	Beaver	17.4	Spanish Fork	3.20	Green River	12.46
Borer River	909.3	Jordan	16.0	Beaver River	1.22	Beaver River	5.67
Jordan River	838.9	Uinta	14.8	Uinta	1.07	Duchesne	5.60
Bear River	842.0	Utah Lake	14.8	Cedar Creek	0.90	Summit	5.54
Utah Lake	834.8	Bear River	13.5	Duchesne	0.83	Summit	4.62
Huntington Creek	792.9	U. S. Reclamation Service Canal	10.3	Summit Creek	0.72	Cedar Creek	4.06
Sevier River	772.5	Lake Fork	9.2	Lake Fork	0.72	Red Creek	4.00

quantities of the respective elements yet it is evident in a number of cases that the quantity of plant food carried to a soil by the irrigation water is sufficient to assist in maintaining the fertility, for it is quite certain that where the waters are rationally used the quantity of potassium, phosphorus, or nitrogen carried to the soil exceeds that removed in the drain waters.

UTAH AGRICULTURAL COLLEGE
LOGAN, UTAH

A NEW YELLOW DYE AND LIGHT FILTERS MADE FROM IT

By C. E. K. MEES AND H. T. CLARKE

Received January 2, 1919

In the early days of orthochromatic photography the dye generally used for the preparation of light filters was picric acid, this having the advantage of simplicity and cheapness and of great efficiency, picric acid absorbing the ultraviolet almost completely, and having a very sharp cut in the spectrum. The disadvantage of picric acid, however, is that it is unstable to light, filters made with it soon turning brown. For this reason the early gelatin filters were made chiefly with tartrazine, which is very stable and gives permanent filters. Tartrazine, however, has the disadvantage that its absorption in the ultraviolet is unsatisfactory and even moderately deep tartrazine filters transmit appreciable amounts of ultraviolet, thus detracting very much from their efficiency. For this reason filter yellow, introduced by Hoechst in 1907, rapidly displaced tartrazine as the best dye for filter making and has held that position ever since.

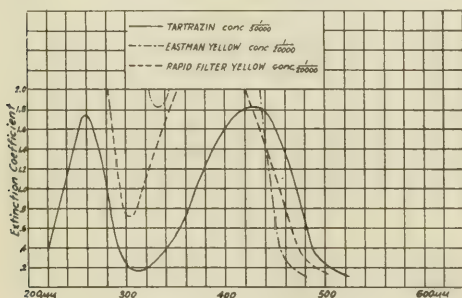


FIG. 1

Filter yellow is extremely stable, absorbs the ultraviolet strongly with the exception of a transmission band at 300μ , which, since it is absorbed by glass, is of little importance, and has a satisfactorily sharp cut for the preparation of orthochromatic filters. A disadvantage of filter yellow, which has always been recognized, however, is the fact that its absorption curve is less sharp than that of picric acid, and for many purposes, especially the preparation of very light filters, a dye possessing the stability and ultraviolet absorption of filter yellow but of greater sharpness of cut would be desirable.

When the need arose for light filters of high efficiency for aerial photography the necessity for such a dye

became pressing, and we undertook a search for such a material. After a great number of trials it was found that suitable absorption and stability were possessed by the phenylglucosazones.

When certain sugars, such as glucose, are warmed with a solution of phenylhydrazine in dilute acetic acid, yellow precipitates are produced possessing definite crystalline structures, by which the sugars may be characterized. These yellow substances are known as osazones, those formed with phenylhydrazine being termed phenylosazones. On measurement of the absorption spectrum of glucose phenylosazone it was found that the absorption curve was very sharp and extended far into the ultraviolet, and since the material is known to be stable, it appeared that a dye prepared from it would possess the properties required for the preparation of light yellow filters.

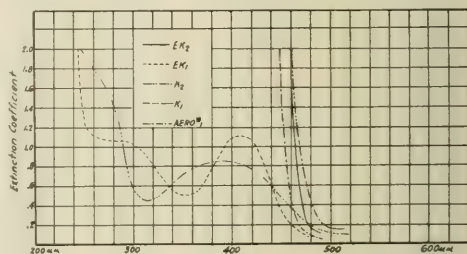


FIG. 2

Glucose phenylosazone is insoluble in water so that to obtain a dye it is necessary to have a salt-forming group present in the molecule, and to produce a dye suitable for use with gelatin, it is desirable that this group should be an acid one. To obtain such a derivative of glucose phenylosazone which will form salts with metals, it is merely necessary to substitute for phenylhydrazine a derivative containing an acid group, and condense glucose with it in the same manner. Several such derivatives were tried and the most satisfactory result was obtained with glucose phenylosazone-*p*-carboxylic acid. This was prepared in the following way:

p-Nitrotoluene was oxidized to give *p*-nitrobenzoic acid. This was then reduced to *p*-aminobenzoic acid, which was diazotized and gave *p*-hydrazinobenzoic acid or phenylhydrazine-*p*-carboxylic acid. The glucosazone of this acid is a yellow crystalline compound insoluble in water and almost insoluble in alcohol. It forms a sodium salt which is extremely soluble in water but which can be precipitated from concentrated solutions by the addition of alcohol, and this sodium salt of glucose phenylosazone-*p*-carboxylic acid has been adopted by us for the preparation of light filters under the name of "Eastman Yellow."

In Fig. 1 are shown the absorption spectra of tartrazine, filter yellow, and Eastman yellow, from which it will be seen that the Eastman yellow has a sharper cut than filter yellow and as strong an absorption in the ultraviolet.

Light filters prepared from it retain these characteristics, and these light filters have been prepared

and specified under the names of EK-1 and EK-2 light filters. A special filter for aerial photography has been adopted by the American forces under the name of Aéro No. 1.

Fig. 2 shows the absorption curves of these light filters.

As regards stability, it was found on test that the new dye was not quite so stable to light as filter yellow but was superior to all other yellow dyes tried and its stability is amply sufficient for the preparation of light filters since it requires weeks of exposure to direct sunlight to produce a change even in the lighter colored filters.

RESEARCH LABORATORY
EASTMAN KODAK COMPANY
ROCHESTER, N. Y.

PARA CYMENE. II—THE UTILIZATION OF CYMENE FOR THE PREPARATION OF PHOTOGRAPHIC DEVELOPERS¹

By HERBERT A. LUBS

Received February 24, 1919

For some time this laboratory has been engaged in a study of cymene and its derivatives with the idea not only of preparing new derivatives of cymene, but also improving the methods of preparation of those already known and the development of their possible commercial application.

Two of the more extensively used photographic developers are *p*-aminophenol and quinol (hydroquinone). Similar substances can be prepared from cymene, and are described in the literature, but their commercial applications in photography have apparently not been investigated. Both *p*-aminocarvacrol and thymoquinol can be obtained from carvacrol. The preparation of *p*-aminocarvacrol is relatively simple and a fairly good yield is secured.

The patent recently granted to McKee² on the preparation of carvacrol from cymene seems to make possible the development of an abundant source of supply of this phenol, which hitherto was prepared only in small amounts.

The process of McKee³ involves the sulfonation of cymene and a subsequent alkaline fusion of the sulfonic acid. The preparation of a phenol on a small laboratory scale by such a method is usually not very satisfactory because of the poor yield from the alkaline fusion. The writer has found that a yield of 85 to 90 per cent of carvacrol can be obtained by diazotizing aminocymene, dropping the cold diazo solution into dilute sulfuric acid and simultaneously steam-distilling. This is a very satisfactory laboratory method for the preparation of carvacrol. The 2-aminocymene can be obtained in good yields by a method described in the first paper on *p*-cymene.

p-AMINOCARVACROL

Tests of this compound showed it to be a very promising photographic developer.⁴ Comparisons of

¹ "Para Cymene. I—Nitration, Mononitrocymene," THIS JOURNAL, 10 (1918), 453.

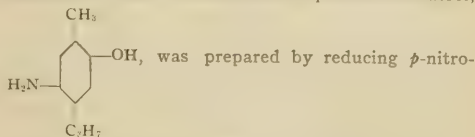
² U. S. Patent 1,265,800, May 14, 1918.

³ THIS JOURNAL, 10 (1918), 982.

⁴ Tests were made by H. A. Piper of the Science and Research Department, Bureau of Aircraft Production, since the photographic research of that organization was handled in this laboratory.

monomethyl *p*-aminophenol (commercially known as metol), *p*-aminophenol, and *p*-aminocresol with *p*-aminocarvacrol were so favorable to the last-named as to warrant a detailed investigation of its properties. The preliminary results indicate that *p*-aminocarvacrol is more satisfactory than *p*-aminophenol, but not quite so good as *p*-aminocresol or "metol," so far as lasting quality of the bath is concerned, but equally good with respect to quality of tones secured in the finished prints.

METHOD OF PREPARATION—*p*-Aminocarvacrol,



socarvacrol by means of ammonium sulfide. For the laboratory preparation of *p*-nitrosocarvacrol the method of Klages¹ is quite satisfactory. The following description is essentially the procedure of Klages, with slight modifications.

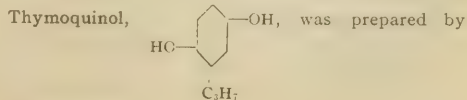
Ten grams of carvacrol are dissolved in 40 g. of alcohol, saturated with hydrochloric acid gas at 0°. To the cooled solution add an aqueous solution of 5 g. of sodium nitrite in 10 cc. of water. Before addition, the nitrite solution is diluted with an equal volume of alcohol. In a few minutes the solution becomes a pasty mass. This is dilute with water, filtered, and washed. The crude nitrosocarvacrol thus obtained is not further purified but used in this form.

REDUCTION—The crude nitrosocarvacrol is dissolved in about 10 times its weight of 10 per cent ammonia and filtered from the tar. A rapid stream of hydrogen sulfide is passed into the ammoniacal solution and the aminocarvacrol is precipitated as practically colorless leaves. The solution is then cooled and filtered, the precipitate dried with suction, washed with cold water, and dried in a vacuum desiccator over sulfuric acid. In case it is necessary, the aminocarvacrol can be recrystallized by boiling with hot water to which animal charcoal has been added, filtering and cooling the solution.

To prepare the hydrochloride, which is much more soluble in water than the free base, the aminocarvacrol is suspended in a small amount of water and about the theoretical amount of hydrochloric acid added. The solution is heated and filtered while hot. To the hot solution concentrated hydrochloric acid is added until a precipitate begins to form. When the crystallization is completed by cooling the solution, the hydrochloride is removed by filtration, and dried *in vacuo* at 75°.

From 10 g. of carvacrol about 5 g. of aminocarvacrol in quite a pure condition were usually obtained.

CH₃



¹ Ber., 32 (1889), 1518.

sulfonating carvacrol and oxidizing the sulfonic acid by means of potassium bichromate. The quinone thus produced was reduced by means of sulfur dioxide. The yields were very poor and since this compound, from preliminary determination, shows no advantage over ordinary quinol, work along this line was not further prosecuted.

p-Aminothymol was also prepared, but this base did not seem to be so satisfactory a developer as the corresponding carvacrol derivative. One disadvantage is the relatively low solubility of the free base in water.

SUMMARY

p-Aminocarvacrol is a very satisfactory photographic developer, and its preparation and use for such a purpose would furnish a means of using a portion of the large amount of *p*-cymene which is not being utilized at present.

COLOR LABORATORY
BUREAU OF CHEMISTRY
WASHINGTON, D. C.

A METHOD FOR THE PURIFICATION OF CERTAIN AZO DYES

By HERBERT A. LUBS
Received February 24, 1919

In the preparation of the direct cotton dyes of the benzidine group, the dye is usually precipitated from the solution by means of sodium chloride. The method is also used in the case of certain acid wool dyes. As a result of this procedure, commercial specimens of such dyes contain varying amounts of inert inorganic material. For certain pharmacological investigations it was desired to obtain a dye of this sort as free from salt as possible.

The method was originally developed for the purification of brilliant Congo R. In order to test the general applicability of the method, Congo red, brilliant orange R, cotton dyes, and azorubin, an acid wool color, were investigated.

Because of the simplicity of the method as developed and its possible use to those who wish to prepare dyes of this type free from inorganic and certain organic impurities, a brief description of the procedure used is given.

PURIFICATION OF DYES

Fifty grams of crude brilliant Congo R, No. 370,¹ are dissolved in 100 cc. of distilled water and filtered. The solution is heated to boiling and solid sodium acetate added until the dye is practically completely precipitated. This requires about 350 g. of the solid sodium acetate. The precipitate is sucked as dry as possible on a Büchner funnel, and then boiled with 250 cc. of 95 per cent alcohol. The suspended dye is then removed from the alcohol by filtration. The digestion with alcohol is repeated several times. A comparatively small amount of dye is dissolved by the alcohol.

One gram of crude dried material gave 32.7 per cent sulfated ash
One gram of purified dried material gave 25.9 per cent sulfated ash
Calculated as sodium, this corresponds to 8.4 per cent. Theory for sodium is 8.4 per cent

¹ The number refers to Schultz, "Farbstofftabellen." Weidmannsche Buchhandlung, 1914.

Azorubin and Congo red were also purified by this method, and the following figures are given to indicate the extent to which the impurities are removed.

AZORUBIN No. 163

One gram of crude dried dye gave 48.3 per cent sulfated ash
One gram of purified dried dye gave 26.8 per cent sodium sulfate
Sodium found, 8.8 per cent. Theory for sodium is 9.2 per cent

CONGO RED No. 307

One gram of crude dried material gave 50.6 per cent sulfated ash
One gram purified dried material gave 21.4 per cent sodium sulfate
Calculated as sodium, this corresponds to 6.9 per cent. Theory for sodium is 6.6 per cent

Besides removing inorganic impurities, the procedure described also removes certain organic impurities usually present in commercial dyes of this type. This fact is of special importance when the compound is to be used for pharmacological purposes.

For those dyes which cannot be purified by other simpler procedures, this method is of general application if the sodium salts can be precipitated from aqueous solution by sodium acetate and if they are relatively insoluble in hot 95 per cent alcohol. The amounts of sodium acetate and of alcohol to be used naturally vary with each dye.

In the case of those dyes which cannot be satisfactorily separated from the solution by filtration, centrifugalization should be of great assistance in securing a pure product.

COLOR LABORATORY
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INTERMEDIATES USED IN THE PREPARATION OF PHOTSENSITIZING DYES. I—QUINOLINE BASES

By L. A. MIKESKA, J. K. STEWART AND LOUIS E. WISE
Received February 24, 1919

A recent article¹ from this laboratory outlined briefly the methods of preparation of a number of photosensitizing dyes and dye intermediates. Since then we have made a thorough study of the best conditions for the synthesis of intermediates required in the preparation of pinaverdol, pinacyanol and dicyanin, the three most important photosensitizing dyes. The methods of preparation are described in this and in the following paper.

The four bases required in the preparation of these dyes are quinoline, quinaldine, *p*-toluquinoline, and 2,4-dimethylquinoline. All of these are well-known organic compounds, whose syntheses are recorded in the patent and chemical literature. The most important of these may be briefly reviewed. The Skraup synthesis of quinoline is so well known that it requires no further description. Hitherto the most satisfactory synthesis of quinaldine (or toluquinoline) has been that of Döbner and Miller,² which depends upon the condensation of paraldehyde with aniline (or toluidine) hydrochloride, and which is quite similar to the process described in D. R. P. 24317 (1882). 2,4-Dimethylquinaldine is usually prepared by Beyers's³ method, in which ethylidene acetone (prepared from acetone, paraldehyde, and hydrogen

¹ Wise and Adams, THIS JOURNAL, 10 (1918), 801.

² Ber., 16 (1883), 2465.


³ J. prakt. Chem., [2] 33 (1886), 401.

chloride) interacts with aniline hydrochloride. Unfortunately all of the preceding methods are cumbersome and time-consuming, and in certain cases the purification of the bases is difficult and the yields are disappointing.

Since our problem involved the production of the pure bases on a fairly large laboratory scale, the above methods were carefully studied and gradually simplified. After performing a large number of orientating experiments, we succeeded in modifying each method in turn so that the products could be obtained far more expeditiously than by the older methods without materially decreasing their yield. In all cases the tedious steam distillations, which made the older methods so burdensome, have been dispensed with. In many cases extraction has been resorted to in place of distillation. In the purification of toluquinaldine and quinaldine certain precautions have been adopted which appear to materially improve the quality of the product.

The procedures which up to the present have proved most satisfactory in our hands are given in detail in the following experimental part:

EXPERIMENTAL

QUINALDINE, —Two hundred grams


of aniline are added gradually to 400 g. concentrated hydrochloric acid, and the solution cooled. A mixture of 120 g. nitrobenzene and 300 g. paraldehyde is then slowly poured into the acid solution, which is constantly agitated during the addition. The reaction is exothermic, and the temperature must be controlled so as not to rise above 60° C. If this precaution is neglected, resinification may occur and the subsequent yield may be decreased. After the mixture has been well shaken, it is heated for 1 hr. in a water bath. Further heating causes excessive tar formation. The excess of nitrobenzene and certain other impurities should be immediately removed by extracting the heavy acid solution with ether (or other suitable immiscible solvents). The aqueous solution is then rendered alkaline, using a concentrated solution of crude sodium hydroxide, and controlling the temperature of the neutralization, whereupon a black oil, consisting of a mixture of quinaldine, aniline and tar, separates. (It is also probable that this oil contains some tetrahydroquinaldine which has been formed during the course of the reaction.)

The oil is extracted with ether, and the ethereal solution dried with sodium sulfate. The ether is then removed (and recovered) and the residue distilled at about 200 mm. pressure. A distillate boiling at 150–220° is thus obtained. The amount of crude oil obtained approximately equals the weight of aniline taken. Since repeated fractional distillations of this oil invariably lead to impure quinaldine, the following chemical procedure is adopted: The crude oil is dissolved in an equal weight of concentrated hydrochloric acid, and the solution cooled to 0° C.

Sodium nitrite is then added to the solution until this reagent is present in decided excess, whereupon an oil separates. (It is quite possible that this is nitroso-tetrahydroquinaldine, which would be formed at this point if tetrahydroquinaldine were present in the crude oil.) The oil is removed by extraction with ether, *precautions being taken to maintain a temperature of about 0° C.*, so as to prevent decomposition of the oil. The residual acid solution is then heated to decompose the diazonium salts, cooled, and rendered strongly alkaline with aqueous sodium hydroxide. The quinaldine which separates in the form of an oil is removed by extraction with ether. The ethereal solution is dried with sodium sulfate, the ether removed, and the residual oil fractionally distilled under ordinary pressure. The greater portion boils at 243–244° (uncorrected) and is pure quinaldine.

Calculated for $C_{10}H_9N$: N = 9.79 per cent. Found: N = 9.60 per cent, 9.64 per cent.


The yield is about 25 per cent, calculated on the basis of the aniline used. Fairly large quantities of quinaldine can thus be prepared in two days.

p-TOLUQUINALDINE, —The prep-

aration of *p*-toluquinaldine is essentially similar to that of quinaldine, with the exception that the oxidizing agent is omitted from the initial mixture and that *p*-toluidine is used in place of aniline. It is convenient to use 190 g. of *p*-toluidine, 300 g. of concentrated hydrochloric acid, and 225 g. of paraldehyde. In this case the paraldehyde may be added slowly to the *hot* acid solution of *p*-toluidine hydrochloride. The methods employed for the removal of paraldehyde, separation and diazotization of the crude oil, and the purification of *p*-toluquinaldine are identical with those described under quinaldine. *p*-Toluquinaldine is obtained in the form of large, colorless crystals melting at 55°; boiling at 266–270°; rapidly turning brown on exposure to air or light.

Calculated for $C_{11}H_{11}N$: N = 8.92 per cent. Found: N = 8.87 per cent, 8.83 per cent.

The yield varies from 40 to 45 per cent, calculated on the basis of the *p*-toluidine taken.

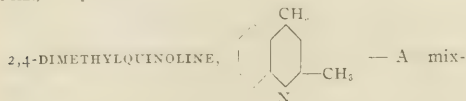
QUINOLINE, —To 72 g. of nitrobenzene,

vigorously boiling under a reflux condenser, is slowly added a mixture of 114 g. of aniline, 360 g. of glycerol, and 300 g. of concentrated sulfuric acid. The reaction carried out by this method¹ is much less violent than in the case of the Skraup synthesis. After the last portions have been added the heating is continued for 2 hrs. longer. The syrupy solution is then diluted with water, the excess of nitrobenzene removed by extraction with ether, and the aqueous mother liquor rendered alkaline. The crude oil which separates is extracted with ether, the ethereal solution dried with sodium sulfate, the ether removed, and

¹ Walter, *J. prakt. Chem.*, [2] 33 (1894), 549.

the residual oil distilled at 200 mm. pressure. Unchanged aniline remaining in the distillate is removed by diazotizing¹ in hydrochloric acid and heating the solution. The acid solution is then rendered alkaline, the supernatant quinoline extracted with ether, the ether solution dried, the ether removed, and the residual oil distilled at atmospheric pressure. Quinoline thus obtained boils at 238° (uncorrected). The yield is 65 per cent of the calculated amount, based upon the weight of aniline taken.

Calculated for C_9H_7N $N = 10.86$ per cent. Found: $N = 10.73$ per cent, 10.69 per cent.



ture of 120 g. of paraldehyde and 200 g. of acetone is saturated with dry hydrochloric acid and allowed to stand for 24 hrs., care being taken to exclude moisture. The mixture is then slowly added to 200 g. of aniline dissolved in 400 g. of hydrochloric acid, and the syrup finally heated during 1 hr. (in a water bath) under a return condenser. On rendering alkaline, a yellow oil separates from the solution. The oil is extracted with ether, and the ether evaporated. The residue, without further purification, is dissolved in an equal weight of hydrochloric acid and diazotized. Here again precautions are taken to remove nitroso compounds by extraction of the cold acid solution with ether. The aqueous solution is rendered alkaline and the yellow oil extracted with ether. The usual procedure is followed in the final purification of the 2,4-dimethylquinoline. The compound, which is obtained in 25 to 30 per cent yield, based upon the weight of aniline taken, boils at 260–264° (uncorrected) under ordinary pressure.

Calculated for $C_{11}H_9N$ $N = 8.92$ per cent. Found: $N = 8.78$ per cent, 8.73 per cent.²

The above procedure is very much simpler and far more rapid than that outlined by v. Bayer.³

COLOR LABORATORY
BUREAU OF CHEMISTRY
WASHINGTON, D. C.

INTERMEDIATES USED IN THE PREPARATION OF PHOTSENSITIZING DYES. II—QUATERNARY HALIDES

By CARL H. LUND AND LOUIS E. WISE
Received February 24, 1919

The second step in the synthesis of photosensitizing dyes is the formation of quaternary iodides from the bases described in the preceding paper. These compounds result from the direct addition of methyl, ethyl or other alkyl iodide to the quinoline base. Many of these addition products have been described in the literature, but there is too little available information on the best conditions for the preparation of these compounds.

¹ No special precautions are necessary. Tetrahydroquinoline is not present.

² Our thanks are due to Messrs. Jenkins and Ellis, of the Nitrogen Laboratory of the Bureau of Chemistry, for the analytical data given in this paper.

³ *Loc. cit.*

We therefore undertook a systematic study of the synthesis of the quaternary iodides with a view to establishing the simplest conditions which would give satisfactory yields of the pure compounds. Our many experiments need not be described in detail. After carrying out the addition reaction under varying conditions—in pressure flasks, in flasks under reflux condensers, with and without the use of various solvents, and with varying amounts of the components—we find that it is best to use equimolecular amounts of the alkyl iodide and the base and to carry out the reaction in a round bottom flask surmounted by a worm condenser. The flask should never be filled beyond one-third¹ of its capacity.

Depending on the nature of the base used, the reaction may proceed spontaneously and violently (as in the case of quinoline methiodide) or it may require external heating (as in the case of quinaldine ethiodide). The presence of an α -methyl group in the molecule appears to decrease the rate of reaction.

The product is usually obtained in the form of a solid cake, which may be gradually dissolved by treatment with hot alcohol. The iodide crystallizes from the alcoholic solution on cooling. In general, the yields of the quaternary halide are satisfactory, varying from 60 to 80 per cent of the theoretical. We have found, however, that small amounts of impurities in the reagents may decrease these yields very materially.

All the quaternary halides are crystalline compounds of a more or less pronounced yellow color. Many of them melt with decomposition. All of them are water-soluble and ionize in solution. The iodine content of any quaternary base may be rapidly and accurately determined by a slight modification of the Volhard method. This method served a useful purpose in permitting us to judge the purity of our products.

From the standpoint of the producer of photosensitizing dyes the following quaternary halides are perhaps the most important: quinoline methiodide and ethiodide, quinaldine ethiodide, toluquinaldine methiodide, and 2,4-dimethylquinoline ethiodide. We have prepared relatively large amounts of these compounds and small amounts of a few other analogous iodides, all of which are described in the experimental part.

EXPERIMENTAL

QUINOLINE METHIODIDE—When small amounts of this product—less than 100 g.—are required, the following procedure is convenient: Equimolecular amounts of methyl iodide and quinoline are mixed in a round bottom flask, and allowed to stand at room temperature under a reflux condenser. The mixture gradually becomes warm and crystals begin to appear in the flask. Since the reaction is exothermic, the mixture finally reaches a temperature at which the methyl-iodide boils vigorously. When this point is reached the flask must be cooled in an ice bath to keep the reaction from proceeding too violently. After a

¹ This simple precaution is necessary. Well-annealed flasks filled half full frequently cracked during the course of the reaction.

yellow cake of the methiodide has formed, the flask is immersed in a hot water bath and heated for several hours to insure a complete reaction. The solid cake in the flask is then covered with 95 per cent alcohol and the heating continued until the methiodide has dissolved. On cooling and stirring, a crop of small, bright yellow crystals is obtained which are shown to be quinoline methiodide, monohydrate, $C_9H_7CH_2I \cdot H_2O$. In the recrystallization of the crude methiodide it is necessary to use enough 95 per cent alcohol to insure the presence of sufficient water to form this monohydrate, otherwise a mixture of the monohydrate and anhydrous methiodide (melting 90° to 120°) is obtained and recrystallization is required. The monohydrate melts at 70° to 71° (uncorrected). The melting point recorded by Marckwald and Meyer¹ is 72° . The yield varies from 70 to 80 per cent of the theoretical.

Calculated for $C_9H_7CH_2I \cdot H_2O$: I = 43.91 per cent. Found: I = 43.93 per cent.

By allowing the monohydrate to stand for several days over sulfuric acid *in vacuo*, complete dehydration takes place. The melting point of the dehydrated compound is 131° to 133° (uncorrected). Marckwald and Meyer² give 133° as the melting point of the anhydrous compound.

Calculated for $C_9H_7N \cdot CH_2I$: I = 46.82 per cent. Found: I = 46.66 per cent.

In the preparation of larger amounts of quinoline methiodide, it is expedient to modify the above method since it becomes almost impossible to control the reaction by cooling with an ice bath (as described). The following modification is used: Methyl iodide is heated to boiling in a flask connected by means of a two-hole stopper, with a reflux worm condenser and with a dropping funnel. The source of heat is then removed and the quinoline added through the dropping funnel at such a rate that moderate refluxing of methyl iodide is maintained. After all the quinoline has been added, the mixture is allowed to cool. From this point on the procedure is identical with that outlined above.

QUINOLINE ETHIODIDE—The procedure is very similar to that used in the formation of the methiodide. In this case initial heating on the steam bath is required to start the reaction after the components have been mixed. The reaction then proceeds with such violence that the flask must be removed from the bath and rapidly cooled. The crude cake is recrystallized from 95 per cent alcohol, and anhydrous quinoline ethiodide is obtained in the form of bright yellow crystals melting at 155° to 157° (uncorrected). Miethe and Book³ give a melting point of 156° to 157° . The yield varies from 75 to 85 per cent of the theoretical.

Calculated for $C_9H_7N \cdot C_2H_5I$: I = 44.53 per cent. Found: I = 44.35 per cent.

QUINALDINE METHIODIDE—Only small quantities of this compound were prepared and we have made no systematic study of the conditions for obtaining the best yields. The methiodide on recrystallization

from 95 per cent alcohol is obtained in the form of lemon-colored needles which melt at 190° (uncorrected). Döbner and Miller¹ give a melting point of 195° .

Calculated for $C_{10}H_9N \cdot CH_2I$: I = 44.54 per cent. Found: I = 44.40 per cent.

QUINALDINE ETHIODIDE—Equimolecular amounts of quinaldine and ethyl iodide are mixed in a flask which is then connected with a reflux condenser. The mixture is heated on a steam bath for 18 to 20 hrs. The crude cake thus obtained is then heated under a reflux condenser with just enough 95 per cent alcohol to cause complete solution. (This requires about 8 parts by weight of alcohol to 1 part of the crude ethiodide.) On cooling, the alcoholic solution deposits quinaldine ethiodide in the form of coarse, straw-colored or brown needles, decomposing at 231° to 234° (uncorrected). Miethe and Book² who previously prepared this compound give the melting point as 234° – 235° .

Calculated for $C_{10}H_9N \cdot C_2H_5I$: I = 42.44 per cent. Found: I = 42.30 per cent, 42.20 per cent.

The yield of ethiodide was 70 to 80 per cent of the theoretical. When the alcoholic mother liquors from the first crop of crystals are concentrated to one-tenth of their initial volume, a second crop of the ethiodide is obtained. This represents only about 5 per cent of the theoretical yield, and the crystals are so impure that they require further purification.

The procedure outlined above proved very satisfactory, and we found no difficulty in preparing several kilograms of the ethiodide by this method.

Attempts to shorten the procedure met with little success. When the initial time of heating on the steam bath was decreased to 10 hrs., the reaction did not go to completion, and yield of ethiodide was materially decreased. Similarly no advantage was gained by carrying out the reaction at a higher temperature (150°). In this case we also obtained a 70 to 80 per cent yield.

p-TOLUQUINALDINE METHIODIDE—Equimolecular amounts of p-toluquinaldine and methyl iodide are heated together under a reflux condenser for several hours. The crude cake is recrystallized from 95 per cent alcohol. The ethiodide is obtained in the form of fine, pale yellow, fluffy needles, decomposing at 246° – 247° (uncorrected). Möller³ gives the melting point as 236° – 237° . The compound was dried at 120° before it was analyzed.

Calculated for $C_{11}H_{11}N \cdot MeI$: I = 42.44 per cent. Found: I = 42.14 per cent, 41.94 per cent.

The yield obtained varies from 65 to 75 per cent of the calculated amount.

p-TOLUQUINALDINE ETHIODIDE—Equimolecular quantities of p-toluquinaldine and ethyl iodide are heated together on the steam bath under a reflux condenser for about 18 hrs. The resulting solid cake is recrystallized from alcohol in the usual manner. The ethiodide forms granular, yellow crystals decomposing at 213° – 216° (uncorrected). The yield varies from 65 to 70 per cent of the theoretical. Bing,⁴ who previously

¹ Ber., 16 (1883), 2468.

² Loc. cit.

³ Ann., 242 (1887), 311.

⁴ "Ueber einige neue Isocyanine u. deren Einwirkung auf Bromsilbergelatine," Techn. Studien, 2 (1914), 12.

¹ Ber., 33 (1900), 1884.

² Loc. cit.

³ Ber., 37 (1904), 2009.

prepared this compound, obtained a 34 per cent yield of the ethiodide, which melted at 217° .

Calculated for $C_{17}H_{15}N_2RI$: I = 40.54 per cent. Found: I = 40.08 per cent.

2,4-DIMETHYLQUINOLINE ETHIODIDE—A mixture of equimolecular parts of 2,4-dimethylquinoline and ethyl iodide is permitted to stand at room temperature over night and then heated under reflux condenser on steam bath for 5 to 6 hrs. The product, when recrystallized from alcohol, yields granular, yellow crystals, m. p. $223-225^{\circ}$ (uncorrected). Beyer¹ gives the melting point as 214° . The yield is about 50 per cent of the theoretical.

Calculated for $C_{17}H_{15}N_2EI$: I = 40.54 per cent. Found: I = 40.17 per cent.

DETERMINATION OF IODINE—The analytical procedure for the determination of iodine in quaternary bases is as follows: A weighed sample (about 0.3 g.) of the iodide is transferred to a 500 cc. heavy walled bottle (provided with a ground-in glass stopper). The halide is dissolved in 200 cc. of water, and 5 cc. of 50 per cent nitric acid (free from halogens and oxides of nitrogen) are added to the mixture. A standardized 0.05 *N* silver nitrate solution is then gradually run into the mixture, which is vigorously shaken after the addition of each 5 cc. of the solution. When an excess of silver nitrate is present 3 cc. of a saturated ferric-ammonium alum solution (indicator) are added and the mixture is again thoroughly shaken. The precipitated silver halide need not be removed by filtration. The excess of silver nitrate is then titrated with 0.07 *N* ammonium thiocyanate solution. The first permanent (salmon) pink coloration in the solution marks the end-point of the titration. The percentage of iodine is calculated by the usual method.

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SYNTHESIS OF PHOTOSENSITIZING DYES²

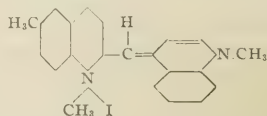
PINAVERDOL AND PINACYANOL

By LOUIS E. WISE, ELLIOT Q. ADAMS, J. K. STEWART AND CARL H. LUND
Received February 24, 1919

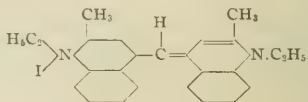
The photosensitizing dyes that have gained the ascendancy in panchromatic plate manufacture are two derivatives of quinoline, termed, "pinaverdol" and "pinacyanol" by the German dye manufacturers. Since 1916, these dyes have also been produced by British manufacturing chemists under the names "sensitol green" and "sensitol red," respectively. We have made more than fifteen dyes of this general type.³ A study of their absorption spectra, together with the results of photosensitizing experiments carried out under the direction of Drs. Merrill and Burns, of the Bureau of Standards, and by Mr. H. A. Piper, of the Chemical Section of the Science and Research Department of Aircraft Production, has

shown the identity with the above-named German and British products of two of our dyes, which we have termed, respectively, "Pv. I" and "Pc. IX."

Pinaverdol is prepared from a mixture of the methiodides¹ of toluquinaldine and quinoline by the action of alkali and air. The probable constitution² is best represented by the formula:



Pinacyanol is prepared from a mixture of the ethiodides¹ of quinaldine and quinoline, by the action of formaldehyde and alkali. The constitution of this dye is still in doubt, but from present indications it is problematical whether the quinoline ethiodide actually enters into the reaction. If it does not, the formula² of the dye becomes



When pinacyanol is treated with an excess of silver chloride under proper conditions, it is quantitatively converted into the corresponding chloride (Pc. XII). The greater solubility of this chloride renders it more suitable than pinacyanol (iodide) for use in bathing plates.

In the synthesis of these dyes we have been guided largely by the German patents³ which give good descriptions of the methods of preparation, but which fail to emphasize a few necessary precautions. The details of our own procedure for the preparation of Pv. I and Pc. IX and XII and absorption curves of the dyes are given in the following experimental part:

EXPERIMENTAL

PV. I (PINAVERDOL OR SENSITOL GREEN)—Fourteen grams of *p*-toluquinaldine methiodide and 25.8 g. of anhydrous quinoline methiodide are dissolved in 400 cc. 95 per cent alcohol. The solution is heated to boiling and 77 cc. of 0.7 *N* alcoholic potassium hydroxide (= 3.0 g. of potassium hydroxide) are gradually added from a burette. The mixture is maintained at its boiling point for 5 min. after the addition of the alkali is complete. Fifty cubic centimeters of alcohol are then added, and the crimson-colored solution is permitted to cool slowly. A blue-black, granular, crystalline mass is deposited. The crystals are filtered and dried. The weight of the crude dye is about 5.5 g. (about 25 per cent of the theoretical). The product is pulverized, the powder introduced into an extraction thimble and extracted with ether in a Soxhlet apparatus, until the extract is no longer

¹ *J. prakt. Chem.*, [2] **33** (1886), 406.

² The work on photography formerly carried on in connection with the Chemical Section of the Science and Research Department of the Bureau of Aircraft Production is now being completed by the Color Laboratory, Bureau of Chemistry, Washington, D. C.

³ Wise and Adams, *This Journal*, **10** (1918), 801.

¹ Cf. preceding article.

² The mechanism of the formation of these dyes has been discussed in an earlier communication from this Laboratory (Wise and Adams, *Loc. cit.*).

³ Pinaverdol, D. R. P. No. 167,159, Example 1 (1903); Pinacyanol, D. R. P. No. 172,118, Example 1 (1905).

colored. Ether removes an unidentified yellow substance. The extraction is then repeated using absolute methyl alcohol, until the extract shows but a slight pink coloration. Ordinarily a brick-red powder remains in the extraction thimble.

The combined methyl alcohol extracts are then concentrated gradually and the warm saturated solution is seeded with a few crystals of pure pinaverdol. On very slow cooling, Pv. I crystallizes in beautiful, metallic needles resembling brass splinters. If the solution contains impurities, is concentrated too far, or is cooled too rapidly, the dye shows a tendency to crystallize out suddenly in fine, blue-black needles. In this form the dye is less pure than that obtained on slow crystallization.

The yields of pure dye are invariably low, the highest yield being about 3 g. (13 to 14 per cent of the theoretical amount).

Calculated for $C_{24}H_{21}N_3I$: I = 28.9 per cent. Found: I = 28.95 per cent, 28.95 per cent, 29.04 per cent.

The foregoing procedure presents only a slight modification of that outlined in the German patent.¹

The following method for the preparation of Pv. I is still more convenient in that it yields a pure product without the tedious extraction with ether and methyl alcohol:

Fourteen grams of the toluquinaldine methiodide and 25.8 g. of quinoline methiodide (anhydrous) are dissolved in 400 cc. hot absolute methyl alcohol. The solution is heated to boiling in a beaker and 90 cc. of 0.53 *N* solution of sodium methylate in methyl alcohol are very gradually added to the mixture, which is then slowly evaporated to about $\frac{1}{2}$ of its initial volume. The hot solution is then transferred to an Erlenmeyer flask and seeded with a few crystals of pure Pv. I. The flask is then loosely stoppered and the solution permitted to cool very gradually. Within 24 hrs. the bottom of the flask becomes coated with the characteristic brassy crystals of Pv. I, from which the mother liquor may be decanted. The crystals can be freed from the adhering solution by washing first with methyl alcohol-ether mixtures and finally with ether alone. Further concentration of the mother liquors may yield additional small amounts of Pv. I. The total yield is about 12 per cent of the calculated amount. Spectrometer readings show that the product obtained by this method is identical with the German pinaverdol and a colorimetric comparison of the alcoholic solution of both the German pinaverdol and our product indicates that the dyes are of the same order of purity.

The following data are taken from the detailed account of the crystallographic and optical properties of Pv. I, published by Dr. Edgar T. Wherry:²

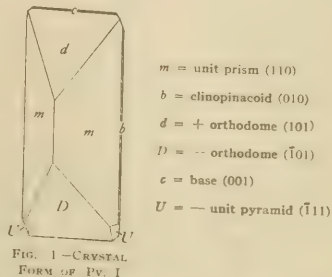
Crystal system: monoclinic, $a : b : c = 1.1014 : 1 : 1.6053$, $\beta = 88^\circ 20'$. Habit: (see Fig. 1) usually prismatic (unit prism and small clinopinacoid), terminated by large faces of the two orthodomies; frequently showing small faces of the base, negative unit pyramid and unit clinodome; and occasionally other forms.

¹ Cf. preceding article.

² J. Wash. Acad. Sci.

Metallic reflection: from faces in the prism zone, brass-yellow; from unit domes and pyramids, beetle-green; from base and faces adjacent to it, bronze-violet.

Optical properties: transparent for white light only in very thin crystals, but red light is transmitted by thicker ones. (For study by the immersion method aqueous liquids must be used.) Refractive indices only roughly determinable; for $\lambda = 0.625$, $\alpha = 1.6$, and $\gamma = 1.8$. Extinction, in the acute angle β , 5° . Pleochroism strong, violet-brown to deep greenish brown.



PC. IX (PINACYANOL OR SENSITOL RED)—A solution of 90 g. of quinaldine ethiodide and 85.5 g. of quinoline ethiodide in 3 l. of 95 per cent alcohol is heated to boiling under a reflux condenser in a large, round bottom flask. When the air in the flask has been completely displaced by alcohol vapor, a freshly prepared mixture of 90 cc. of 16 per cent (aqueous) sodium hydroxide solution and 60 cc. of formalin solution (40 per cent formaldehyde) is poured through the condenser into the flask, care being taken not to chill the reaction mixture far below its boiling point. After the addition, the color of the alcoholic solution changes rapidly from yellow to purplish blue. Six hundred cubic centimeters of hot water are then added to the mixture, which is rapidly heated to boiling and maintained at its boiling point for about 15 min. On slow cooling, a mass of lustrous blue-green needles is deposited from the solution. The product is filtered on a Buchner funnel and washed with small successive portions of ice-cold alcohol, and finally with ether. Since further concentration of the mother liquor is unprofitable, the dark red filtrate is discarded. The yields of dye obtained by the above method vary from 23 to 27 g.

Calculated for $C_{24}H_{21}N_3I$: I = 26.35 per cent

Calculated for $C_{24}H_{21}N_3I$: I = 27.14 per cent

Found: I = 26.27 per cent, 26.55 per cent

Found in a sample of British sensitol red: I = 26.7 per cent

The product is fairly soluble in hot alcohol, yielding a purplish blue solution. It is very nearly insoluble in water.

From absorption data and the results of photosensitization experiments, further purification of the dye appears to be unnecessary. Accompanying absorption curves indicate that our dye is identical with samples of the German (Hoechst) and the British (Ilford) product.

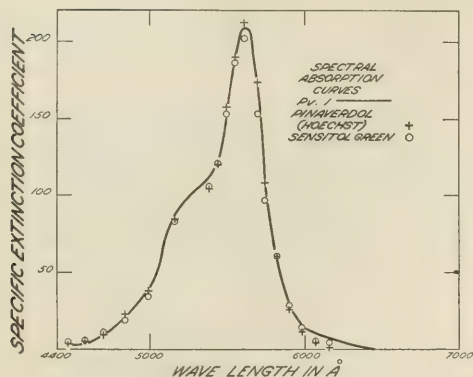


FIG. 2

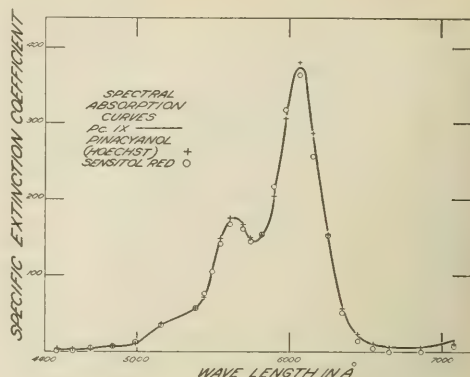


FIG. 3

The above procedure for the syntheses of Pc. IX is very satisfactory. The only precaution that need be emphasized is that air should be excluded (as far as possible) from the alcoholic solution of the ethiodides prior to the addition of the alkaline formaldehyde solution. Air, in the presence of alkali, causes the formation of red isocyanine dyes, which undoubtedly appear in the mother liquors from Pc. IX.

Although quinoline ethiodide is one of the reagents used in the above procedure, we have no direct evidence that it is involved in the reaction forming the dye. When this quaternary halide is omitted from the reaction mixture, and a corresponding weight of potassium iodide added, a dye which we have termed Pc. X is formed. This dye resembles Pc. IX very closely, and may be identical with it. In this case, however, the crude product requires further purification, and the yield is disappointing.

Pc. X is prepared as follows: A solution of 90 g. quinaldine ethiodide in 3 l. of alcohol is heated to boiling under a reflux condenser. Precautions are taken to exclude air. A mixture of 52 cc. of 13 per cent sodium hydroxide solution (=O= 45 cc. of 16 per cent sodium hydroxide solution) and 60 cc. of 40 per cent formaldehyde solution is then run into the boiling mixture, to which is subsequently added 600 cc. of an aqueous 10 per cent potassium iodide solution. The mixture is then boiled for about 20 min. On cooling, 21 g. of a greenish black crystalline product is obtained, which after two recrystallizations from 70 per cent alcohol (containing small amounts of potassium iodide) is obtained in the form of shimmering, green needles. The yield is about 8 g.

Calculated for $\text{C}_{18}\text{H}_{15}\text{N}_2\text{I}$: I = 26.35 per cent. Found: I = 26.84 per cent.

Whether or not Pc. X is identical with Pc. IX is still undetermined. Its absorption spectrum is certainly very nearly identical with that of Pc. IX, and its sensitizing power is practically the same as that of Pc. IX.

PC. XII (CHLORIDE CORRESPONDING TO PINACRYANOL).—Pc. IX may be quantitatively converted into the corresponding chloride (Pc. XII) by the following treatment: 2.41 g. (1/200 mole) of Pc. IX are dissolved

in 25 cc. of cold concentrated hydrochloric acid, and the solution is slowly poured into an Erlenmeyer flask containing 2.2 g. of freshly prepared silver chloride suspended in 25 cc. of concentrated hydrochloric acid. The mixture is shaken thoroughly for several minutes, after which 4 to 5 volumes of water are added. The solution turns blue, and a finely divided precipitate of silver chloride is formed. The latter is filtered off, and the filtrate rendered very faintly alkaline with aqueous potassium hydroxide. The treatment precipitates the dye (Pc. XII) in the form of dark blue sludge. The product is washed with water on the centrifuge until the washings are neutral to litmus, and is then filtered. Without separating it from the filter paper, the crude dye is transferred to a 300 cc. flask and extracted (under a reflux condenser) with 150 cc. of 80 per cent ethyl alcohol. The hot alcoholic solution is filtered and on cooling very slowly the dye crystallizes in the form of flat, blue-green needles which show a tendency to mat together. Careful concentration of the mother liquor yields two additional crops of the chloride. The total yield of the dye is about 1.8 g.

Calculated for $\text{C}_{18}\text{H}_{15}\text{N}_2\text{Cl}$: Cl = 9.07 per cent. Found: Cl = 8.33 per cent.

Both analysis and absorption data indicate that the compound contains water of hydration or alcohol of crystallization, but this point has not been settled.

Reports from the Bureau of Standards and from the Ansco Research Laboratories indicate that the chloride (Pc. XII), because of its solubility, possesses marked practical advantages as a photosensitizer over the corresponding iodide (Pc. IX).

ABSORPTION SPECTRA.—The spectrophotometric measurements were made with a König, Martens, and Grünbaum spectrophotometer. The dyes were studied in 95 per cent alcohol solution in a cell 1 cm. thick against a similar cell containing solvent alone. The concentrations of solution used were 0.01 g. per l. or 0.005 g. per l., according to the maximum absorbing power of the substance.

The results are given in terms of the specific extinction coefficient of the dye, that is, the numbers of liters of solution in which 1 g. of the dye should

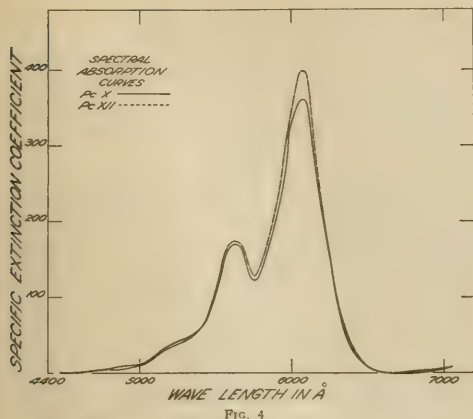


FIG. 4

be dissolved to give a solution of which a 1 cm. layer would reduce exactly 10-fold the intensity of a beam of light of the wave length in question.

In Figs. 2, 3 and 4 the absorption spectra of the dyes prepared in this laboratory are shown by the full or broken lines, those of the German and British preparations studied by crosses and circles, respectively.

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RELATION OF FLUORINE IN SOILS, PLANTS, AND ANIMALS¹

By L. A. STEINKOENIG

Received November 4, 1918

Fluorine is so generally distributed in the mineral, vegetable, and animal kingdoms that one must expect to find it in soils, the source of supply of inorganic constituents of plants and indirectly of animals. Among the fluorine-bearing minerals found in soils examined mineralogically by McCaughey and Fry² are the following: biotite, found in 21 soils out of 25 examined, tourmaline in 21, muscovite in 20, apatite in 12, fluorite in 4, and phlogopite in 1. In 8 soils biotite was found to be abundant, in one soil tourmaline, and in 6 soils muscovite. The amount of fluorine carried by these minerals³ varies as follows: biotite, trace to 4.23 per cent; tourmaline, 0.06 to 1.19 per cent; muscovite, 0.12 to 1.26 per cent; apatite, 1.31 to 3.86 per cent; fluorite, 48.9 per cent; phlogopite, 0.82 to 5.67 per cent. Fluorine is a common constituent of igneous rocks.⁴ Gautier⁵ found it to be an almost universal constituent of volcanic rocks, and Danelli⁶ found it in amounts of 3.5 to 4.88 per cent

in Palestine phosphates.¹ Charles² found fluorine in 88 out of 93 samples of mineral and sea waters tested, the amount of sodium fluoride lying between 0.005 and 0.012 g. per l. River waters examined by Gautier and Clausman³ were found to contain 0.02 to 0.6 p. p. m. Hillebrand⁴ found 5.2 p. p. m. fluorine in the water from Ojo Caliente, near Taos, N. M., and Gautier⁵ found the spring at Vichy to contain 0.435 mg. and the one at Luxiel 0.296 mg. fluorine per liter. Carnot⁶ found 0.822 g. fluorine per cu. m. of ocean water. The occurrence of fluorine in spring and stream water is a strong indication of the presence of fluorine in the soils of the region from which they draw their supply of water.

TABLE I

PLANT	Fluorine in 100 g. Fresh Substances Mg.
Grains:	
Corn meal.....	0.83
Corn bran.....	0.59
Corn meal.....	1.17
Corn bran.....	0.36
Corn meal.....	0.71
Rye meal.....	0.52
Barley meal.....	0.20
Rice.....	0.80
Legumes:	
Kidney beans.....	1.70
Lentil.....	1.56
Kidney beans (green).....	0.019
Lucern.....	1.30
Crucifers:	
Cabbage (head).....	0.088
Cauliflower.....	0.21
French turnip (root).....	0.14
Radish root.....	0.06
Cress.....	0.24
Long radish.....	1.45
Mustard seed.....	0.76
Mustard leaves.....	0.01
Fruits:	
Pear pulp.....	0.022
Apple pulp.....	0.034
Apple skin.....	0.76
Peach meat.....	0.29
Peach stone.....	0.74
Apricot meat.....	0.30
Cherry meat and skin.....	0.37
Strawberry.....	0.12
Miscellaneous:	
Potatoes.....	0.084
Tomatoes.....	0.20
Buckwheat.....	2.17
Sorrel.....	13.37
Carrots (root).....	0.036
Asparagus (young shoot).....	0.52
Spinach.....	0.37
Beet.....	1.00
Walnut.....	0.68
Hay.....	0.40
Straw of grains.....	0.94
Poplar (wood).....	0.34
Poplar (bark).....	0.34
Fir (wood).....	1.30
Pine.....	1.45
Oak (wood).....	0.59
Oak (bark).....	0.48
Birch (wood).....	1.06
Birch (bark).....	5.90
Walnut (wood).....	0.60

Woodman and Talbot⁷ found fluorine in all of a large number of samples of barley, malt, brewing sugars, ales, and beers with a standard content of 10 mg. per liter. Kickton and Behncke,⁸ in 90 per cent of the wines they examined, found fluorine in amounts too small to be considered fluorine added as a preservative. An average of 2.65 mg. of fluorine in 100

¹ Soils are largely made up of more or less disintegrated rock, and the minerals named above furnish a source of supply of inorganic compounds to the plants growing on the soils.

² *Compt. rend.*, **144** (1907), 37, 201.

³ *Ibid.*, **158**, 1389.

⁴ U. S. Geological Survey, *Bull.* **113** (1893), 114.

⁵ *Compt. rend.*, **157**, 820.

⁶ *Ann. Mines*, [9] **10** (1896), 175.

⁷ *J. Am. Chem. Soc.*, **29**, 1362.

⁸ *Chem. Abs.*, **4** (1910), 3118.

¹ Published with the permission of the Secretary of Agriculture.

² U. S. Dept. Agr., Bureau of Soils, *Bull.* **91** (1913).

³ Dana, "A System of Mineralogy," Pub. by John Wiley & Sons, Inc., 1914.

⁴ Clarke, "Data of Geochemistry," U. S. Dept. of Int., Geol. Survey, *Bull.* **618** (1916).

⁵ *Compt. rend.*, **157**, 820.

⁶ *Rend. soc. chem. ital.*, [2] **4**, 165.

g. of dried material was found by Gautier and Clausman¹ in the examination of 63 food plants. It was found more abundant in the leaves and in the skins of the fruit than in the pulp. A high phosphorus content usually went with a high fluorine content although the fluorine to phosphorus ratio was found more variable in plant than in animal tissue.² Gautier³ found fluorine to be beneficial to the growth of plants in artificial media in the majority of cases and in some cases to be of doubtful value. The content of fluorine found by Gautier and Clausman in some plants examined are given in Table I.

Seldom does the percentage of fluorine rise above 0.002 per cent and most times is under 0.001 per cent. This would place it among the rarer elements in plants and its concentration runs more nearly parallel to rubidium⁴ than any other element.

P. Charles⁵ found 2 to 4 mg. fluorine per 100 g. dried material of land mollusks and concluded that fluorine is present in all mollusks and that it is an "agent of formation and consolidation of the skeletons of all animals." Fluorine was found in the leaves⁶ of the plants on which the mollusks feed and the land mollusks were found to contain a considerably smaller amount of the element than the marine variety. G. Sontag⁷ determined that the normal content of teeth and bones of a dog is not over 0.3 per cent, but by feeding sodium fluoride to the animal it could be raised to 1.73 per cent in dried fat-free bones and 1.29 per cent in dried teeth. Gautier⁸ divides the organs of the animal body into three classes:

1—Tissues of highest vitality, such as nerve tissue, glands, muscles, lungs, etc. (with approximately 1 to 4 mg. fluorine per 100 g. dried matter) with fluorine to phosphorus ratio of 1 to 450.

2—Tissues of medium vitality such as bones, tendons, cartilage, etc. (with an average of 42 mg. fluorine per 100 g. dry substance), with a fluorine to phosphorus ratio of 1 to 125.

3—Tissues of lowest vitality and destined to be eliminated (with an average of 14 mg. fluorine per 100 g. dry substance) with a fluorine to phosphorus ratio of approximately 1 to 6. Gautier⁹ regards fluorine as the agent which fixes phosphorus in the cell to form an organic nitrogenous compound, one part serving to unite with 350 to 750 parts of phosphorus in the most vital tissues. Edarek¹⁰ found from 2.2 to 23 g. fluorine per kilogram of dried tissue in different organs of two accidentally killed men. The constant occurrence of fluorine in the living tissue of both animal and plant and its association with phosphorus is a strong indication that it plays an important rôle in the life of the cell.

In the soils examined, fluorine was determined by

Merwin's method¹ with slight modification. The method followed is here briefly outlined:

Two grams of soil are mixed with 6 g. of sodium and potassium carbonate mixture and fused carefully over the Bunsen flame. The melt is disintegrated in 250 cc. of water and manganates are reduced by a drop of alcohol. 3 g. of ammonia carbonate in solution are added to the mixture. The solution is filtered through a washed filter paper and slowly evaporated with 1 g. of ammonium carbonate to a volume of 50 cc. and filtered into a 100 cc. measuring flask. 3 cc. of 3 per cent hydrogen peroxide are added and the solution brought to slight acidity (indicated by orange color) with 1:3 sulfuric acid. 3 cc. of concentrated sulfuric acid are then added and the solution brought to room temperature by a short immersion in ice water. After bringing to volume and mixing, the solution is compared with one containing 0.01 g. oxidized titanium oxide (TiO_2) in the same volume and of the same acidity. With the standard at 100 divisions on the tube of the colorimeter, the reading of the blank (due to bleaching action by sodium sulfate) should not be much over 120. If it is, sodium and potassium carbonate containing less fluorine should be used. The difference between the test reading (with standard solution at 100 divisions) and the reading of the blank, divided by 23,000 gives the grams of fluorine in 2 g. of sample.

Duplicates on soils containing the lower amounts of fluorine, usually agreed within 0.01 per cent and those containing the higher amounts within 0.05 per cent. The average values were taken. Merwin's method is recommended by earlier authors.²

Difficulty was experienced on account of the presence of chromium in one of the samples (Cecil clay subsoil, Charlotte, N. C., $\text{Cr}_2\text{O}_3 = 0.025$ per cent). The yellow color of the chromate produced during fusion persisted and interfered with the colorimetric determination.³ In the remaining samples there was no trouble from this source. The method is not delicate enough to indicate with certainty the presence of 0.01 per cent fluorine, so as much as this may be present in places where it was reported as not found or as a trace. Results of the determination are given in the following table:⁴

TABLE II

SOIL AND LOCATION	Depth Inches	Fluorine Per cent
Norfolk sandy loam, 3 1/2 mi. east of Laurinburg, N. C.	0-8	0.01
	8-36	0.01
Hagerstown loam, Conshohocken, Pa.	0-8	0.11
	8-24	0.15
Gloucester stony loam, Marlboro, N. H.	0-8	0.02
	8-36	0.03
Cecil sandy loam, Charlotte, N. C.	0-8	0.01
	8-36	0.01
Cecil clay, Charlotte, N. C.	0-6	Not Found
	6-36	Not Tested
	0-10	0.01
Durham sandy loam, Archer, N. C.	10-36	0.02
York silt loam, Bethany, S. C.	0-10	0.05
	10-22	0.05
Louisa loam, 1 mi. northeast of Trevilians, Va.	0-10	0.01
	10-36	Trace
Penn silt loam, Norristown, Pa.	0-9	0.03
	9-24	0.02

¹ U. S. Dept. of Int., Geological Survey, *Bull.* **423** (1910), 192.

² Wagner and Ross, "A Modified Method for the Determination of Fluorine with Special Application to the Analysis of Phosphates," *TRANS JOURNAL*, **9** (1917), 1116; and Adolph, *J. Am. Chem. Soc.*, **37** (1915), 2500.

³ Chromium when present in amounts over 0.015 per cent Cr_2O_3 presents a rather difficult problem in this method as the solution has to be kept alkaline to prevent the escape of fluorine, and chromium is not easily reduced in dilute solution (to precipitate as chromium hydroxide). It might possibly be removed in a solution slightly acid with acetic acid using silver nitrate as a precipitant.

⁴ For composition of these soils with respect to other elements see U. S. Dept. Agr., *Bull.* **123**. In some cases samples of soils of the particular type could not be obtained from the same location. In these cases samples from as near this location as possible were used.

¹ *Compt. rend.*, **162** (1916), 105.

² *Ibid.*, **162** (1916), 105.

³ *Ibid.*, **160** (1915), 194.

⁴ U. S. Dept. Agr., *Bull.* **600** (1917), 9.

⁵ *J. pharm. chim.*, [6] **26**, 101.

⁶ P. Charles, *Compt. rend.*, **144**, 1240.

⁷ *Chem. Zentr.*, **1** (1916), 1095.

⁸ *Compt. rend.*, **76** (1914), 170.

⁹ *Ibid.*, **158**, 159.

¹⁰ *Z. physiol. Chem.*, **69**, 127.

Fluorine occurs in the soils examined in amounts averaging 0.03 per cent, approximately the same concentration as some of the rarer elements, namely, vanadium, zirconium, and strontium. The soils carrying with them stones made up of mica schist (Hagers-town loam, York silt loam, and Gloucester stony loam) contained the relatively higher amounts of fluorine.

SUMMARY

The original source of fluorine in the soil (average

composition 0.03 per cent fluorine) in such minerals as biotite, tourmaline, muscovite, apatite, fluorite, and phlogopite. Higher content of fluorine may be expected in soils carrying larger amounts of mica. The roots of the plants absorb it and transmit it to the animals consuming these plants. Animals also obtain fluorine from spring water.

BUREAU OF SOILS
DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

LABORATORY AND PLANT

A SCRUBBER FOR AMMONIA DISTILLATIONS

By B. S. DAVISSON

Received January 21, 1919

Two of the most glaring errors encountered in ammonia distillations are those from entrained alkali and the soft glass used in the construction of distilling bulbs and adapters. It becomes necessary to eliminate these errors when determining small amounts of nitrogen where it is of importance to determine small differences, as in plant and bacterial nutrition studies.

The error from the solubility of the soft glass can be eliminated by using apparatus made of Pyrex glass. This glass has been found to be superior to any other glass for use with weak acids and, furthermore, it does not show a tendency to become brittle on continued use.

The Hopkins bulb, which has been long in use, does not prevent alkali from passing into the receiving acid. It has been found in this laboratory that the entrained alkali can be satisfactorily removed when the vapors are scrubbed through water previous to condensation. Several scrubbers have, therefore, been constructed. The one found most suitable is made of Pyrex glass and is shown in Fig. 1. The large bulb has a capacity of 200 cc., which gives it a satisfactory condensing surface. The small bulb on the inlet tube has three openings in the same horizontal plane.

The first steam, which passes into the scrubber, condenses on the surface of the bulb and flows down about the small bulb and there acts as a scrubbing solution for the remaining vapors. As soon as the water becomes hot it is subjected to a long period of steam distillation. A period of 30 min. in which about 90 cc. of distillate are collected in the first 20 min. permits the accumulation of about 15 to 20 cc. of solution in the scrubber. This solution is, of course, neutral or slightly alkaline and the long period of steam distillation removes all the ammonia from the solution. A great many of these solutions have been tested with Nessler's at the end of the distillation and in no case was ammonia found. As soon as the distillation is finished and the flame removed, the solution is sucked back into the distilling flask.

The procedure of distillation used in this laboratory consists in steaming for 15 min. after draining the condensers, and it is desirable, although not essential, that the adapter be provided with a small

perforated bulb. This will insure better scrubbing of the steam than is accomplished with a straight tube. The adapter recommended is shown in Fig. 2.

Some data are presented here to show the errors of the distilling apparatus commonly employed for ammonia distillation and for the accuracy obtainable with the new devices attached to the tin condenser. The tin condenser used for obtaining these data had never been employed for ammonia distillations but had been used for preparing distilled water. The solutions were distilled at such a rate that about 90 cc. of distillate were collected in 20 min. The condenser was then drained and the distillation continued for 15 min. The receivers were removed, cooled, and the contents titrated. *N*/50 sulfuric acid and sodium hydroxide were used as titrimetric standards.

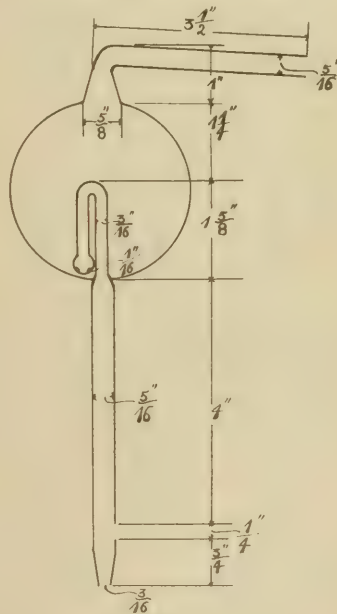


FIG. 1

The data recorded in Table I were obtained by distilling ammonia-free water, and the error shown is due to the solubility of the soft glass of the Hopkins

bulb and the adapter. The average, 0.33 cc., is equivalent to 0.09 mg. of nitrogen.

TABLE I—ERROR FROM SOLUBILITY OF SOFT GLASS

Acid Taken Cc.	Recovered Cc.	Error Cc.
25.62	24.99	-0.63
25.20	24.92	-0.28
25.07	24.74	-0.33
25.03	24.78	-0.25
25.05	24.78	-0.27

Using the same apparatus with 100 cc. of 50 per cent sodium hydroxide (ammonia-free) and 150 cc. of distilled water for each distillation, the data in Table II were obtained to show the ineffectiveness of the Hopkins bulb for preventing entrained alkali from passing into the receiving acid. The error shown

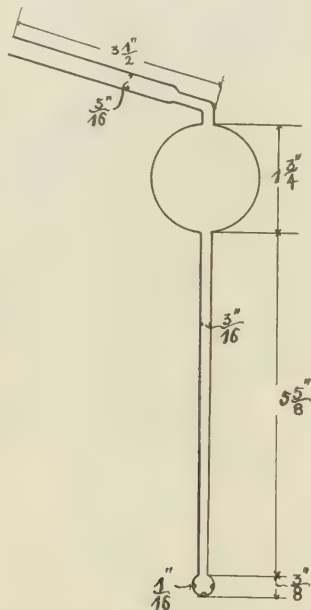


FIG. 2

here is the combined error of the soft glass and entrained alkali. The average, 0.78 cc., is equivalent to 0.216 mg. of nitrogen. This error is too large to be tolerated in any analytical work. Furthermore, it is not a constant error and cannot, therefore, be corrected for by blank distillations.

TABLE II—ERROR FROM ENTRAINED ALKALI AND SOFT GLASS

Acid Taken Cc.	Recovered Cc.	Error Cc.
25.05	24.35	-0.70
25.05	24.32	-0.73
25.30	24.39	-0.91
25.07	24.24	-0.83
25.00	24.27	-0.73

The Hopkins bulb and the adapter were then replaced by the new devices and distillations again made as above. The results are found in Table III and they show that the errors from the soft glass and entrained alkali have been eliminated by the employment of the scrubber and adapter made of Pyrex glass. The error is approximately the same as that found for

TABLE III—DISTILLATION OF DISTILLED WATER

Acid Taken Cc.	Recovered Cc.	Error Cc.
25.04	25.00	-0.04
25.03	25.05	+0.02
25.00	24.99	-0.01
25.00	24.98	-0.02
25.00	24.99	-0.01

DISTILLATION OF STRONG ALKALI

Acid Taken Cc.	Recovered Cc.	Error Cc.
25.14	25.14	-0.00
25.00	24.97	-0.03
25.00	24.97	-0.03
25.00	24.97	-0.03
25.10	25.12	+0.02

titration alone, 0.02 cc., which is equivalent to 0.005 mg. of nitrogen. To show further that no alkali passes through the scrubber, 100 cc. of ammonia-free 50 per cent sodium hydroxide and 250 cc. of distilled water were subjected to distillation and 3 portions of 80 cc. each of distillate were collected, leaving at the end of the distillation 110 cc. of strong alkali. The distillates were then boiled until free of carbon dioxide, cooled, and were found to be neutral to methyl red, less than one drop of $N/100$ sulfuric acid being sufficient to impart a distinct acid reaction to the solution. Three such distillations gave identical results.

LABORATORY OF SOIL TECHNOLOGY
OHIO AGRICULTURAL EXPERIMENT STATION
WOOSTER, OHIO

RECOVERY OF PLATINUM AND ALCOHOL FROM THE POTASH DETERMINATION

By A. E. SMOLL

Received December 16, 1918

There have been worked out several methods for the recovery of platinum used in the potash determination, but never has there been one, at least to the author's observation, for the recovery of the alcohol. At the current price of alcohol, where grain alcohol is used in the determination, it proves to be quite an item where large numbers of the potash estimations are made. It is true, however, that in some instances part of the alcohol has been redistilled, but it was found that the slight amount of acetaldehyde present had the tendency to lower the potash results on the subsequent determinations. With this thought in mind, the author has worked out a method whereby the platinum is reduced to platinum black as by the zinc and hydrochloric acid method, and with a little additional attention the alcohol is also recovered.

The alcoholic washings are saved in the usual manner until a few liters have accumulated, 5 liters or more being advisable. A 2-liter distilling flask is connected with a condenser, preferably a coil condenser, and the alcoholic washings are transferred to the flask and distilled with the usual precautions. The electric hot plate is the most reliable source of heat and will eliminate the fire risk. A small metal disk which will accommodate the bottom of the flask is partly filled with sand and the flask allowed to stand in this. If a hot plate with three heats is used it can be so regulated as to meet the demand of the operator. Small pieces of glass rod $1/4$ inch in length rounded over at each end will prevent bumping and can be easily washed free of any adhering platinum black which is reduced upon boiling of the solution.

The distillation is carried on until the boiling point of the distillate is 100° ; this will insure all the alcohol being removed. The flask is then emptied of what remains, including the bulk of the platinum black that has been reduced. Then the flask is refilled and the operation repeated until all the washings have been treated. At the end the flask is washed free of all the platinum black.

At this point the platinum has all been reduced and can be washed and treated further in its recovery as in the method where zinc and hydrochloric acid are employed.

The next procedure is the removing of the aldehyde from the alcohol, which is easily accomplished by means of fractional distillation. The flask is set up as in the first operation except that this time it is connected directly with an Allihn condenser, serving the purpose of a reflux condenser. As the aldehyde boils at about 21° and the alcohol at 78° , their separation is easily effected. Warm water should run through the Allihn condenser and should be so regulated that at the outlet the temperature is 58° . This is hot enough to allow the aldehyde to escape and at the same time condense the alcohol provided the boiling is not too vigorous.

At the top of the Allihn condenser is a delivery tube that leads to the coil condenser used in the first operation. This can be used to condense the aldehyde and what small amount of alcohol is liberated.

The distillation is carried on until the distillate from the coil condenser shows no trace of aldehyde. A simple and delicate test is made by mixing a few crystals of phenol with 5 cc. of concentrated sulfuric acid in a test tube. Three cubic centimeters of the distillate from the outlet of the condenser are caught in a test tube, one cubic centimeter of the acid mixture added and the whole shaken. If there is a trace of aldehyde a reddish brown solution will result; if not, a colorless solution will persist. The operation is continued until the alcohol is freed of all the aldehyde.

Then the alcohol is removed, the flask refilled with the alcohol containing the aldehyde, and the operation repeated until all the alcohol has been freed from the aldehyde. When the distilling is completed, if the volume of the distillate of the aldehyde mixture is sufficient, it can be re-distilled to recover alcohol liberated with the aldehyde.

Then a few pieces of sodium hydroxide are added to the distilling flask which can be connected directly with the coil condenser and the alcohol is distilled until the sp. gr. 0.8645 is obtained. This is the specific gravity of the alcohol used in the washing of the potassium chloroplatinate as given by the official methods.

The first impression may be that the operation is lengthy and requires considerable attention, but in actual use it is quite the opposite. In fact, it can be handled along with the regular laboratory work and inconvenience one very little. Last year the author recovered 40 liters of alcohol in this manner in connection with the platinum recovery and the process required only little attention. Where a large number of potash determinations have to be made, necessi-

tating in the course of time the consumption of large quantities of alcohol, it is well worth considerable effort to recover the alcohol.

CHEMICAL LABORATORY
JACOB DOLD PACKING COMPANY
WICHITA, KANSAS

A SIMPLIFIED SIGNAL DEVICE FOR THERMOMETRIC READINGS—COAL CALORIMETERS

By H. S. VASSAR

Received February 20, 1919

In a recent number of *THIS JOURNAL*¹ appeared a description by Chas. A. Myers, Jr., of a timing device used in the chemical laboratory of the New York Navy Yard for giving "warning" and "reading" signals when making calorimeter determinations.

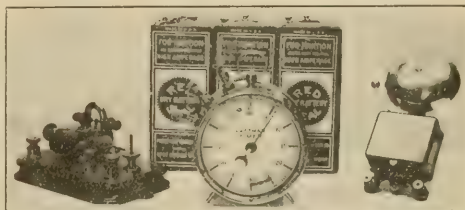


FIG. 1

In applying this equipment to a smaller laboratory where but two calorimeters are in operation certain changes have been made simplifying the equipment and giving very satisfactory results.

The apparatus used (Fig. 1) consists of one 20-ohm relay, one single stroke bell, 3 dry cells, and the same "timer" as that used by Mr. Myers, connected as shown in the accompanying sketch. Aside from the simple wiring the only labor required was that of placing the contacts on the clock and wiring them to the 3 binding posts on the clock face.

Instead of cementing platinum foil contacts to the clock face, contact pieces cut from German silver are fastened in place with small machine screws and nuts.

In installing this equipment the switches for starting and for cutting the half-minute signal "in" or "out" were mounted on the edge of the calorimeter table convenient to the operator; the relay, bell, and

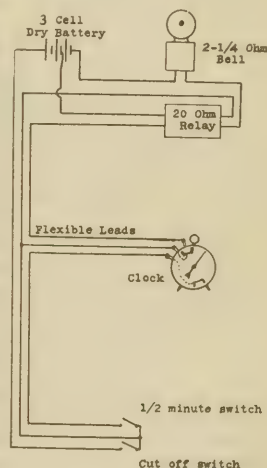


FIG. 2—TIME SIGNAL DEVICE FOR COAL CALORIMETER

battery were placed on the under side of the table, and the clock with its flexible leads at any convenient point. This leaves the calorimeter table clear.

The single signal for both "warning" and "reading" has been found perfectly satisfactory.

Attention is called to these modifications to enable small laboratories to receive the benefits of Mr. Myers' equipment with somewhat less labor in the construction of the device.

TESTING LABORATORY
PUBLIC SERVICE ELECTRIC COMPANY
NEWARK, NEW JERSEY

A DEVICE FOR REMOVING PLUGS FROM STOPCOCKS¹

By VERNON C. ALLISON

Received February 17, 1919

It is very annoying to have a stopcock stuck on a piece of calibrated apparatus, or, in these days of high prices, on any piece of apparatus. This frequently happens in burettes, separatory funnels, glass set-up systems, and apparatus used in gas analysis work, due to the use of caustic, bichromate, and many other solutions.

The common method of removing the stuck plug is to place a small piece of wood on the plug and to more or less gently hammer the wood, resulting in a great many cases in the barrel being cracked, the plug chipped, and, in complex apparatus, breakage of important parts. If, however, a steady pressure is exerted on the plug with the glass in contact with nothing but wood, the plug can easily be removed without damaging either barrel or plug.

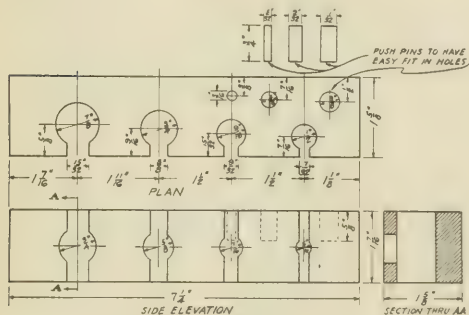


FIG. 1—STOPCOCK STEM REMOVER

The two accompanying figures show a device which has been used very successfully at the Pittsburgh station of the Bureau of Mines. Fig. 1 shows the device designed to operate over almost any size stopcock in common use and is constructed of hard maple or lignum vitae, making it very strong and durable. Fig. 2 illustrates the method of applying the steady pressure with a vise in case of loose apparatus. If the stuck stopcock is located on a set-up piece of apparatus, a U-clamp can be substituted for the vise.

¹ Published by permission of the Director of the Bureau of Mines.

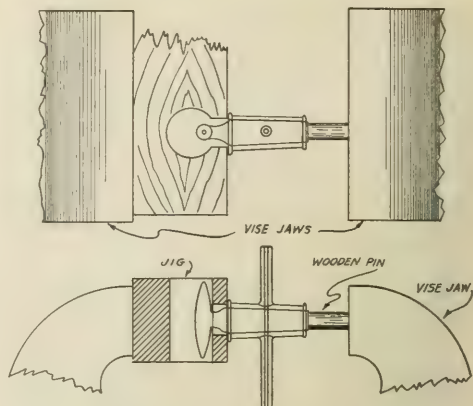


FIG. 2—METHOD OF OPERATING STOPCOCK STEM REMOVER

About 20 stopcocks have been removed with this device with no casualties, and in one instance, 7 stuck stopcocks on burettes were successfully removed in 4 min.

CHEMICAL RESEARCH LABORATORY
PITTSBURGH EXPERIMENT STATION
BUREAU OF MINES, PITTSBURGH

DATA ON PLATINUM GAUZE USED AS A CATALYZER FOR THE OXIDATION OF AMMONIA. TABLE OF WEIGHTS AND ACTIVE SURFACE OF PLATINUM, AIR SPACE, ETC., SHOWN FOR A UNIT OF ONE SQUARE INCH OF GAUZE OF A GIVEN MESH AND DIAMETER OF WIRE

By ALVIN ALLEN CAMPBELL

Received December 14, 1918

The tables listed below are figured on the basis of one square inch of gauze as a unit.

TABLE I—ACTIVE SURFACE OF PLATINUM IN ONE SQUARE INCH OF GAUZE

Mesh	Diam. Wire Inch	Pt Surface Sq. In.
80	0.0026	1.3373
80	0.0030	1.5841
100	0.0026	1.6951
120	0.0020	1.4748
150	0.0015	1.4821
150	0.0020	1.9573

The first section shows the mesh or number of wires from center to center each way per linear inch. The mesh should be accurate and can only be made so when woven on an automatic loom.

TABLE II—WEIGHT PER SQUARE INCH OF GAUZE IN GRAMS

Mesh	Diam. Wire Inch	Wt. per Sq. In. Gram
80	0.0026	0.33815
80	0.0030	0.46592
100	0.0026	0.42268
120	0.0020	0.29863
150	0.0015	0.21009
150	0.0020	0.37329

Under the heading "Diameter of Wire" a factor of error, either plus or minus, must be taken into consideration for the reason that it would be practically impossible to draw any considerable amount of extra fine wire to a given size with a working tolerance of

0.0001 in. The factor of error to be taken into consideration would be 0.021 per cent. This figure has been taken from the actual working of many thousand ounces of platinum gauze and from the theoretical weights should the wire be of correct diameter and exact in size. It would follow that the factor of error must be taken into consideration, not only in weight, but in all other calculations.

TABLE III—AIR SPACE PER SQUARE INCH OF GAUZE

Mesh	Diam. Wire Inch	Air Space Sq. In.
80	0.0025	0.6272
80	0.0030	0.5774
100	0.0026	0.5676
120	0.0020	0.5715
150	0.0015	0.5990
150	0.0020	0.4886

The active surface per square inch is the actual surface of platinum exposed to the gases being oxidized.

It has been stated by some eminent chemists that platinum of the highest purity is necessary to obtain the best efficiency of operation, but this theory seems to have been disproved by recent experiments in which efficiency of operation as great as that given by pure platinum was obtained by the use of gauze fabricated from an alloy containing 99 per cent platinum and 1 per cent iridium. This alloy has in addition the mechanical advantage that it makes possible the drawing of a finer wire and consequently the weaving of a finer mesh.

TABLE IV—SURFACE IN SQUARE INCHES PER CUBIC CENTIMETER OF PLATINUM

Mesh	Diam. Wire Inch	Active Surface Sq. In.
80	0.0026	79.9058
80	0.0030	72.6111
100	0.0026	88.0941
120	0.0020	109.0701
150	0.0015	154.8643
150	0.0020	115.3401

There are certain impossible manufacturing conditions in the fabrication from C. P. platinum wire of gauzes of extra fine sizes. While it is quite possible to draw and even weave with C. P. stock the very fine sizes, the limit as to the finest size of the wire used should be set as 0.003 in. diameter; in making finer wire than this the cost of manufacture increases out of proportion with that of the finer sizes when a platinum-iridium alloy is used.

TABLE V—ACTIVE SURFACE IN SQUARE INCHES PER GRAM OF PLATINUM

Mesh	Diam. Wire Inch	Active Surface Sq. In.
80	0.0026	4.148
80	0.0030	3.401
100	0.0026	4.013
120	0.0020	4.962
150	0.0015	7.058
150	0.0020	5.243

In the fabrication or weaving of platinum gauze it is necessary to utilize a compensating tension on the warp wires. Owing to this lack of stretch and to the fragility of C. P. platinum, the operation of working with wire finer than 0.003 in. becomes a very costly operation. By using a platinum-iridium alloy as stated, we find the added cost of drawing and weaving eliminated and brought down in line with the graduation of the finer sizes of wire and mesh.

While it is quite possible to fabricate gauzes from wire as fine as 0.001 in. in diameter, the question confronts us as to the strength of the gauze in operation as a catalyzer. We have to take into consideration the air pressure. Table III gives amount of free air space for the different sizes of wire and mesh. However, that is not the only thing which must be taken into consideration. At a temperature of possibly 900° C. the metal has less resistance to pressure of air or gases than at lower temperatures. There is also the change in the surface as it becomes spongy and continues to become more spongy until the gauze lacks power of resistance for further use.

A gauze of C. P. platinum made 80 meshes per inch and fabricated from 0.003 in. wire has shown about 25 per cent longer life than a gauze of the same mesh made of 0.0026 in. wire. This additional life is made possible by the greater cubical content and added tensile strength of the platinum wire used. We are told, however, that the catalyzer made of 0.0026 in. wire is more efficient. This is probably due to the difference in cubical contents of the metal used and to the fact that the spongy surface of the lighter wire becomes greater in volume. However, the lighter gauze is very fragile and the greatest care must be exercised in handling it. A gauze made of a mesh of 120 per inch and of a wire of 0.002 in. diameter, using an alloy of 99 per cent platinum and 1 per cent iridium, has several advantages over the coarser meshes woven of a heavier wire where their use is only for mechanical strength. For instance, the air resistance is about the same for 120-mesh 0.002 in. wire as 80-mesh 0.003 in. wire, the 120-mesh gauze of the platinum-iridium 0.002 in. wire being much stronger than the 80-mesh C. P. platinum 0.003 in. wire, with a showing of better than 60 per cent additional active surface for the same weight of metal. It would follow that the life of a gauze should be increased even beyond that of the 80-mesh 0.003 in. gauze of C. P. platinum. Also, were the finer mesh gauze used, the openings through which the gases pass would be considerably smaller and of a greater number, thereby giving a quicker and more even oxidation, while we have not decreased the air space or increased the resistance.

In compiling the above tables, the writer refers to the active surface as the entire surface exposed to the atmosphere. Some chemists make the claim that only one-half of the total surface of gauze is active under the oxidation process; we claim that there is no basis for the statement that the entire surface is not active. We know that after the ammonia gases pass through the heated gauze a complete oxidation takes place and theory tells us that the greater percentage of change takes place upon contact with the outer side of the catalyst; however, it would appear that the inner side of the gauze would take care of any incomplete oxidation of the element. The active surface is therefore figured as being the entire surface of the small wires composing the gauze.

SYMPOSIUM ON THE FUTURE OF CERTAIN AMERICAN-MADE CHEMICALS

Papers presented at the 57th Meeting of the AMERICAN CHEMICAL SOCIETY, Buffalo, N. Y., April 9, 1919

SOME PRESENT-DAY PROBLEMS OF CHEMICAL INDUSTRY

By RAYMOND F. BACON AND WILLIAM A. HAMOR

A century ago the research chemist walked forth upon the then limited American industrial world to attempt the improvement of commodities and the development of new branches of manufacture. Notwithstanding his displayed diligence and skill, however, it has been only in the last decade that technological investigation has become recognized by industry as the instrument of its extension; and now a welcome public support has come, for no section of the community remains unaffected by properly executed, carefully planned research. The financier has become its paraclete, because by means of scientific discovery there may be opened up new and promising fields for investment and reliable methods of safeguarding investments which he has already made; the manufacturer recognizes it as the parent of his technical practice, for it has either founded or facilitated his plant process—an asset which enhances his standing and enables him the more readily to raise capital for his business; the educationalist is its enthusiastic advocate, because research activity develops new fields for study and demands novel methods of training; while the artisan is benefited by the fact that the more extensive the investigational work, the greater the probability of maintaining the lead in industry and the greater the ultimate national prosperity. It is, of course, impossible to form even an imperfect estimate of the monetary equivalent of the colossal value to which the accumulated scientific inquiries of mankind have given rise; one fact is demonstrable, however, and that is that by far the greatest part of the summated value of the manufacturing industries of the present owes its existence to and depends for its continuance upon the labors of the scientific investigator.

Of the vast annual income which is realized by our industrialists a constantly increasing amount is finding its way back to furnish the means of providing fresh discoveries and fertilizing the field upon which reliance must be imposed for the production of fresh growths of industrial enterprises.

Manufacturers who have been benefited by the application of science to industry have not been content to await chance discoveries, but have established well-equipped laboratories and strong research staffs. Then, too, a tendency toward national economy and a fear of the depletion of certain natural resources have directed attention to the importance of the scientific conservation of these unreplaceable assets. Moreover, some large industrial corporations have found it expedient to keep before the public the fact that investigations on a large scale ultimately bring considerable benefit to the community generally; that every scientific discovery applied in industry reacts to the public gain; and that consequently great industrial organizations are justified, since it is only where there are large aggregations of capital that the most extensive and productive research facilities can be obtained. American industrialists are now spending approximately \$10,000,000 annually on technological investigation. There are a large number of manufacturing corporations and associations of manufacturers whose annual expenditures on research range from \$50,000 to \$500,000, and the tendency for each important industrial firm is towards the establishing of its own research laboratory. Certain of our research laboratory forces have been increased from 250 to 500 per cent in the last 10 years, and since August 1914, the staffs of a number of the largest laboratories have been

enlarged from 25 to 100 per cent. The research work thus commenced by corporations appears to develop through certain more or less well-defined stages, according to the character of the industry. These stages have been discussed elsewhere¹ and need not be referred to here at length. The following outline is indicative of their general scope:

- 1—Research applied to the elimination of difficulties in manufacture.
- 2—Research having some new and specific commercial object.
- 3—Research in pure science with no specific commercial application in view.
- 4—Research applied to public service.
- 5—Research for the purpose of establishing standard methods of testing and standard specifications connected with the purchase of raw materials.

This paper presents a résumé of the types of techno-chemical problems which are at present engaging research attention—problems which several years ago were either accorded no consideration or were unknown, but which are now the subject of contemporary concern.²

SOME METALLURGICAL PROBLEMS OF TO-DAY

The attention of present-day steel investigators has been especially attracted to the nature of β -iron and the question of the existence of δ -iron. The form of the solidification diagram for iron-carbon alloys has not been definitely fixed, and in addition to the former double diagram, based on the labile equilibrium, there is also a unique diagram based upon the pseudobinary equilibrium. In the theory of steel solidification, efforts have been made to explain the nature of martensite and to assign to it a place in the diagram. The iron-carbon system is one of the most complex, if not the most complex, known to metallography. Present theories are faulty and incomplete, but have eventuated in valuable practical results.

In blast-furnace practice there is needed some method of increasing the basicity of the slag without increasing its temperature; very little information is available regarding the amount of sulfur which can be expelled with the top gases; the control of manganese is comparatively incomplete; little is known of the general subject of the effects of variation in the carbon content of the different kinds of iron, and consequently we are unacquainted in detail with methods for the systematic control of carbon; and there is a lack of experimental knowledge relating to the action of a considerable percentage of vanadium in the blast-furnace charge. Reference may also be made here to the problem presented in the production of ferrovanadium alloys directly from iron ores containing vanadium; this is difficult because vanadium goes into slag very readily.

The following are some of the many other problems in siderurgy: the recovery of manganese as an alloy from slags high in manganese; the extension of the commercial uses of open-hearth and converter slags, particularly a broad study of their use in ceramics; the improvement of the quality of cast iron or pig iron of ordinary coke grade, to make it the equal of higher-priced charcoal iron; the influence of β -iron on the hardening of steel; the rela-

¹ Hamor, *Sci. Mon.*, 1918, p. 324.

² On May 14, 1915, I addressed the Chicago Section of the American Chemical Society on "Some Problems of Chemical Industry," and the discourse was duly published, in condensed form, in *THIS JOURNAL*, 7 (1915), 535. However, a number of omissions occurred in that brief report, and, at the request of my colleagues, I endeavored to supply, principally for the research workers in our universities, the additions necessitated for completion of the presentation. This paper appeared in *J. Soc. Chem. Ind.*, 36 (1917), No. 1. The present contribution is supplemental to these earlier reports.—R. F. B.

tive merits, as regards corrosion, of various iron products, and especially pure iron, as compared with ordinary open-hearth and copper-bearing steels; the cause of internal transverse defects in rails; and the recovery of by-products from blast-furnace gases.

In spite of the success already attained with acid-resisting irons, there are still factors of difficulty to be overcome. All alloys of low silicon content, say under 10 per cent, are attacked very readily by sulfuric, hydrochloric, acetic, and citric acids. These alloys are not exceedingly brittle, but alloys containing from 16 to 18 per cent of silicon, while they are very resistant to sulfuric, hydrochloric, acetic, and citric acids, are extremely brittle, and are so very hard that it is impossible to machine them in any other way than by grinding with high-speed abrasive wheels. These points are decided drawbacks in many cases against the utilization of acid-resisting iron, and experiments are still being continued to improve the tensile strength of the metal, and produce an alloy that will be both malleable and machinable.

In the field of non-ferrous metallurgy the flotation process continues its phenomenal growth, and not only is it being constantly applied in new plants, but substantial additions are being made to the knowledge of its action. Not only is flotation having its effect on ore-dressing, but also the metallurgical processes are being revised because of the different characteristics of flotation concentrates from the former material which the metallurgist had to treat. The weak spot in flotation continues to be the handling of complex ores involving differential flotation. Some progress has been recorded, but there is still a long way to go to reach the ultimate solution. Preferential flotation is one of the most pressing problems in connection with flotation in the United States. In Australia the separation of lead and zinc is common practice, and likewise in this country the same separation is made with fair success in some districts; but where a complex ore contains lead, zinc, and iron, flotation can as yet be said to be unsuccessful as far as anything approaching a complete separation is concerned, especially the flotation of zinc from iron. Sometimes where the iron sulfide has become tarnished it does not float as rapidly as the zinc sulfide. While a universally accepted flotation theory has not been evolved, the constant advances being made along this line are bringing us nearer to this end.

In no branch of the metallurgy of zinc¹ is there more need for improvement than there is in means and methods for desulfurizing blende. The increase in the supply of flotation slimes has simply served to emphasize the old difficulties. It has become increasingly evident that the greatest troubles in the electrolytic extraction process for zinc precede the electrolysis itself. With the proper electrolyte there is no serious difficulty in performing the electrolysis; but it may prove expensive to remove impurities in the hydrometallurgical part of the process for the purpose of obtaining the right kind of electrolyte. There may also be difficulties in making an adequate extraction of zinc in leaching the ore.

Little progress has been made in the flotation of gold ores during the past several years, and the newer but less complete process is now considered unlikely to become a serious rival to established methods of treatment. The major tonnage of gold ores is treated by a leaching process, and the substitution of flotation would probably necessitate additional reduction plant to insure a finer product than is now economically practicable. There is, however, a possibility for the introduction of flotation for the concentration of the residues from some cyanide mills treating gold ore, in the same manner as has been found beneficial in Canada. In the few instances where the tailings from amalgamation plants are too refractory for cyanide treat-

ment it has been shown that flotation may be adopted with a fair chance of success.

The leaching of gold ores in open vats is, in fact, one of the leading methods of metallurgical treatment, but there has been little recent technological progress to report. Copper metallurgists have adopted the method extensively, and installations like the Ajo leaching plant of the New Cornelia Copper Company indicate that the last word has not been said as to improved and economical leaching practice. The principle involved is often the same with both metals, though conditions differ. The applicability of leaching to gold ores is extensive, although there has been an inclination in some quarters to consider the method out of date, and to reserve research and improvement for other and more complicated processes, which necessitated more frequent readjustments to the varying conditions encountered. There is no question as to the comparative cheapness per ton capacity of a large leaching plant, as compared with the equipment necessary for any other wet-chemical method. The resulting low cost of operation would be an added incentive to the inclusion of a large tonnage of gold ore reserves, now considered as unprofitable because of the expense of reduction to slime, the difficulty of entirely isolating, for precipitating purposes, dissolved gold associated with slime, and the high cost per ton when operations are carried out on a small basis.

In copper metallurgy there is predicted the substitution of the electric for the fuel-fired furnace; the production of matte from ore, its solution, and production directly into metal—or, again, the extension to all copper ores of hydrometallurgical methods. Our achievements in 25 years, the changes wrought in methods, indicate still greater results to follow. There continues to be little market for tellurium and a correspondingly small production. Tellurium, like selenium, is a by-product from the electrolytic refining of copper. The domestic production is capable of large expansion if market conditions should warrant, as almost all blister copper contains recoverable quantities of tellurium. Much of this would be saved, if a demand existed, at prices of, say, \$1.50 to \$2.50 a pound.

Glassmaking took about one-third of our supply of arsenic in 1917, substituting some arsenic for antimony; but, in view of the lowered price of antimony, this demand has fallen off and new industrial applications are wanted. Its use in insecticides is now the most important for arsenic. The uses of antimony are very limited, which is especially surprising in view of the fact that it can be employed as a substitute for tin in certain cases. The position of tin is such as to warrant research to determine whether antimony could not replace the quantity of tin used in many industries; to illustrate, antimony can be used in the place of tin in electric cable work. The supply of antimony is capable of taking care of a much larger demand than exists at the present time.

Since tin has become scarce, cadmium has been increasingly used as a substitute for tin in solder, such as the "half-and-half" lead-tin solder. Though cadmium is worth half as much again as tin, it can be profitably substituted for that metal in some solders, for less cadmium and more lead is used; moreover, the tin available is normally required for uses for which there is no substitute. The supply of cadmium can easily be increased to meet any reasonable demand. It is therefore highly desirable that some research laboratory undertake an intensive study of cadmium, particularly of cadmium alloys, to determine fully the availability of cadmium as a substitute for tin and to discover new uses for it.

Among the less used metals, the alkaline earth elements are begging utility. There is no doubt that calcium could be produced economically even by methods now known if it were manufactured on a large scale to fill an extensive demand, but markets therefor must be established by the discovery of important new uses. Results of commercial significance might

¹ On other problems encountered in the metallurgy of zinc, see Bacon, *Science*, N. S., 40 (1914), 877; and *This Journal*, 7 (1915), 535.

be obtained by the investigation of the alloys of calcium and its application as a chemical purifying agent in melting and casting metals. Calcium has been used abroad as a substitute for ferromanganese in the de-oxidation of steel. In the cases of barium and strontium, uses could be developed if methods were known by which these metals could be isolated cheaply; while with magnesium there is now a plentiful supply and novel applications are being sought for the metal and its alloys. Beryllium is another metal whose properties should receive broad investigation, for at present its known uses do not justify its cost. Metallic columbium and tantalum are now being manufactured, and additional uses are desired for them and their derivatives.

The production of boron and ferroboron of uniform quality requires expert study. The application of boron in the metal industry has just been touched; it is used as a scouring agent for copper and in making aluminum bronzes. Cheap and pure chromium is now unobtainable; the electrolysis of its fused salts is difficult on account of their high melting points, but perhaps the electrolysis of aqueous solutions of chromium salts could be so controlled that heavy deposits would be produced. Then, too, chromium electroplating is for many purposes superior to nickel, but the technique of constantly producing perfect plating has not been accomplished.

Since there is no lack of raw materials, broad study should be made of the methods for producing pure titanium, zirconium, and uranium, and of their prospective uses. The same statement also applies to molybdenum, although the greatest need of the molybdenum industry at the present time is a more economic utilization of its sources of raw material; in general, the deposits have been neither properly prospected nor opened up, and too often not wisely worked.

A very important electrometallurgical development awaiting a successful solution is the direct manufacture of steel from iron ore. Another branch of chemical manufacture which would assist in helping to consume electrical power is the fertilizer industry. This includes the nitrogen-fixation industry and the electrical extraction of soluble phosphates from phosphate rock. The electrical method is stated to afford completely soluble phosphates, while with the old sulfuric acid process only a relatively small percentage of phosphorus is rendered soluble.

PROBLEMS IN REFRACTORIES

Of all the anxious inquiries coming in from our manufacturers, those pertaining to refractories are perhaps the most generally important. Why is it that roof brick often wear away from the sides, forming "stalactites;" is the destructive agency slag or spawling? How can dolomite be treated so that its slaking tendencies will be reduced to those of magnesite? Can brick be made to give longer service in the rotary cement kiln? Can more resistant brick be made for the checkers of enameling furnaces—brick which will resist the slagging action of iron scale and yet be refractory? What are the most desirable percentages of iron oxide to be added in making "synthetic magnesite" for basic bottoms? And is the addition of ferric oxide absolutely necessary? What are the most undesirable impurities in silica brick and how can silica brick be treated so as to eliminate excessive spawling? What are the primary reasons for the failure of graphite crucibles? A pyrometer tube is desired which will not warp at high temperatures, and which will be strong, dense and impervious to gases. Can electric-furnace products ever be used in blast furnaces, heating furnaces, etc., or will failures occur because of erosion, spawling, or causes other than heat? Still other queries relate to the mechanical aspects of the manufacture of refractories. Can more efficient machinery be invented in order to remove the great personal factor in the making of fire clay and silica brick? And will more efficient kilns be more generally adopted? Several problems from the iron and steel industry are also of consid-

erable interest. Can alumina be satisfactorily made (sintered) into a dense, hard refractory without the aid of a bond, thus obviating the troublesome shrinkage which occurs at temperatures far below the melting point of alumina? And finally, there are the troubles in the case of refractories for open-hearth furnaces. The principal source of difficulty is the slagging tendency of the dust, which is derived partly from the producers and partly from the charges. Perhaps a satisfactory means of suppressing the dust might be devised, but another way out of the trouble consists in replacing the acid bricks of the checkerwork by basic ones. In this connection a pertinent question is, what constitute the best checker bricks—light and porous or hard and dense products? Magnesite and silica brick have been tried with good results, while dolomite brick, which have been suggested for experimentation, have not been made successfully.

It is becoming increasingly evident that the greatest single problem in chemical technology is the one of refractories. There are many industrial problems that now appear to be impossible of commercial solution, which could be immediately solved, provided we had some ideal refractory substance which would retain its shape and strength at high temperatures, would not be acted upon by the acid or alkaline constituents of a charge or by the gases evolved during the reaction, and would be sufficiently strong and tough to resist erosion, etc.

OTHER PROBLEMS OF INDUSTRIAL INORGANIC CHEMISTRY

Many problems exist in the field of mineral technology. The American strontium industry is still in its infancy; there is a more difficult road to travel here than in the now well-developed barium industry, although the demonstration of the commercial possibilities of strontium products has been made and rapid expansion may be certainly expected. A more plentiful supply of fluorite should cheapen and improve the lenses and prisms used in the construction of optical instruments. The present demand is limited, but will increase, and optical fluorspar brings \$1.00 per lb. Perhaps suitable crystallized calcium fluoride could be prepared by a synthetic process. The grading of asbestos has not been standardized; consequently it is difficult to compare prices, except as between the same grades of the same producer. This condition is aggravated by the fact that the grades are numerous, passing gradually from one to the other, and varying in value from \$5.00 to \$1500.00 per ton. The buying of tungsten ores in accordance with definite grades and specifications also requires standardization. The changing of specifications and the uncertainty respecting the marketability of tungsten ores and concentrates have made it difficult for some producers to satisfy themselves regarding the prices received for their products.

Under conditions such as have prevailed during 1917 and 1918, nearly any grade of flake graphite is salable, and there are no definite standard governing specifications. Consequently the buyer may now prefer the imported graphite, for which there are fairly well recognized standards. It would seem advisable for the domestic producers, either to adopt standards for different grades of flakes, in order that when imported graphite comes on the market more freely they may be better able to meet the competition, or so to regulate their milling methods that they may be able to prepare special grades based on the purchaser's specifications. It is probably impossible to standardize grades for the whole country, owing to the different methods of treatment necessary for different types of ore; but where conditions are essentially the same over a large area, as in the Alabama field, cooperation among the producers might result in the establishment of two or three standard grades, based on the percentage of graphitic carbon and size of flake, with a guaranteed minimum of silica and iron. This would give the producers a far stronger position in the market and make the crucible manufacturers more ready to use domestic flake. Graphite

for other uses, such as for lubricants, pencils, foundry facings, and paints, will probably continue to be in good demand, but unless the deposits are large and cheaply mined, the prices of the grades required for these uses do not make them profitable to the producer. Here again the expected competition of the graphite dust from Madagascar and Ceylon and amorphous graphite from Mexico, as well as artificial amorphous graphite, will be difficult to meet.

Better milling methods, resulting in a higher graphite content of the dust produced, will materially aid the situation. For instance, dust as ordinarily produced at flake graphite mines carries about 40 per cent of carbon and is sold at less than 1 cent per lb., but the same dust, when refined to a degree of purity suitable for use as a filler for dry batteries, commands many times this figure. Perhaps it may be found feasible to manufacture many graphite products in the vicinity of the mines.

New uses are desired for tripoli and gypsum; and the employment of slate in the manufacture of blackboards and school "slates" has so decreased that new applications are wanted to replace this loss of market. Then there are the problems in connection with the use of the natural abrasives, emery and corundum; with these there is wide variation in the composition of different shipments; but since the development of high-grade artificial abrasives and the exploitation of larger corundum deposits in Ontario, little corundum has been produced and only a small quantity of emery has been mined in the United States, and accordingly new uses are being sought for these minerals. The abrasive garnet market is also limited and shows little tendency to extension at present. Reference may be made here to several problems in the technology of fuller's earth, the literature of which is unsatisfactory. Little is known regarding the qualities of fuller's earth which adapt it to its applications; there is a needless obscurity concerning the changes which it occasions in oils and to which it is itself liable; it is not clear why certain earths possess a tendency to cause spontaneous combustion in the material from the filter presses; and what is the cause of the malodor which sometimes accompanies the use of a particular earth?

The utilization of the waste products of various chemical manufactures is in need of investigation. How can sulfide of arsenic residues from the purification of sulfuric acid and residues containing appreciable amounts of selenium be most advantageously used? Then we have the waste hydrochloric acid from metal pickling, the waste chromium sulfate liquors resulting from the oxidation of organic substances, the residue from the manufacture of acetic anhydride, the maize residue from the manufacture of butyl alcohol, chrome leather scrap, and Mimosa bark residue.

PROBLEMS OF INDUSTRIAL ORGANIC CHEMISTRY

The organo-chemical industry holds out engaging opportunities for chemical research and the inquiries which it submits are well illustrative of the opportunities which exist for co-operative investigation as well as explanatory of the prevailing anxiety for new ideas in manufacture. More numerous, perhaps, than any others are queries regarding coal products and their manufacture; these problems¹ and those of the related petroleum industry² have been considered at length elsewhere, and accordingly will not be discussed here.

The problems awaiting investigation in the field of experimental phytochemistry are quite numerous. In fact, the formation of an organic raw-material research association would seem to be desirable in order that there might be systematically studied the many problems connected with the cultivation, breeding, and diseases of plants, and the furnishing of raw materials in rela-

tion to the requirements of the various chemical manufacturers concerned, a special department or division thereof being organized for each industry, or raw material. In this way, for example, the plant products industries could be greatly strengthened by the interconnection of economic botany and chemistry. Many of our plants are wasted either because of a lack of knowledge regarding their possibilities or because of a deficiency of interest in their industrial development. The processes for obtaining rubber from guayule sap could be improved by further research; the method employed for extracting wax from candellila is crude; Algeria and osage orange contain dyestuffs, but have received practically no attention; the commercial possibilities of mesquite seed and wax are unknown, and the same statement applies to the wax or gum from prickly pear cactus; no suitable process is known for degumming ramie fiber and making it suitable for spinning; there is no knowledge of the industrial possibilities of bear grass; the use of rice straw and cotton stalks as paper-making materials requires more study; and the castor bean, sunflower, and camphor tree are well adapted to the coastal plain of Texas and should constitute the bases of well-established industries.

A study of the best time of cutting the wood, the best type of tree, and its conditions of growth in relation to the wood cellulose produced from it would be of real material value in paper-making and the manufacture of artificial silk. It has been predicted that, in time, special crops may be cultivated for the production of paper-making materials. For nitration purposes, the uniformity of the cotton used is of the greatest importance. It has been claimed that cotton produced in a cold, wet season does not nitrate as readily as cotton grown under more favorable weather conditions. Consequently, improvements tending to afford cotton of greater uniformity will also affect favorably the uniformity of the waste cotton. The following are some of the problems which confront the planter of cotton: What is the action of various fertilizers on the yield of cotton and on the quality of the fiber produced? Are there available any fertilizers which can be substituted for potash, and, if so, what conditions must be observed in their application to the soil? And then there are the problems in preventing the production of stained cotton during seasons of excessive rain and in bleaching stained cotton a pure white.

An elaborate research into the physiological processes involved in the formation of tannins in the barks of various woods would probably yield full information as to the best periods and methods of harvesting. There is much need in the essential oil industry for the correlation of the conditions of cultivation and breeding with the quantities and qualities of oils obtained. The metabolic processes underlying the production of the various constituents of the essential oils, which in many cases render them so valuable, are not understood. Another field, rich in opportunity, which exists in the domain of chemical dendrology, is the investigation of the conditions necessary for the formation and exudation of all resins and the changes undergone by them, whereby they become of value as raw materials for the manufacture of varnishes and lacquers. Then, too, the origin, nature, and functions in the tree of the latex, which carries the rubber, are not known precisely. So-called "natural coagulation" was a failure in the earlier days of the plantation rubber industry, but recently a system of carrying on "natural coagulation" under anaerobic conditions has been experimented with and may be developed into a useful process. It is still believed by some that fine Para is superior to plantation, but it is probable that further knowledge and experience will alter this view. And, finally, there are many vegetable dyestuffs which, by improved methods of cultivation, breeding, and selection of the plants, or of the extraction of the coloring matters, might be successfully exploited.

Ethyl alcohol is made in quantity by the action of yeast on

¹ Bacon, *This Journal*, 7 (1915), 535; and also *J. Soc. Chem. Ind.*, 36 (1917), No. 1.

² Bacon and Hamot's "American Petroleum Industry," 2 (1916), 798.

sugar and starch; amyl alcohol is produced by the fermentation of protein substances, and there is a bacillus for obtaining butyl alcohol from starch. The question accordingly arises, why should we not find or develop cultures for the production of propyl alcohol, and, especially, methyl alcohol? It is known that *n*-propyl alcohol is among the products of the fermentation of starch by the anaerobic *Amylobacter butylicum* and *A. aethylicum* of Duclaux, and that it is also a secondary product of the alcoholic fermentation by *Saccharomyces*, occurring in most fusel oils; but no technical process has been devised for its zymochemical production. A similar condition exists with respect to methyl alcohol, which is among the products of the fermentation of glycerol by *Bacillus bobocypicus*, of the bacterial fermentation of calcium glycerate, and of the fermentation of the juice of the sugar cane by a special (wild) yeast; perhaps extensive research would eventuate in the development of a commercially operable process. The desirability of systematic investigation of this nature suggests the initiation of attempts to find microorganisms for making certain higher alcohols in the factory. Some of these alcohols are excellent waxes, and, to illustrate, cetyl alcohol and melissyl alcohol are too exorbitant in cost when separated from spermaceti and beeswax, respectively. It is indeed probable that a number of processes now based upon chemical reactions could be more efficiently conducted by bacterial agencies.

The chemistry of the production and utilization of vegetable oils is susceptible of expansion in several interesting and profitable directions:

- 1.—Extracting oil by solvent processes which will make greater yields and yet not extract deleterious substances along with the oil, and which will not be subject to great fire risk.
- 2.—Treating the residue (cake) to free it from all traces of the solvent, to make it a proper cattle feed.
- 3.—Refining oils by methods causing least possible loss, and producing the highest grades of edible oils, tasteless and odorless, both liquid and solid.
- 4.—Utilizing the by-product of refining to the best advantage to recover the fatty acids free from objectionable color and from foreign matter; and the further transformation of the finished product into the finest soaps and other useful merchandise.
- 5.—Making cottonseed flour and bread therefrom that will be an acceptable and merchantable product.
- 6.—Treatment of recovered fiber to make an infinite variety of profitable merchandise.

Research in the margarine industry will continue to have for its object the production of a food identical with butter, and it will involve the investigation of the following problems:

- 1.—The production of a synthetic fat similar in composition to a butter fat, or of a mixture of natural fats physiologically identical with butter fat.
- 2.—The production of an artificial or synthetic milk.
- 3.—The production of a suitable butter flavor.
- 4.—The production of a margarine not inferior to butter in vitamins or accessory substances.

It has been well said that "the dyestuff factory cannot progress nor even exist upon the cast-off products of other factories. The history of the dyestuff industry shows that financial success follows the research laboratory." About 175 dyes are now being made in the United States from American raw materials and intermediates; these products are equal in shade, strength, and working qualities to those of the pre-war types and include members of all groups of colors formerly used in American mills; but owing to the pressure of other work during the past 3 years, American research chemists have not been able to devote energy to the discovery of new dyes. Present methods of testing dyes are empiric and subject to a wide limit of error. To illustrate, chemical analysis may show a dye to be 99 per cent pure and still inferior for dyeing to another sample of the same dye only 90 per cent pure. Dye tests are made in a manner that aims to duplicate, on a small scale, the actual application of the color. Slight differences in conditions, such as water used, may greatly influence the results of tests by two different laboratories.

Colorimetric methods are more recent, but have many limitations, for the products of different factories may vary just enough to interfere with the use of the colorimeter. It is essential to devise methods to meet the objections mentioned and so facilitate the commercial development of the dye industry along proper lines of control.

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THE FUTURE OF CELLULOSE ACETATE

By H. S. MORK

Retrospect of the commercial history of cellulose acetate reveals that this material has had an up-and-down career. To the query why this should be so, the fundamental answer is cost; qualifying factors are patents and industrial "politics."

In general, the obvious characteristics of cellulose acetate products resemble those of cellulose nitrate products, whether films, fibers, plastics, or varnishes. The potent objection to cellulose nitrate products for general industrial purposes (excepting explosives) is their easy ignition and high rate of combustibility. Concomitant with this property due to the combined nitric acid is the destructive effect produced on one or another type of supports by the liberation of even small quantities of such a strong acid as nitric acid under conditions of use favoring slight or partial hydrolysis of the cellulose nitrate.

As a general proposition nearly everything (except explosives) that can be made from cellulose nitrate can be made from cellulose acetate. The manipulations necessary for conversion into commercial products are similar as to processes but vary as to chemicals required, viz., solvents, "softeners" or camphor substitutes, etc. Utility in some instances is governed by cost of conversion and final effect, or in other words, the properties of the products resulting from conversion.

At the present time and as a result of chemical developments during the war, conversion costs of the two esters are not materially different. All this is aside from the initial costs of the esters. Cellulose acetate has always been more expensive than cellulose nitrate because acetic anhydride, the effective acetylating agent, has always been more expensive than nitric acid, the effective agent of nitration. Also cellulose acetate contains more combined acetic acid than the industrial nitrates do of combined nitric acid. The spread between the prices of acetic anhydride and nitric acid is now and has always been too great to permit cellulose acetate products to be a direct competitor of cellulose nitrate products without regard to the differences in properties. It is the general belief that this difference in cost will always exist. On the other hand, statements have been made recently that it is not impossible to make cellulose acetate as cheaply as cellulose nitrate. That it has not been done does not necessarily mean that it never will be done. The recent large-scale developments in the manufacture of acetic acid from acetylene by way of acetaldehyde perhaps offer the best promise of very cheap production of acetic anhydride. By modification of this process it is possible to produce ethylidene diacetate, from which acetic anhydride can be made directly. If the manufacture can be conducted on a large enough scale and the process be brought up to a high state of efficiency, it is not impossible that acetic anhydride can be produced sufficiently cheap to make cellulose acetate a direct competitor of cellulose nitrate. The uses of cellulose acetate will be in part controlled by the development of this anhydride process or one equally as promising.

The whole future of cellulose acetate is not by any means controlled by the necessity of price competition with cellulose nitrate products, for the obvious reason that the noninflammability of cellulose acetate products is a distinct and invaluable property. There are a large number of applications where

the dangers in the use of a highly inflammable material like cellulose nitrate justifies the higher price for a non-inflammable product. Some of these applications are developing by sheer force of virtue. Others are slow in reaching their justifiable use through commercialism or industrial "politics." It is not necessary to elaborate on this point. Some day a holocaust will wipe out industrial "politics" and cellulose acetate will be found to be on deck, unless in the meantime something new has developed to take its place.

The war has perhaps been the best booster of cellulose acetate, because in airplane construction it has developed its biggest use. Cellulose acetate dopes for shrinking airplane wing fabrics not only possess the desired property of noninflammability but have also demonstrated their superiority in durability and minimum degrading effect on the fabric. No one who has been close to airplane production seriously doubts that there is a big future ahead of it. Travel through the air in heavier than air machines is industrial progress and nothing, therefore, can more than temporarily impede its development. If the present method of fabric wing covering is going to persist, then a large use for cellulose acetate is in prospect.

Perhaps, however, one of the biggest uses for cellulose acetate in the future is in the production of artificial silk. The manufacture of artificial silk from cellulose nitrate has been a commercial enterprise of many years' standing but cellulose nitrate silk cannot be marketed as such, on account of its extremely high inflammability. It therefore has to be denitrated with the result that it loses its waterproof properties and on denitration becomes closely similar to viscose and cuprammonium silks and suffers great loss of strength when wetted. Cellulose acetate silk, on account of its relatively low inflammability, can be marketed without deacetylation and therefore all the waterproof properties of cellulose acetate are retained. Silks made from it are, when wet, about three times as strong as the other types of artificial silks, but aside from the waterproof properties, cellulose acetate silk has dyeing, or perhaps better expressed, has resist properties which give it distinct individuality as a textile fiber which practically affords it a market at any price below that of spun silk.

The production of cellulose acetate silk in the United States has been retarded rather than helped by the war, because the silk industry had to yield up its raw products to the airplane requirements. Now that the war has ceased and the production of acetic anhydride has been expanded in this country, cellulose acetate silk and other non-war uses of cellulose acetate ought to come in for a new lease of life.

ARTHUR D. LITTLE, INC.
CHARLES RIVER ROAD
CAMBRIDGE, MASS.

PHENOL

By A. G. PETERLIN

Before the war this country's consumption of phenol was about 9,000,000 lbs. per year. The bulk of it came from England, and was obtained from coal-tar distillates directly. A small part was synthesized from benzol. The general impression here is that this synthetic phenol was made in German plants, subsidized, and kept in existence by the Government for war purposes.

The production in the United States during the war continually increased. At the time of our entry into the struggle it amounted to 75,000,000 lbs. per year, and after that time plants were erected so that at the end we had capacity to produce more than 150,000,000 lbs. Of this, not more than 2,000,000 lbs. was obtained directly from coal-tar distillates by extraction with caustic soda.

At the present time the consumption in this country is not much greater than 6,000,000 lbs. per year, about equally divided

between the drug and disinfectant, the dyestuff, and the synthetic resin industries. This means that there was at the time of the armistice a sudden cessation of manufacture and use on a comparatively huge scale, and stocks on hand altogether out of proportion to the possibility of use in times of peace. In private and government hands to-day there are at the very least 30,000,000 lbs. of phenol. The Government wants to know what to do with it. No adequate suggestion has as yet been made; perhaps some of you can answer the question. The Bureau of Public Health Service at Washington has refused it as a gift; phenol has come to be a very specialized anti-septic; it has been displaced by cheaper, safer, and more powerful materials in the wider fields of disinfection.

Before the war phenol sold at about 9 cents per lb., and although our own coal tar was an inadequate direct source, England was able to supply both the United States and Germany with all they required in excess of their home production. The pre-war price of say 8 cents was an exceedingly low one; it was not sufficient to insure that all of the phenol available from coal-tar oils was extracted, or separated from the mixture of phenol and cresols which was extracted. On a basis of pre-war prices for labor and material, it is possible that phenol might be synthesized from benzol at a cost of between 10 cents and 15 cents per lb. Were the present stocks absorbed, one or two synthetic phenol plants might operate in this country and insure a home production equal to our needs at a cost no greater than a fair cost of imported phenol plus the present duties. For the present the plants are idle—the wastage of war—and are likely to remain so, so far as the production of phenol is concerned.

CHEMICAL DEPARTMENT
THE BARKETT COMPANY
NEW YORK CITY

THE PREPARATION OF PURE ORGANIC CHEMICALS

By H. T. CLARKE

Members of this Division will recall that at the Cleveland meeting last fall Dr. C. E. K. Mees, Director of the Research Laboratory of the Eastman Kodak Company, announced that a department of the laboratory was being organized to supplement the work taken up by the chemical manufacturing department of the University of Illinois for the supply of the pure organic substances required for research which had before the war been obtained almost exclusively from Germany. At that time the department of Synthetic Chemistry, as this section of the Eastman Kodak Research Laboratory is called, had been in existence for too short a period to have afforded any tangible results, and we feel it our duty to take this opportunity of reporting progress to the Section, the members of which were so good as to give their approval and support to the undertaking.

The work of the department falls into three main divisions: first, the synthesis of substances, for which there is an immediate or a potential demand, which are not available on the open market; second, the purification of substances obtainable in technical quality from chemical manufacturers; and third, the distribution of the materials thus prepared and those purchased in pure condition from manufacturers and from individual chemists in university laboratories.

As can readily be understood, it is our principal aim to bring our products to the highest state of purity it is possible for us to obtain, without consideration of yield or of labor involved, and products with the quality of which we are satisfied we designate as Eastman Organic Chemicals. We do not consider it desirable to print upon the label a specification of the purity of the contents of the bottle, but we shall be glad to furnish, on application, information, including the approximate date of preparation, relevant to the purification or testing of any substance supplied.

It has been decided to distribute, in addition to the pure substances, products of two other grades. For synthetic work the chemist is frequently satisfied to employ materials which, while of good quality, are not yet in the highest state of purity attainable, and inasmuch as in many cases the labor involved in the final purification constitutes the larger factor in the cost of the finished product, a grade designated as "Practical" is also obtainable. In this class we place such technical products as we ourselves find sufficiently pure to serve as starting materials. This group likewise contains certain products synthesized or prepared from crude materials by ourselves, the quality of which we consider sufficiently high for synthetic work, but which requires considerable additional labor to convert into the highly purified form. These materials can naturally be obtained at a considerably lower price. In the "Practical" class are also included certain inorganic substances which are frequently employed by organic chemists.

The third class consists of materials of standard technical quality. It is as a rule difficult for chemists in university and similar laboratories to obtain such products in small quantities, first, because they frequently do not know to whom to apply for them, and second, because large chemical manufacturers rarely desire retail business of this character. As above stated, certain technical products have been classified as "Practical" whenever it has been established that their quality justifies such classification.

The preparative work in our laboratory is carried out entirely by women, the majority of whom have come direct from college with the bachelor's degree. They are assisted by girls who have had a year or so of chemistry in high school, sufficient to convince them that they possess a natural inclination towards the practice of chemistry. It has been attempted, during these first months, to make the work as varied as possible in order to give the staff a wide experience. This policy was moreover largely necessitated by the variety of materials demanded and by the small size of the laboratory. No attempt has been made to build up large stocks of any individual substances; when the method of preparation had been worked out and 5 or 10 kilos at the most prepared, attention was turned to a new preparation.

At the present time some 175 preparations have been undertaken and in 140 cases working methods have been satisfactorily established. Of these preparations 92 are synthetic operations and 83 are purifications of technical materials. The choice of the preparations undertaken is being determined on the one hand by the substances for which inquiry is made and on the other by the materials at our disposal. Particular attention is thus being given to reagents required for analytical work, including indicators, and to attempts to develop new or hitherto

rare substances from materials such as *n*-butyl alcohol, ethylene chlorohydrin, and trimethylene glycol, which have only recently become readily available in quantity.

I desire to express my deep appreciation of the support which has been given to us by the chemists of this country, not only as represented by the AMERICAN CHEMICAL SOCIETY but also of the chemical manufacturing firms and university laboratories. In particular, I desire to acknowledge my indebtedness to the Dow Chemical Company, the National Aniline and Chemical Company, the du Pont de Nemours Company, the Hercules Powder Company, the Mallinckrodt Chemical Works, and the Monsanto Chemical Company for their kindness in advising us not only of their regular products but of materials which they manufacture for themselves alone, and in arranging for the supply of these products to us for this work. Supplies of a few less common substances have been obtained from the Special Chemicals Company of Chicago, who has been so good as to assist us in extending our list of materials. It also gives me great pleasure to acknowledge the kind coöperation of Dr. H. I. Jones, of the University of Oklahoma, who has prepared for us stocks of several substances, and of Dr. W. D. Turner of the School of Mines of the University of Missouri, who has undertaken the preparation of a number of materials in the laboratory of chemical technology under his direction at Rolla, Mo. Dr. Turner, who has equipped a laboratory with small-scale technical apparatus, will, it is hoped, be able not only to give his students a course of almost unique educational value, but defray the expenses of his department by supplying urgently needed substances. We should enthusiastically welcome further coöperation of this nature, as well as that of individual workers, for whom we hope to act as a clearing house for new or rare compounds. If chemists will advise us of new or uncommon substances which they have prepared in the course of their researches, we shall be ready to purchase these of them for redistribution to other chemists requiring small quantities for comparison or experimental purposes.

Finally, it is with the greatest pleasure that I acknowledge our indebtedness to Dr. Roger Adams, whose admirable work in continuation of that initiated by Dr. Derick at the University of Illinois is familiar to all organic chemists. Not only has the manufacturing department of his laboratory from the outset kept us supplied with its pure products, but it has communicated to us the working methods by which the substances were prepared. It would be difficult for me adequately to express our gratitude to Dr. Adams and his colleagues for their encouragement and coöperation.

RESEARCH LABORATORY
EASTMAN KODAK COMPANY
ROCHESTER, N. Y.

FOREIGN INDUSTRIAL NEWS

By A. McMILLAN, 24 Westend Park St., Glasgow, Scotland

METAL RESERVES

The announcement that the British Ministry of Munitions intends to publish at monthly intervals statistics of the stocks held on the first day of each month seems to have given satisfaction to the industry, if we are to judge from contemporary comment, as it is important that the trade should know at intervals the position as regards supplies of the principal metals. The first of these returns, which is exclusive of old metal and scrap, shows that on January 1, 1919, the Ministry held of copper, 36,000 tons; spelter G. O. B., 22,273 tons; refined spelter, 8,017 tons; aluminum, 11,957 tons; soft pig lead, 62,852 tons; nickel, 2,096 tons; aluminum regulus, 3,508 tons. In addition to these stocks, the Ministry holds large quantities of scrap, mainly brass.

HYDROCARBONS FROM CERIUM

Quoting from *Ann. chim. the Chem. Trade J.*, 64 (1919), 30, says that the carbides of the cerium group of metals when decomposed with water give off gas which is, in all cases, a mixture of hydrogen, and saturated hydrocarbons consisting of ethane, propane, isobutane, but no methane and no hydrocarbons of the ethylene or acetylene series. The different constituents of this gaseous mixture, while invariably present, vary in their relative proportions according to the velocity of the reaction which is dependent on the physical state of the carbide. The metallic hydroxides produced are those corresponding to the sesquioxides. Cerous hydroxide was isolated in the pure condition as a white compound which fixes oxygen in the cold with evolution of heat and formation of ceric hydroxide.

NEW METALS AND ALLOYS

In an article dealing with the nonferrous metals, *Times Engineering Supplement* (January 1919) says that, in comparison with ferrous metallurgy, the nonferrous branch includes a large number of metals and alloys, some of which are comparatively new and in one or two instances the product is of a quite recent period. The serious challenge of the position of copper by aluminum and its alloys is a phase of development which is calculated to have far-reaching results and the competition between these two important metals for new practical applications has opened up a wide field of work. There has been a notable increase in the production of copper alloys, notably cupro-nickel, and there is the authority of Dr. Carpenter for the statement that this higher output has been associated with a marked improvement in practice. When to copper and aluminum are added nickel, zinc, tin, lead, and antimony with their alloys, the extent and importance of the industry are at once evident. Much of the new work has been in connection with light alloys to meet the requirements of the aircraft industry and new compounds, some possessing remarkable properties, have been placed at the service of manufacturers. Duralumin, which is a typical example, has a tensile strength up to 35 tons per sq. in. with a specific gravity of only 2.8. There has also been a considerable development in the production of electrolytic zinc, and the output of distilled zinc, largely used in munition work, has been greatly increased. There is also the new industry which is concerned with powdered nonferrous metals which is a noteworthy development, and pioneer work in the revival of magnesium manufacture, which had been surrendered to Germany, has been undertaken with considerable success. The article deals also with methods of melting, corrosion, etc., and gives an account of advances made in nonferrous metal manufacture in England during recent years.

GERMAN SUBSTITUTES IN INSTRUMENT MAKING

In the *Z. Instrumentenk.*, September 18, 1918, H. Kruss discusses the various substitutes which have been in use and expresses the opinion that, as far as possible, use should be made of the brass substitutes even in normal times. Copper was commandeered in Germany in 1916 and instrument makers had to find a substitute for the brass which had been so largely used. In many cases iron and steel were found quite serviceable though trouble was experienced through the iron castings not being quite so neat and accurate as the brass ones, and there was less demand for iron castings of high finish. The chief material used was zinc as such and in various alloys. Cobalt replaced nickel in electroplating when nickel became scarce and, in general, alloys were merely varnished. Iron, zinc, and aluminum have also been made use of by electrical engineers as substitutes in various ways. Cellulose preparations impregnated with various substances have been introduced as insulating material under different trade names such as cellon, tenazit, turbonit, and wenjazit.

NEW NORWEGIAN INDUSTRY

According to the *Anglo-Norwegian Trade Journal*, previous to the war most of the electric lamps required in Norway were imported from Germany. Two years ago the Norsk Elektrisk Lampefabrik was established at Drammen, as the first Norwegian enterprise for the manufacture of electric lamps. The lamps made proved so good that the works had to be enlarged and new buildings are now ready for use. Up to recently, the production was about 4,000 lamps per day, now it will be considerably increased. The lamps of this company were quickly acknowledged to be first class, but, owing to the home demand, the number exported has been limited. The superintendent of these works was formerly similarly employed in Switzerland.

CONCRETE RAILWAY SLEEPERS

In a system of railway construction, says the *Times Engineering Supplement* for January 1919, devised by Signor Valeri, of Asti, Italy, and tried on the line between Asti and Altavilla, a series of interlinked sleepers of reinforced concrete is arranged lengthwise beneath each rail. The sleepers are triangular in shape and as each of them rests on a pedestal with the center of its base only it is claimed that they are capable of a rocking motion which permits a certain resiliency of the rail. Each sleeper supports the rail at two points, and at these a block or cushion of hard wood is interposed with a bolt for anchoring the rail to the sleeper. These supports are about the same distance apart as is usual with ordinary cross sleepers. The rails are held to gauge by means of tie rods, of which as a rule one is provided for each pair of oppositely arranged sleepers. These gauge bars engage the rail by means of clamps that grip the base of the rail, which, therefore, has not to be drilled. The objects aimed at in the design are: uniform elasticity; greater exactness in, and better maintenance of, the level of the line and the gauge; resistance by canting at least equal to that possessed by lines as constructed at present; and less creeping of the rails. Should the level of the track have to be rectified, the requisite adjustment may be obtained by altering the height of the wooden cushions between the rails and the sleepers.

ACTION OF SILICON TETRACHLORIDE ON IRON

According to an article in the *Chem. Trade J.*, 64 (1919), 99, if metallic iron is brought into contact with silicon tetrachloride at an incandescent heat, chloride of iron will be produced and silicon separated off at the same time. Hitherto, the process has only been used for coating the incandescent bodies of electric heating and lighting devices with silicon so as to protect them from all atmospheric influences. Recent experiments made by a Vienna firm have shown that the reaction in question also affords a basis for providing all kinds of metal articles with a thick coating of silicon, or of a silicon compound, whereby they are rendered not only air-, but also acid-proof. The articles in question, if of iron, are treated while hot with halogen compounds of silicon. Non-metallic articles must first of all be treated with a metallic coating to which the silicon or silicon compound is subsequently applied.

THE GERMAN STATE RAILWAYS

One of the most astounding signs of the times, says *Engineering*, 107 (1919), 91, and one which may have a grave effect on German trade, is the altered financial position of the German state railways. The Prussian State Railway yielded a surplus of \$81,250,000 in the year 1913. For the year 1917, the surplus had receded to \$4,500,000, and for the current financial year a deficit of \$331,250 is reckoned upon. For the coming year (1919) the deficit is expected to be some \$750,000 and this for a figure of cost for the state railways stated before the war to be some \$1,750,000,000. For last year (1918), the average wage under the railway amounted to about \$320 per individual, for 1919 it is calculated at \$1,055, an increase of 230 per cent. An increase in the tariff of 100 per cent is looked upon as necessary.

CANADIAN PAPER AND PULP INDUSTRY

The prosperity of the paper and pulp industry in Canada is indicated by some figures recently issued by the Dominion Bureau of Statistics, Ottawa. According to the report, exports of paper and pulp for the twelve months ending September amounted to \$67,000,000 in value. Exports of wood pulp amounted to 10,918,824 cwt., valued at \$30,400,000. The exports of printing paper for the year totaled 12,822,712 cwt., valued at \$36,670,000.

IRISH MINERAL OUTPUT

Statistics published in a special report and dealing with the output of coal and other minerals in Ireland in 1917 indicate the progress which is being made, and it is known that during the past year the output of coal was considerably increased to meet the conditions imposed by the rationing scheme, which greatly accentuated the shortage for industrial requirements in Ireland. The total amount of coal raised in 1917 was 95,646 tons, of which over 80,000 tons were anthracite. This variety of coal was mainly obtained from the Kilkenny mines, which produced 61,746 tons, the remaining tonnage being obtained from Queen's County, 14,156 tons, and Roscommon, 12,487 tons. For much of this coal a price of \$5 was realized at the pit mouth, the total value of the whole output being given as \$435,820. In the coke industry 395,368 tons of coal were carbonized, producing 188,704 tons of coke. The iron ore industry raised 54,533 tons having an average iron content of 38.44 per cent and producing 20,972 tons of pig iron. The value of the iron ore raised is given as \$71,330. Some experimental working with zinc ores was undertaken in Sligo, but only 16 tons were obtained, which yielded 5 tons of zinc.

GERMAN DYE TRADE INDUSTRY

Judging from statements in the German technical press, says the *Times Trade Supplement* for February 1919, it seems doubtful whether any helpful purchases of dyestuffs can be made in Germany for some time to come. The Rhine color works are utterly disorganized. Bayers, the great Elberfeld and Leverkusen firm, report that their men are doing 50 per cent less work than before the war and are demanding higher wages. Peace products—the term is easily understood—were 5 per cent only of the output during the war, owing to the lack of the necessary crudes and intermediates. This disposes of the oft-repeated tale of the vast accumulation of dyestuffs with which it was pictured that Germany was prepared to flood the world's market. What is of more importance, however, is that, in spite of the complete cessation of the production of ammunition, the total output now equals 10 per cent with no immediate prospect of increase. The labor unrest, the increased cost of raw materials, the total disappearance of the country's organization in foreign countries, are all touched on in a doleful report and the directors hint at economic collapse. Undoubtedly the other big German companies with 80 per cent at least of their business depending on the export trade are in a similar case and it seems that the outlook for the German dye trade is not quite so bright as one was led to expect from reports issued during the war.

ANNEALING CARBON ELECTRODES

According to the *Times Engineering Supplement* for February 1919, the Davis Furnace Company, of Luton, England, have made a gas-fired furnace for annealing amorphous carbon electrodes to the order of a large steel works in the Midlands, which have an annual output of electric steel exceeding 30,000 tons. The furnace is 9 ft. wide by 5 ft. deep and 9 ft. high and can take 6 electrodes of sizes up to 22 in. in diameter. The walls are made of a special refractory material 9 in. thick and the heat is obtained from 6 "fan-air" burners consuming town's gas under a slight supplementary air pressure of about 6 in. water-column. The burners, which have each a $1\frac{1}{2}$ in. gas service and a $2\frac{1}{4}$ in. air supply, are placed three on each side of the furnace, and fire into combustion chambers or tunnels 12 in. wide by 5 in. high arranged under the floor of the heating chamber. The operation of annealing requires the accurate maintenance over long periods of temperatures ranging from 450° to 600° C. and the best results are obtained if the electrodes are annealed in a vertical position.

PURIFICATION OF ALUMINUM

According to a report in the *Chemical Trade Journal*, 64 (1919), 165, F. Milius, while experimenting on the purification of aluminum in the Reichsanstalt, Berlin, found that he could remove the silicon by fusing the metal with sodium nitrate but not the iron. On the other hand, the iron could be extracted by dilute hydrochloric acid while the silicon could be removed at the same time. His aluminum contained from 0.4 per cent to 2 per cent of impurities, mainly iron and silicon, in addition to traces of carbon, sulfur, phosphorus, and nitrogen. In the extraction he made use of aluminum purposely impregnated with up to 16 per cent of iron and chilled. Treatment with hydrochloric acid of 0.2 per cent reduced the iron to 0.1 per cent, but only 20 per cent of his aluminum was recovered as metal. When experiments were carried out with a very slowly cooled sheet aluminum, the iron content was reduced from 1 per cent to 0.1 per cent and a yield of 60 per cent of metal obtained. Aluminum surfaces which had taken up iron during the manufacture were successfully freed of iron by treatment with the same acid. An aluminum free from iron can thus be prepared by treatment with hydrochloric acid when part of the metal can be sacrificed. Milius also states that aluminum will crystallize as pure chloride from solutions in hydrochloric acid. It was also observed that when the metal was very slowly cooled in the mold, the porosity increased from the outside inward and that a rigid pipe formed. The percentage of impurities varied strongly in such cases in the different zones.

FRENCH ELECTROCHEMICAL INDUSTRY

In France, as in other countries, says the *Z. angew. Chem.*, the electrochemical industry is being rapidly developed. The production of chlorates and sodium and their derivatives by means of electric current generated by water power was established before the war, but great extensions are now called for. The Société d'Electrochimie is increasing its capital from 10 $\frac{3}{4}$ million francs to 15 million with a view to meeting industry requirements of the coming peace-time. The prospective needs of the dyestuff manufacturers have had a weighty influence in bringing about the decision to extend the works.

MAGNET STEELS

A good deal of research work has been done on magnet steel at the Reichsanstalt, Berlin, during the war, says *Engineering*, 107 (1919), 263, but only part of it has, so far, been published in the *Wissenschaftliche Abhandlungen*. One of the points investigated is the substitution of chromium steel for tungsten steel. Bar magnets of chromium steel stored for a year without being exposed to any disturbance kept their magnetic moment constant within 0.3 per cent and less. In all cases, the changes were within the limit of the experimental error in the second half of the year. As regards constancy to heat variations and concussions and temperature coefficient, the chromium steel proved equal to tungsten steel. In coercive force and residual magnetism the best chromium steel did not come up to the best tungsten steel. The temperature coefficient of the magnetic moment diminishes with increasing content of dissolved carbon and was found to be zero in a 1.4 per cent carbon steel. To investigate the suitable ratio of length to diameter in the case of bar magnets, a chromium steel originally 22 cm. in length and 0.6 cm. in diameter was gradually shortened to a length of 2.4 cm. This shortening raised the temperature coefficient from 2.4 up to 4.2 per cent. The ratio of length to diameter, l/d , was also found not to be without influence on magnetometer determination of the coercive force. When the value l/d fell below 10, these determinations gave too low values; practically, the point is not important.

LABOR SAVING IN SHIPS' STOKEHOLDS

An essential feature of the labor-saving system of firing ships' boilers invented by Erith's Engineering Co., 70 Gracechurch St., London, is the employment of water-tube boilers set at a higher level than is the case with hand firing, so as to permit the use of self-cleaning inclined underfeed stokers which continually discharge the ash and clinker to a low-level ash gangway at the rear of the boilers. The coal, instead of being taken by hand from the bottom of longitudinal bunkers, is lifted mechanically by a self-filling grab and mechanically transported to high-level hoppers, whence it is supplied down chutes to the mechanical stokers. It is stated that with this system in a 5,000 shaft h. p. ship, burning about 100 tons of coal a day, the three water-tube boilers required could be fired with less than a third of the number of men needed for the equivalent six four-flued Scotch boilers with hand-firing. Each stoker would normally work at two-thirds of its full capacity; hence, in case of failure of any one unit, the other two would be able to carry the full load.

PAINTING STEEL CEILINGS

The *Oil and Color Trade Journal*, 55 (1919), 827, gives the following as a method of preparing steel ceiling sheets with a gloss: After the sheets are stamped they are dipped into a thin liquid composed of a little zinc white and varnish thinned down with benzolene. Not enough zinc white is added to make the finish opaque, though this is hardly material, since the finish is applied by a painter who would much prefer a different prime coat, one quite dead or flat. If the steel has not been primed or coated in the factory, it is the duty of the painter to cleanse it of grease and dirt with benzolene or with alkaline solution. When dry, a coating of raw or boiled oil should be given, adding a little drier to the raw oil. While the makers of steel ceilings who prime the sheets use a primer with a pigment bath—zinc as a rule—yet it is still true that the best primer is the simple pure oil, raw or boiled. After priming with the oil and after it has become dry, any desired paint may be applied, although usually a gloss paint is given for preference. A soft, flattish effect is, however, sometimes used.

RUBBER VULCANIZATION WITHOUT SULFUR

Some years ago a series of papers by I. Ostromyolenski appeared in the *Journal of the Russian Physics and Chemistry Society* on vulcanization without sulfur by means of organic compounds resembling sulfur at the melting point, vapor tension at vulcanization temperature, solubility in rubber, and other properties. He first tried trinitrobenzene and afterwards dinitrobenzene and nitrobenzene, picric acid, peroxides, and other compounds, and came to the conclusion that the vulcanizing agent must be able to promote polymerization and to oxidize ethylene derivatives. Chemically, says *Engineering*, 107 (1919), 271, his researches were very interesting, but he was indefinite as to the mechanical tests of his vulcanized rubbers. Repeating many of his experiments and testing the mechanical properties of the products, H. P. Stevens (*J. Soc. Chem. Ind.*, 1917, p. 107) did not arrive at any satisfactory results. It appears that E. Burschoten, of the Netherlands rubber testing station at Delft, has again taken up the investigation, but he also has failed to obtain satisfactory vulcanization. He experimented with the compounds recommended by the Russian chemist, adding the various organic and inorganic accelerators. A certain amount of success was realized with lead oxides and in some other cases, but the vulcanized rubber always lost its strength again within a few weeks. Burschoten also questions the importance of oxidation. The oxidizing agents which he tried, *viz.*, arsenic acid, potassium permanganate, sodium nitrate, etc., did not affect the rubber in the way he intended.

RAPE STRAW AS PAPER MATERIAL

The *Paper Maker*, 57 (1919), 152, quoting from *Papier Zeitung*, states that rape straw may be used as a paper and fodder material. Examination of the rape plant gave the following figures: cellulose, 30.31 per cent; pentosans, 24.10 per cent; lignin, 40.06 per cent; and ash, 5.53 per cent. The composition of the plant substance is somewhat similar to that of cereal straw, which suggests that rape, like straw, might be used as a raw material both for paper-pulp and for fodder. A pulp prepared by the soda process had the composition: cellulose, 55.60 per cent; pentosans, 30.50 per cent; lignin, 10.10 per cent; and ash, 3.77 per cent. In consequence of the higher proportion of lignin in the rape straw as compared with the cereal straw, a sharper treatment is necessary in order to obtain a similar degree of resolutions. The pulp would be described from a technical point of view as a half-cellulose such as is employed for the manufacture of boards.

VACUUM-JACKETED VESSELS OF PORCELAIN

According to a report in *Engineering*, 107 (1919), 292, jacketed vessels of porcelain suitable for holding liquid air and made by the Royal Porcelain Factory, Berlin, have been tested at the Reichsanstalt. One vessel has a capacity of 2.75 liters and it was compared with a glass vacuum-vessel of the same size, both being silvered inside. When charged with liquid air, the porcelain vessel lost 28 g. per kg. of liquid by evaporation, while, under the same conditions, the glass vessel lost 40 g., both vessels being about one-half full. In this case, therefore, the porcelain was superior to the glass vessel. In similar tests made with water at varying temperatures above freezing point, the advantages were reversed, the glass proving the better heat insulator.

STRAINS IN QUENCHED AND COLD-DRAWN BRASS

Experimenting with cylinders of brass, 20 or 40 mm. in diameter and 160 mm. in length, A. Portevin (*Comptes rendus*, December 23, 1918) finds that these cylinders quenched in water after heating up to 760° C. or 850° C. displayed peculiar internal stresses when tested 15 days after quenching. The exterior of the cylinder was in a state of compression, the longitudinal stress amounting to about 10 kg. per sq. mm. Below the surface these stresses decreased and changed sign in the interior of the cylinder, finally a state of tension of about the same magnitude being observed at the center of the bar. The phenomena appeared reversed in experiments with cold-drawn brass. The drawn brass developed surface crusts, was easily broken on bending, and showed tension on the surface and compression in the interior. The stress values were higher than in the previous case and more unequal, the tension stress amounting to 24 kg. per sq. mm., the compression to 11 kg. per sq. mm. By drawing quenched bars, instead of annealed bars, the limits of brass drawing might be extended. He does not say that he actually made the experiments.

DRILL PROTECTOR

A drill protector, put on the market by Brown Brothers, Great Eastern St., London, is designed to prevent the breakage of small drills and by increasing their life to decrease the expenditure on them. Its function is to stiffen the shank of the drill, and it consists of a length of hard brass drilled from one end to the other and slotted on one side for about three-quarters of its length. Its internal diameter is equal to that of the drill to which it is applied, and the drill is inserted in it with the cutting point projecting from the chamfered end to a length equal to the depth of the hole that has to be bored. The split end of the projector is inserted in the drill chuck so that it is secured to about half an inch of its length, the chuck being tightened up in the usual manner.

SCIENTIFIC SOCIETIES

FIFTY-SEVENTH MEETING AMERICAN CHEMICAL SOCIETY, BUFFALO, N. Y., APRIL 7 TO 11, 1919

PROGRAM OF PAPERS

GENERAL SESSION

Address of Welcome. GEORGE F. BUCK, Mayor of Buffalo.
 Response. WILLIAM H. NICHOLS, President, American Chemical Society.
 The Future of American Chemical Industry. WILLIAM H. NICHOLS,
 American Chemical Industries and the Tariff Commission. WILLIAM
 S. COLBERTSON, U. S. Tariff Commission.
 The American Spirit in Chemistry. EDGAR F. SMITH, Provost, University
 of Pennsylvania.

Mustard Gas Symposium

1. General Properties. W. D. BANCROFT.
2. Mustard Gas at the Front. (Lantern.) B. C. GOSS.
3. Chlorhydrine Synthesis. M. GOMBERG.
4. Sulfur Chloride Synthesis. J. B. CONANT.
5. Manufacture of Mustard Gas. WILLIAM MARSHALL.
6. Tests. A. B. LAMB.
7. Accelerated Hydrolysis. R. E. WILSON.
8. Permeability of Protoplasma. CLOWES, LILLIE and CHAMBERS.
9. Permeability of Skin. CLOWES, MARSHALL and SMITH.
10. Protective Ointments. R. E. WILSON.
11. Protective Clothing. A. E. HILL.
12. Protective Clothing. CLOWES, PERROTT, GORDON and GREENS-FELDER.
13. Persistency. A. B. LAMB.
14. The Action Exerted by Antagonistic Electrolytes on the Electrical Resistance and Permeability of Emulsion Membranes. G. H. A. CLOWES.
15. Some Reactions of Mustard Gas. O. B. HELFRICH and E. EMMET REID.

AGRICULTURE AND FOOD CHEMISTRY DIVISION

- W. D. RICHARDSON, *Chairman* T. J. BRYAN, *Secretary*
1. Sampling Tankage and the Effect of Moisture on the Ammonia Content. PAUL SMITH.
 2. Light Weight vs. Heavy Oats. P. F. TROWBRIDGE.
 3. Soft Corn—Its Composition and Nitrogen Distribution. GEORGE SPITZER, R. H. CARR and W. F. EPPLE.
 4. A Modified Valenta Test for Butter. CHARLES P. FOX.
 5. Heat Penetration in Processing Canned Foods. (Lantern.) W. D. BIGELOW, G. S. BOHART and ALLAN C. RICHARDSON.
 6. A Further Study of the DeRoode Method for Determining Potash. T. E. KESTY.
 7. The Loss of Moisture from Sugar Samples under Different Methods of Preservation. C. A. BROWNE and G. H. HARDIN.
 8. Diets of Various Birds and Mammals. W. D. RICHARDSON.
 9. The Diets of Various Peoples in the Light of the Vitamine Doctrine. W. D. RICHARDSON.
 10. The Indispensability of Milk in the Adult Diet. W. D. RICHARDSON.

BIOLOGICAL CHEMISTRY DIVISION

- I. K. PHELPS, *Chairman* R. A. GORTNER, *Secretary*
1. Capsaicin, the Pungent Principle of Capsicum. E. K. NELSON.
 2. The Relation of the Physical Properties of Organic Compounds to Their Toxicity to Insects. WILLIAM MOORE.
 3. Studies of the Chemotherapeutic Type upon Insecticides and Fungicides. C. L. ALSBERG.
 4. The Absence of Fat-Soluble—a "Vitamin" in Glanular Fats. A. D. EMMETT and G. O. LUDOS.
 5. The Nutritive Value of Peanut and Soy Bean Flours as Supplements to Wheat Flour. C. O. JOHNS, A. J. FINES and MABEL S. PAUL.
 6. A Volumetric Method for the Detection and Estimation of Neutralizers in Dairy Products. L. W. FERRIS.
 7. Carbon Monoxide—a Respiration Product of Kelp. SEYMOUR C. LANGDON.
 8. The Effect of X-Rays on the Length of Life of *Tribolium Confusum*. WHEELER P. DAVEY.
 9. The Occurrence of Gossypol in Different Varieties of Cottonseed. C. L. ALSBERG, E. W. SCHWARTZ and E. T. WHERRY.
 10. Criticism of the Eckert Method of Determining Nitrogen by the Kjeldahl Method in Nitro Derivatives. I. K. PHELPS.
 11. A Discussion of the Accuracy of the Determination of Nitrogen in Organic Substances by the Kjeldahl Method. I. K. PHELPS.
 12. Do Mold Spores Contain Enzymes? (By Title.) NICHOLAS KOPFLOFF and LILLIAN KOPFLOFF.
 13. The Influence of Ammonium Hydroxide on the Oxidation of Acetone and on the Acetone Yield from the Oxidation of Butyric Acid. (By Title.) EDGAR I. WITZEMANN.

14. The Biological Test for Determining the Fertilizer Needs of a Particular Soil or Crop. R. P. HIBBARD and S. GUSHBERG.
15. The Quantity and Composition of Ewes' Milk: Its Relation to the Growth of Lambs. (By Title.) RAY E. NEIDIG.

INDUSTRIAL CHEMISTS AND CHEMICAL ENGINEERS DIVISION

H. S. MINER, *Chairman*H. E. HOWE, *Secretary*

I—Symposium on Library Service in Industrial Laboratories

1. The Public Library in the Service of the Chemists. ELWOOD H. MCCLELLAND, Technology Librarian, Carnegie Library of Pittsburgh.
2. Axioms in the Use and Abuse of Special Libraries. HELEN R. HOSMER, formerly of General Electric Co., now with Dr. Geo. W. Crile Laboratory.
3. Methods Employed in the Industrial Library of Eastman Kodak Company. GERTRUDE REISSMAN.
4. Relation of the Library to Industrial Laboratories. W. P. CUTTER, The Chemical Catalog Co., Inc.
5. Functions of the Industrial Library—that of Arthur D. Little, Inc., a Type. E. D. GREENMAN.
6. Functions of a Research Library in the Dyestuffs Industry. JULIAN F. SMITH, National Aniline & Chemical Co., Inc.
7. Interior Publicity as an Aid to the Laboratory. S. M. MASSIE, National Carbon Co., Inc.
8. Long Distance Library Service of the New Jersey Zinc Co. L. A. TAPPEL.
9. Features of the Library of Stone & Webster. G. W. LEE.
10. Work of the Library of The Solvay Process Co. W. I. NEILL.
11. Special Library Service in The Barrett Company. E. C. BUCK.
12. Library Service in the Chemical Department and Chemical Department Laboratories of the E. I. du Pont de Nemours & Company. F. L. GALLUP.

II—Symposium on the Future of Certain American-Made Chemicals

1. Some Present-Day Problems of Chemical Industry. R. F. BACON AND W. A. HAMOR.
 2. A Possible Menace to American Chemical Independence. W. D. COLLINS.
 3. Quality First to Insure Increased Success of the Chemical Industry of the United States. JORIKI TAKAMINE, JR.
 4. Phenol. ALBERT G. PETERREIN.
 5. Cellulose Acetate. H. S. MORSE.
 6. Unusual Organic Chemicals. HANS T. CLARKE.
- Also W. J. HALE, L. M. TOLMAN, H. A. METZ, and general informal discussion.

III—Papers

1. Tactical Uses of Smoke. (Lantern.) BYRON C. GOSS.
2. Chemical Work in the Canning Industry. W. D. BIGELOW.
3. Corrosion Tests on Commercial Calcium Chloride Used in Automobile Anti-Freeze Solutions. (Lantern.) PAUL RUDWICK.
4. Oxidation in the Manufacture of TNT. A. S. EASTMAN.
5. A New Bomb Calorimeter for Industrial Laboratories. W. L. BADGER.
6. Non-Metallic Inclusions in Steel. E. G. MAHIN.
7. Mineral Rubber. GUSTAV EGLOFF.
8. Manufacture of Castor Oil. J. H. SHERADER.
9. Possibility of Commercial Utilization of Oil from Cherry Pits, Tomato Seed and Grape Seed. J. H. SHERADER.
10. Sugar Saving by Home-Grown Sugar Beets. JOHN M. ORT and JAMES P. WITKROW.
11. Testing the Mildew Resistance of Fabrics. F. P. VEITCH and S. S. LEVINE.
12. Testing Materials for Increasing the Water Resistance of Sole Leather. H. P. HOLMAN and F. P. VEITCH.
13. Method for Determining the Water Resistance of Fabrics. F. P. VEITCH and T. D. JARRELL.
14. An Impact Tester for Solid and Corrugated Fiber Board. E. O. REED and F. P. VEITCH.
15. Waterproof Papers for Box Lining and Bale Wrapping. F. P. VEITCH and E. O. REED.
16. Lead-Coated Iron. (Exhibits.) CHARLES BASKERVILLE.
17. Reinforced Lead. (Exhibits.) CHARLES BASKERVILLE.
18. Utilization of Asphaltic Base Acid Sludge from Petroleum. CHARLES BASKERVILLE.
19. Equilibrium Studies on the Bucher Process. JOHN B. FERROUSON and P. D. V. MANNING.
20. Design for Electrically Heated Bomb for Ammonia Synthesis. (Lantern.) R. O. E. DAVIS and H. BRYAN.
21. Purification of Compressed Gases in Testing Catalysts for Ammonia Synthesis. (Lantern.) R. O. E. DAVIS.
22. Preparation of Nitrogen and Hydrogen Mixture by Decomposition of Ammonia. (Lantern.) R. O. E. DAVIS and L. B. OLMSTEAD.

23. Explosion of Gases Used in Ammonia Synthesis. (Lantern.) R. O. E. DAVIS.
24. Some Chemical Needs of the Vegetable Oil Industry. DAVID WESSON.

ORGANIC CHEMISTRY DIVISION

L. W. JONES, *Chairman* H. L. FISHER, *Secretary*

1. The Use of Sulfur Chlorides and Chlorine for the Production of Organic Acid Chlorides from Organic Acids. ROGER ADAMS.
2. Synthesis of Chloride Derivatives—III. R. R. RENSHAW AND C. E. GREENLAW.
3. Trimethyl Phosphine and Certain of Its Derivatives. R. R. RENSHAW AND F. K. BELL.
4. Trimethyl Arsenic and Its Selenide. R. R. RENSHAW AND G. E. HOLM.
5. Phenylimidophosphene and Some Reactions of Formanilide. W. LEE LEWIS AND G. A. PERKINS.
6. The Ammonocarbonous and Ammonocarbonic Acids. E. C. FRANKLIN.
7. The Reaction between Dimethyl Sulfate and Benzene. OLIVER KAMM AND S. D. KIRKPATRICK.
8. Contribution to the Study of the Relationship between Chemical Constitution and Physiological Action. OLIVER KAMM.
9. A Study of Some of the Carbohydrates on the Corn Cob. R. R. RENSHAW AND W. J. SUER.
10. Synthesis and Properties of Certain Dyes Containing the Furan Cycle. R. R. RENSHAW AND NELLIE M. NAVLOR.
11. The Preparation of Pure Organic Chemicals. H. T. CLARK.
12. Acetylene. WILLIAM MALISOFF AND GUSTAV EGOLOFF.
13. Ethane. WILLIAM MALISOFF AND GUSTAV EGOLOFF.
14. The Occurrence of Melezitose in Honey. C. S. HUDSON AND S. F. SHERRWOOD.
15. The Chemistry of Electrical Insulators. H. C. P. WEBER.
16. The Estimation of Mercaptans. R. L. KRAMER AND E. EMMET REID.
17. Alcoholysis as a Factor in the Determination of Saponification Values. A. M. PARDEE AND E. EMMET REID.
18. 1,2-Dichloroether. E. A. WILDMAN AND HAROLD GRAY.
19. Aromatic Ethers. J. M. JOHLIN.

PHARMACEUTICAL CHEMISTRY DIVISION

F. O. TAYLOR, *Chairman* G. D. BEAL, *Secretary*

Symposium on Possibilities in Drug Research

Special papers of the general topic discussed by Charles H. Herty, C. H. A. Clowes, John Uri Lloyd, the Chairman and others.

1. Coöperation Drug Research. F. R. ELDERED.
2. Simple Physical and Biological Models with Which to Study the Penetration and Functions of Drugs. G. H. A. CLOWES.
3. Western Poisonous Plant Investigations. O. A. BEATH.
4. The U. S. P. Assay for Mercurial Ointment. L. F. GABEL.
5. Alkaloids. M. H. WEBSTER.
6. The Preparation of Vitamine-activated Fuller's Earth. ATHERTON SHIDELL AND R. R. WILLIAMS.
7. Further Studies of the Properties of the Vitamine of Brewers' Yeast. R. R. WILLIAMS AND ATHERTON SHIDELL.
8. Chlorotone: Trichlor Tertiary Butyl Alcohol. A Description of Some of Its Properties. H. C. HAMILTON.
9. Color Standards for Cottonseed Oil. (By Title.) H. V. ARNY.

PHYSICAL AND INORGANIC CHEMISTRY DIVISION

W. E. HENDERSON, *Chairman* W. A. PATRICK, *Secretary*

1. Action of Perchloric Acid on Metals and Non-metals. H. H. WILFARD AND A. H. HUISEKIN.
2. Perchloric Acid as an Oxidizing Agent in the Determination of Chromium Vanadium. H. H. WILFARD AND W. E. CAKE.
3. Perchloric Acid as a Dehydrating Agent in the Determination of Silica. H. H. WILFARD AND W. E. CAKE.
4. The Arrangement of Electrons in Atoms and Molecules. IRVING LANGMUIR.
5. Preferential Catalysis and the Purification of Hydrogen. H. S. TAYLOR.
6. New Measurements on the Direct Synthesis of Ammonia. (Lantern.) L. H. ADAMS.
7. Application of the Thermionic Amplifier to Conductivity Measurements. (Lantern.) L. H. ADAMS AND R. E. HALL.
8. Electrometric Titrations, with Special Reference to the Determination of Ferrous and Ferric Iron. (Lantern.) J. C. HOSTETTER AND H. S. ROBERTS.
9. The Effect of Strain on Solubility. (Lantern.) J. C. HOSTETTER.
10. A Method of Growing Large Perfect Crystals from Solution. (Lantern.) ROY W. MOORE.
11. Action of Nitrogen and Hydrogen Mixture on Steel at High Pressure and Temperature. (Lantern.) R. O. E. DAVIS.
12. Comparative Tests of Palau and Rhotanium Ware as Substitutes for Platinum Laboratory Utensils. (Lantern.) L. J. GUREVICH AND E. WICHERS.
13. Hydrogen Overvoltage; Applications to Reduction, Metal Corrosion and Deposition. (Lantern.) D. A. MACLINCIN AND A. W. CONTERI.
14. The Ternary System CaO-MgO-SiO₂. (Lantern.) JOHN B. FERGUSON AND H. E. MERWIN.

15. The Influence of Chemical Composition on the Birefringence in Strained Glass. (Lantern.) ESKINE D. WILLIAMSON.
16. The Determination of Oxygen by the Copper-Ammonia-Ammonium Chloride Reagent. W. L. BADGER.
17. Fluidity and Hydration. (Lantern.) EUGENE C. BINGHAM.
18. The Preparation of Cyanogen Chloride. W. L. JENNINGS AND W. B. SCOTT.
19. Electrolytic Preparation of Permanganates. CHARLES HECKER.
20. A Study of the Constant-Boiling Mixture of Hydrochloric Acid and Water. MARION HOLLINGSWORTH.
21. A Holder for Spools of Iron Wire for Standardization. MARION HOLLINGSWORTH.
22. A New Burette Support. MARION HOLLINGSWORTH.
23. The Rapid Determination of Titanium in Titaniferous Iron Ores. JOHN WADDELL.
24. The Calculation of the Efficiency of the Silent Discharge Process for Nitrogen Fixation. F. O. ANDEREGG.
25. The Viscosity of Casein Solution. I. The Effect of Ph. HARPER F. ZOLLNER.
26. Periodic Vibrations in Gels. J. M. JOHLIN.
27. Boiling Point of Liquids. F. P. SORREL.
28. (1) Molecular State of Water Vapor. (2) Vapor Pressure Depression Equation for Dilute Aqueous Solutions. JAMES KENDALL.
29. Size and Behavior of Suspended Smoke Particles. R. E. WILSON.
30. Influences Exerted by Antagonistic Electrolytes on the Electrical Resistance and Permeability of Emulsion Membranes. G. H. A. CLOWES.
31. The Exact Determination of Molecular Weights by the Boiling-Point Method. E. M. WASHBURN.
32. Solubility of Strontium Nitrate in Anhydrous Alcohol in Alcohol Containing Small Per cent of Water. C. W. FOULKE.
33. (1) Influence of the Age of Ferric Arsenate on Its Peptization. (2) Syneresis of Silicic Acid Gels. H. N. HOLMES.
34. A Study of the Lowering of Vapor Pressure of Water Produced by Absorbed KCl. B. F. LOVELACE, J. C. W. FRASER, AND V. B. SEASE.
35. A Study of the Lowering of Vapor Pressure of Water Produced by Absorbed Mannite. J. C. W. FRASER, B. F. LOVELACE AND T. H. ROGERS.
36. The Volume and Surface of the Pores in Charcoal and the Compression of Adsorbed Substances. W. D. HARKINS AND D. T. EWING.
37. An Electromagnetic and Valence Hypothesis of Heterogeneous Equilibrium and Adsorption. W. D. HARKINS.

WATER, SEWAGE AND SANITATION DIVISION

R. W. WESTON, *Chairman* W. W. SKINNER, *Secretary*

1. Determination of Bromide in Mineral Waters and Brines. W. W. SKINNER AND W. F. BAUGHMAN.
2. Certain War Gases and Health. CHARLES BASKERVILLE.

ANNUAL MEETING DIVISION OF CHEMISTRY AND CHEMICAL TECHNOLOGY, NATIONAL RESEARCH COUNCIL

The meeting was held at the offices of the National Research Council, Washington, D. C., on March 21 and 22, 1919. Mr. John Johnston, chairman of the Division presided.

The chairman made a brief statement concerning the history of the chemical work of the Council and this was followed by a report from the vice chairman, Mr. E. W. Washburn, concerning the work of the Division during the past year.

As a result of drawing by lot the following distribution of members as to terms was obtained:

To serve for one year: Messrs. Alsberg, Bancroft, Derick, Moore, Noyes and Washburn.

To serve for two years: Messrs. Franklin, Johnston, Teeple, Bleininger, Lamb and Parsons.

To serve for three years: Messrs. Francis, Hillebrand, Stieglitz, Fink, Herty and Hulett.

It was voted that the Executive Committee of the Division consist of five members—the chairman and vice chairman of the Division, together with three others elected by the Division.

Mr. Noyes presented for discussion a description of the plans of the Council with reference to the establishment of National Research Fellowships in physics and chemistry.

The chairman appointed Messrs. Bleininger and Hillebrand to act with him as the Nominating Committee. This committee later reported the following nominations:

Chairman of the Division: W. D. Bancroft.

Vice Chairman: Julius Stieglitz.

Executive Committee: C. L. Alsberg, A. B. Lamb, A. A. Noyes.

These nominees were unanimously elected.

Mr. Noyes presented a statement concerning the plans for the formation of an International Research Council and an International Chemical Council. It was voted that the Division express its unqualified approval of the admission of neutral nations to the International Research Council on the conclusion of peace, such nations to be admitted on the same terms as the nations now at war with the Central Powers; and that a delegate be sent to Paris with instructions to this effect, the selection of this delegate to be left to the chairman and the chairman-elect of the Division and the chairman of the National Research Council.

It was also voted that the Division transmit the above action to its constituent societies with the suggestion that each society take action with regard to this matter. See page 394, this issue.

Dr. Stieglitz, chairman of the AMERICAN CHEMICAL SOCIETY Committee on Compendia, presented the recommendations which that committee expects to make to the Council of the AMERICAN CHEMICAL SOCIETY at the April meeting. See page 415, this issue.

It was voted that the Division signify its approval in principle of the recommendations contained in the report and that this approval be transmitted to the Council of the AMERICAN CHEMICAL SOCIETY.

The Report to the Executive Committee of the International Research Council from the Committee on International Cooperation in Chemistry Appointed at the Paris Conference, this being a draft report by Messrs. Haller, Frankland, Moureu, Nasini, Noyes, and Sakurai, was considered paragraph by paragraph and finally approved in the form given in Appendix B.

The minutes of the meeting of the Executive Committee, as displayed in Appendix C, were read and the actions taken approved by the Division.

It was voted that it is the sense of this Division that in the case of fellowships awarded under the auspices of the National Research Council the title "National Research Fellow" be limited to post-doctorate fellowships (*i. e.*, fellowships awarded to candidates having the doctor's degree or an equivalent training); and that other fellowships have simply a title indicating the special field of research, *e. g.*, Research Fellow in Ceramic Chemistry.

It was voted that the Division recommends that all plans looking toward the formation of a separate international council for industrial chemistry should be abandoned and that instead there should be formed only a single International Chemical Council to represent all branches of chemistry.

A number of suggestions were made as to the possible activities of the Division and there was considerable discussion, but no positive action on any of these plans was taken.

APPENDIX B

RECOMMENDATIONS OF THE DIVISION OF CHEMISTRY AND CHEMICAL TECHNOLOGY WITH RESPECT TO THE FORMATION OF AN INTERNATIONAL CHEMICAL COUNCIL

1—That an International Chemical Council be constituted and that, if possible, arrangements be made for transferring the funds originally given to the International Association of Chemical Societies to this International Chemical Council.

2—That the object of the International Chemical Council shall be to initiate and promote international cooperation in chemistry; for example, by arranging:

(a) For international cooperation in the preparation and publication of chemical literature.

(b) For the appointment of international commissions to deal with special chemical questions of standardization (such as atomic weights, nomenclature, etc.).

(c) For international cooperation in the prosecution of special research projects.

(d) For the calling of international chemical conferences for various purposes; and also for the organization of an International Chemical Congress with meetings at stated intervals, and including all of the scientific and technological branches of chemistry.

3—That the International Chemical Council be constituted of delegates from the several allied and neutral countries, the voting strength of each of the several countries being the same as that in force in the International Research Council.

4—That the International Chemical Council be affiliated with the International Research Council, and that the Research Council of each country act as the intermediary in communications between the International Chemical Council and the chemical societies of that country.

5—That the delegates from each country shall in general be chosen by the major chemical societies in that country, but that the number and distribution of such delegates be determined initially by the National Research Council of that country, with the understanding that in countries where a National Research Council shall not have been organized the National Academy itself shall fulfill this function until the National Research Council is organized.

6—That the International Chemical Council, as soon as it shall be organized, shall elect an Executive committee of seven members which shall exercise such functions as may be assigned to it by the Council. The Executive Committee shall appoint an executive secretary, who shall have charge of correspondence and of the central office of the Council.

7—That until the International Chemical Council shall be organized and its Executive Committee appointed, the Committee on International Cooperation in Chemistry appointed by the Paris Conference shall act as a provisional Executive Committee for purpose of organization. Its membership shall, however, be increased by the addition of four members representing industrial chemistry, to be appointed, respectively, by the Royal Society of London, the Academie des Sciences de France, the Accademia dei Lincei, and the National Research Council of the United States. This committee shall elect a chairman and a secretary; but the latter need not be a member of the committee.

8—That the American delegation should initially be constituted as follows:

Four delegates chosen by the American Chemical Society
One delegate chosen by the American Electrochemical Society
One delegate chosen by the American Ceramic Society
One delegate chosen by the American Institute of Chemical Engineers

it being understood that about half of the total number of these delegates shall represent technological chemistry. Further, that this group should preferably meet with the Division of Chemistry and Chemical Technology of the National Research Council for a full discussion of the propositions to be brought up at the International Conference and a determination of the policy to be pursued by the American group.

APPENDIX C

MINUTES OF THE MEETING OF THE EXECUTIVE COMMITTEE OF THE DIVISION OF CHEMISTRY AND CHEMICAL TECHNOLOGY

The following resolutions concerning the policy of the Division with respect to the formation of committees were approved: *Resolved:*

1—That it shall be the policy of the Division to form committees only for the purpose of undertaking definite projects.

2—That all committee appointments be for one year, or until the completion of the work of the committee and the submission of its final report in case less than a year is required.

3—That on the discharge of any committee all of its records shall be sent to the Washington office of the Division for preservation.

The following resolution concerning the formation of a Committee on Ceramic Research was adopted:

Resolved:

1.—That the Division invite the American Ceramic Society to form with it a joint committee on ceramic research of which the representative of the Ceramic Society on the Division shall be chairman *ex officio*.

2.—That the committee consist of five members, two to be nominated by the Executive Committee of the Division and two by the board of trustees of the American Ceramic Society.

3.—That this committee undertake the following work:

(a) Outline a number of important research projects of a character which can be undertaken in university laboratories.

(b) Ascertain in the case of each project what institution is able and willing to undertake the investigation.

(c) Raise by subscription from the industries a fellowship fund for each project, this fund to be used for the establishment of a two-year fellowship, a portion of the fund to be available for traveling expenses, apparatus, supplies, etc. It shall be understood that all funds raised for such purposes shall be paid to the treasurer of the National Research Council, to be disbursed by him under the direction of the Committee on Ceramic Research; and that in connection with all such fellowships regular reports shall be rendered to the chairman of the committee and that a copy of the report be transmitted to each subscriber to the fund.

(d) Make a study of the desirability and possibility of compiling a research census of the ceramic research in progress in the country, and if the preparation of such an index is deemed desirable and practicable undertake its compilation.

(e) In cooperation with the Section on Industrial Research of the National Research Council endeavor to secure the establishment of cooperative research laboratories in those branches of ceramics where such an undertaking seems feasible.

(f) Secure, if possible, a statement of the plans of the Director of the Census with reference to collecting ceramic statistics in the coming census, and endeavor to secure such modification of, and additions to, these plans as it thinks desirable in order that such statistics shall be as complete and as useful as possible.

(g) Take the initiative in attempting to secure the inauguration of cooperative effort by the appropriate agencies in the country in carrying out certain broad projects in ceramic research, such, for example, as the Cooperative Survey of Ceramic Raw Materials, initiated at the Pittsburgh Conference of last May.

It was voted to continue the Committee on Synthetic Drugs for one year to complete the work already under way.

It was voted that the committee on Explosives Investigations be continued in its present form pending further action after interviews with the Army and Navy authorities with reference to the continuance of this committee.

It was voted that it be the policy of the Division not to accept any funds for research which carry any stipulation abridging freedom with regard to publication.

After discussion, the committee nominated Professor E. P. Kohler of Harvard University for membership on the Research Fellowship Board of the Council.

AMERICAN ELECTROCHEMICAL SOCIETY

April 3 to 5, 1919, the American Electrochemical Society met at the Chemists' Club, in New York City. Two hundred and thirty members and nearly a hundred guests registered, and each session was participated in by about a hundred—sufficient to keep the proceedings lively but not so many as to discourage snappy discussion and criticism.

At its meeting Wednesday night the Board of Directors, finding the financial condition of the Society flourishing, appropriated \$2000 for subscription to the coming Victory Loan. The Society already holds \$8000 in Liberty Bonds.

At the annual business meeting of the Society on Thursday morning, April 3, the secretary reported a present membership of 1928, a net gain of 278 in the past year. The result of the election of new officers showed:

President: W. D. Bancroft.

Vice Presidents: J. V. N. Dorr, W. R. Whitney, Carl Hering.

Managers: H. C. Parmelee, R. E. Zimmerman, E. Blough.

Treasurer: P. G. Salom.

Secretary: J. W. Richards.

The Board of Directors reported the election to honorary membership of Prof. Charles F. Chandler, of New York City, and Dr. Edgar F. Smith, of Philadelphia, Provost of the University of Pennsylvania.

A report of the Public Relations Committee (composed of the past presidents of the Society), concerning governmental ownership and operation of water powers, brought out an animated discussion. The report itself was short and came out flat-footedly against governmental ownership and operation; it was accompanied by a presentation of the subject at length by Mr. F. A. J. FitzGerald, in which the unfortunate experiences of Canadian electrochemical industries at the hands of the Ontario Hydro-Electric Commission were held up as a sufficient warning to the United States to avoid similar pitfalls. The opposition to the adoption of the report was in the minority, and it was passed as the sense of the meeting by a large majority. It may therefore be taken as the opinion of the Electrochemical Society that in the present condition of interference of politics in the management of public utilities, and of inefficiency in general in government-run enterprises, that the ownership and operation of water powers by the Government is inadvisable, at least as far as concerns its influence on the industries using large amounts of power.

A resolution was passed endorsing the bills introduced into Congress by Secretary Lane providing for surveys of the water-power resources of the country, and particularly of the power resources of the Atlantic seaboard.

Mr. Edwin J. Prindle addressed the meeting upon the proposed new patent office regulations and patent legislation, and introduced a motion that these proposals, as formulated by the Patent Committee of the National Research Council, be endorsed by the Society. The Society was in hearty accord with the movement, and passed the resolutions.

A committee of the Society reported upon the sign of the potential of the zinc electrode, the majority agreeing upon calling it negative, while a minority wished to retain the positive sign. The meeting decided that, pending a final agreement on this point, the papers published in the Transactions of the Society should use the negative sign for the zinc electrode.

The retiring president of the Society, Mr. F. J. Tone, then made his presidential address, dealing with the problems of reconstruction and readjustment which now face the electrochemical industries. He held that the lessons of the war, obtained at a great price, would be most profitable if their full value was extracted by a proper appreciation of their usefulness, and illustrated this thesis by reference to many industries which had been practically revolutionized by their war experiences.

Dr. E. F. Northrup, of Princeton, then explained the principles of the oscillatory current induction electric furnace. A truly classical paper, containing the full mathematical treatment of this new method of heating, had been written and printed in advance. It is impossible to abstract it; those interested must consult the original paper. Small furnaces operating on this principle are already in commercial use, while larger ones are being studied and designed.

The Thursday afternoon session was filled by reading and discussion of papers:

Uranium. C. GIN. Discussed very clearly by S. C. LIND.

Notes on Electrostatic Precipitation. H. D. BRALEY. Actively discussed and the limitations of the method brought out.

Electrolytic Silver and Gold Refining at Perth Amboy. C. G. GRISWOLD. Describing in detail the Moebius and Wohlwill processes as there used.

A Process of Electrolytically Refining Nickel. G. A. GUESS. In which calcium carbonate is suspended in the electrolyte in the anode compartment and completely precipitates from solution any copper extracted from the anode, thus keeping it out of the cathode nickel.

Electroplating on Iron from Copper Sulfate Solution. O. P. WATTS. A study of using so-called "striking" solutions or dips, as of arsenic salts, in order to first coat the iron with another metal before depositing copper on it.

Remarkable Pitting of Electroplating. O. P. WATTS. An instance of air bubbles separating out of the electrolyte on the work during the night while the bath was not working, and then being plated with lead and causing deep pits when the bath was started in the morning.

The Nelson Electrolytic Chlorine Cell. C. F. CARRIER. A detailed description of the development and present construction and operation of the most extensively used chlorine cell, installed by the Government at the Edgewood Arsenal.

Over one hundred participated in the dinner at the Chemists' Club, on Thursday evening, after which, adjoining to Rumford Hall, W. A. Landis, chief technologist of the American Cyanamid Company, delivered an exceedingly clear and instructive address on the history and present status of the oxidation of ammonia to nitric acid. It was a masterly exposition of the lecturer's first-hand experiences in the development of the electrically-heated catalytic apparatus installed under his direction at the Muscle Shoals government plant, and by which 3500 tons of nitric acid were manufactured. The lecture was finely illustrated and extensively discussed.

Friday was devoted to a Symposium on Released Information—most of it electrochemical or closely related thereto. Dr. W. H. Walker described, with the assistance of numerous lantern slides, the chemical installations under his direction at the Edgewood Arsenal. The other papers were:

Silicon Tetrachloride. O. HUTCHINS. Dealt with the mass production of this very efficient smoke producer, in electric furnaces at Niagara Falls.

Silicon and Titanium Tetrachlorides in the War. G. A. RICHTER. Further description of the manufacture and use of these chemicals.

A Portable Electric Filter for Smoke and Bacteria. A. B. LAMB. Described a miniature Cottrell apparatus run by a small induction coil, the whole being carried by the man using it. A particular feature was the very small air resistance required for operation, and it was noted that bacteria in the air were extracted completely and killed—suggesting its use in plague hospitals.

The Electrolytic Preparation of Fluorine. W. L. ARGO, F. C. MATHERS, B. HUMSTON and C. O. ANDERSON. Described the electrolysis of fused KHF_2 , by which fluorine is as easily prepared as a lecture experiment as chlorine or oxygen.

Production of Sodium Permanganate from Ferromanganese. R. E. WILSON and W. G. HORSCH. Told of the use of ferromanganese as anodes in sodium carbonate solution, producing permanganate at about 80 cents per lb. as a war process.

Lead Plating of Shell Interiors and Boosters. A. G. RENN. Related how the Oneida Community placed its plating facilities at the service of the Government to plate lead on the interior of gas shells. The discussion by Capt. G. A. Roush brought out the further fact that light-weight rejected shells could thus be brought up to proper weight by an extra heavy plating.

Electric Furnace Manufacture of Silicomanganese. B. G. KLUGB. Described making low iron alloys with 20 to 50 per cent of silicon and 20 to 70 per cent of manganese, during the recent shortage of ferro-silicon.

Electric Furnaces Used in Producing War Materials. T. F. BAILEY. Dealt with automatic electric hardening and tempering furnaces for treating cast-steel anchor chains, airplane parts, railway coupling knuckles, etc., and for melting brass, the furnaces being literally shown in action by splendidly taken moving pictures.

White Arsenic for Mispickel. C. A. DORRUS. Described a small plant operated in Connecticut during the war.

The Introduction of the Electric Furnace into Foundry Practice. W. E. MOORE. Improving the Quality of Grey Iron in the Electric Furnace. G. K. ELLIOTT. Described the latest practical use of the electric furnace in the foundry, and were actively discussed by Dr. R. Moldenke and other iron and steel experts.

Friday evening's entertainment and smoker were in the competent hands of Section Q, which kept up the festivities till midnight.

Saturday morning one hundred and twenty packed into four large sightseeing busses, left the Chemists' Club at nine o'clock and passing over the Fifty-ninth Street bridge to Brooklyn,

spent a few minutes in the Loose-Wiles Biscuit Factory, a longer stay at the Wright-Martin Aircraft Plant, and the rest of the morning at the Nichols Copper Works, inspecting the largest copper refinery in the world. The visitors were entertained at lunch by the Nichols Company, and returned to New York in the afternoon.

Altogether it was a most profitable, sociable, instructive meeting, up to the best traditions of this very active society.

LEHIGH UNIVERSITY
SOUTH BETHLEHEM, PA.
April 7, 1919

J. W. RICHARDS

NATIONAL RESEARCH FELLOWSHIPS IN PHYSICS AND CHEMISTRY

In addition to the information given in the April issue of THIS JOURNAL concerning the National Research Fellowships in Physics and Chemistry, supported by the Rockefeller Foundation and administered by the National Research Council, the following statements have been published in a descriptive leaflet by the National Research Council:

National Research Fellows will be permitted to conduct their investigations at institutions that will cooperate in meeting their needs. These needs differ widely from those of students seeking only instruction. Able investigators, actively engaged in productive research, are needed to inspire and guide the work of the Fellows. Research laboratories, adequately manned with assistants and mechanicians, and amply supplied with instruments, machine tools, and other facilities, are indispensable; and funds to provide supplies and to satisfy the constantly recurrent demands of research must be available. Above all, there must exist the stimulating atmosphere found only in institutions that have brought together a group of men devoted to the advancement of science through pursuit of research.

The Research Fellowship Board expects to make arrangements by which educational institutions will associate the Research Fellows with their graduate departments and offer the most favorable conditions for the prosecution of their researches.

The applicant will indicate one or more institutions at which, in his opinion, his research work can be conducted to the best advantage.

In making the appointments much weight will be given to the judgment shown by the applicant in selecting and planning his proposed research.

The Research Fellowships will for the most part be awarded to American citizens who have had training equivalent to that represented by the doctor's degree.

Research Fellows are expected to devote their entire time to research, except that during the college year they may at their option give not more than one-fifth of their time (outside preparation included) to teaching of educational value to themselves, or to attendance on advanced courses of study. They may associate graduate students with their researches. They shall not engage in work for remuneration during the term of their appointment. Fellows who have not received the doctor's degree may, with the approval of the institution, offer their research work in partial fulfillment of the requirements for that degree.

Fellows are expected to submit to the Board shortly before the first of April of each year a detailed report on the progress of their researches. They must also present an account of their researches in form for publication before withdrawing from the Fellowship; and final salary payments will be deferred until this condition is fulfilled. It is understood that all results of investigation by the Fellows shall be made available to the public without restriction.

Fellowship appointments are subject to the condition that after they are accepted by the applicant, they will not be vacated within the year without consent of the Research Fellowship Board.

CALENDAR OF MEETINGS

- American Zinc Institute—Annual Meeting, St. Louis, Mo., May 12, 1919.
American Association of Engineers—Meeting, Chicago, Ill., May 13 and 14, 1919.
American Institute of Chemical Engineers—Summer Meeting, Boston, Mass., June 18 to 21, 1919

American Society for Testing Materials—Twenty-second Annual Meeting, Atlantic City, N. J., June 24 to 27, 1919.

Society for the Promotion of Engineering Education—Twenty-seventh Annual Meeting, Johns Hopkins University, Baltimore, Md., June 25 to 28, 1919.

NOTES AND CORRESPONDENCE

THE SOLDIER, THE SAILOR, AND THE CHEMIST

Editor of the Journal of Industrial and Engineering Chemistry:

Your editorial in the March issue entitled "The Soldier, the Sailor, and the Chemist" proved to be of considerable interest to me, as well as to the directors of the Engineer School at Camp A. A. Humphreys, Va.

Having entered the service in the early weeks of the war as a civilian member of the Gas Warfare Investigations in the Bureau of Mines, I remained with it from the first days of a few rooms in the New Interior Building, through the months of rapid growth, until it was merged into the Chemical Warfare Service. Too much credit cannot be given the men whose vision, energy, and practical consideration initiated the development of chemical investigation in this country. The service and association with them will always be regarded as the best of fortune.

After a careful reading of the editorial, it is admitted that the basic logic cannot be refuted. Yet the statements regarding chemical pedagogy at West Point and Annapolis could be aimed more justly and more severely at a number of our universities. Any justification, however, of former procedure at the Military or Naval Academy is beyond the point. The past is done, and its lessons are but recently left with us. The facts which should have been learned are vivid and demand action. The teacher of chemistry or chemical engineering subjects should realize distinctly that the future welfare and prosperity of the country will be in direct ratio to the caliber of the scientific and technical forces which are developed. A number of capable instructors, following an orderly routine, have allowed themselves to become cloistered. While it is vitally necessary to continue and carry on, in the universities, all research of any scientific value, the teacher is apt to become so imbued with his own tasks and viewpoints, that in training men who are going into industrial organizations, he loses sight of actualities and existing commercial conditions. Perhaps he has been unable to get into any contact with such conditions. By no means should he cut down the detailed investigation incident to his profession, yet he should always attempt to broaden his outlook. The university should pay him a commensurate salary. It is a most natural failing to drift into the belief that one's own problems are of extreme importance; that almost everything else is secondary. Such an attitude may be conveyed, unwittingly, to the student.

With an abundant wealth of natural resources, there is no real reason why this nation should depend upon any other nation for a gram of necessary chemical products. Even granting the absence of raw products, substitutes or artificial substances can, in times of stress, be used or manufactured.

The fundamental need is correct training. The universities, at some point in their chemical courses, should bring out industrial and business relations between the subjects which they are teaching and the application which the man himself must make. Granting that fact as a truism for a chemist, it is of even greater importance to the engineer. If the application and utilization of chemical facts are not clarified, the next subject which he considers will obliterate from his mind a great portion of data which, with a few simple relations, he could retain. In view of the procedure suggested in your article,

the AMERICAN CHEMICAL SOCIETY should be gratified to note that the Chief of Engineers, with the assistance of Gen. Winslow, Col. Peterson, Col. Lyman, and others, had started at Camp A. A. Humphreys, Va., in December 1918, courses in engineering subjects for graduate engineers from West Point. It was a sincere pleasure to receive, in that month, a request from the Chief of Engineers to install and direct at Camp A. A. Humphreys such courses in chemical engineering for the West Point graduates stationed at that camp, as time would permit.

On this occasion, it will be impossible to give to the JOURNAL a complete statement of everything accomplished, or planned. A short résumé, however, will be permitted.

There are now in the school 90 men, ranking from second lieutenant to captain. They are extremely interested, energetic, and of the highest type of American students. In working with them, my impressions have been that the methods used in selecting men for West Point, and later for the Engineer Corps, may be considered extremely satisfactory. The aim of the Chief of Engineers is to make chemistry and chemical engineering real and live subjects, to remove from the minds of the students that element of mystery usually associated with things chemical. New outlines and methods of teaching are being developed. Text books, pamphlets, and problems have been prepared and are now being revised. It is proposed to keep all of them continually modern. Too many texts are permitted to become antiquated before discarding begins. Instead of spending excessive time on development and proof of theories of chemistry, etc., every effort is being made to bring out actual relations and applications of the science. The engineer does not need the detailed and exact facts which the chemist and chemical engineer must have. He need not be an expert laboratory workman. He should, however, know how, where, and why certain products are manufactured, the general outlines of qualitative and quantitative analysis, some organic chemistry, materials to be employed for the manufacture of chemical apparatus, etc., and such fundamental principles of manufacture as the handling of labor and the shipping, storage, cost, etc., of the raw products or finished materials. He should know that, in commercial operations, yield figures are of importance only when connected with data on production and cost. He must realize that textbook equations are very incomplete expressions of reactions, indicating results under ideal conditions.

It may be of value to point out a few concrete illustrations of what is being done. Inorganic chemistry has been considered from an engineering viewpoint. The elements are studied as the construction materials for chemical compounds, just as the engineer considers steel, brass, copper, and the like. The preparation of the elements, with special emphasis on commercial methods, actual uses of the elements, their application to purposes of warfare, such as manufacture of munitions, etc., are first discussed. The methods of shipping and storing of the elements are explained, for instance, the facts that hydrogen and oxygen are purchased in steel cylinders fitted with valves, usually brass, with safety plugs, manufactured according to the Interstate Commerce Commission Regulations, that the gas pressure in the cylinders is about 1800 lbs. per sq. in., that the cylinders used by hydrogen or oxygen manufacturers are tested,

before acceptance, with pressures of 3,000, and in some cases 3,300 lbs. Wherever possible, statements are illustrated by demonstrating the use of the elements in manufactured articles, such as phosphorus smoke grenades, etc. All of the elements are discussed before the general study of compounds begins. The stimulus furnished by warfare research has been indicated as in the production and uses of helium and various other elements. The courses have been divided into lectures or discussions, laboratory experimentation, oral quizzes, and problems. The discussions are based on personal experiences of myself or associates in chemical manufacture, linked with necessary information from standard texts. Few written examinations are held. Later on, in discussing compounds, the system employed with the elements was followed. As an illustration, for commercial purposes, sulfuric acid is usually shipped in steel drums, 50 to 100 gals., or in tank cars; fused caustic soda is shipped in sheet steel drums containing about 700 lbs., or, granulated, in drums or wooden barrels. The purport has been to teach the men the methods by which chemical products are best handled. Safety precautions for workmen have been considered; methods of calculating costs of chemicals and manufactured products, explanations of amortization charges, labor costs, insurance, overhead, etc. In every way possible, excess of introduction has been avoided. The problems have been devised to imitate actual factory conditions, *e. g.*, given a calcium phosphate rock, of known purity, giving a definite actual yield of phosphorus by electrochemical methods, what weight of rock is needed to produce enough phosphorus to fill a number of grenades of definite capacity?

In addition, lectures have been delivered by representative chemists and engineers. Lt. Col. Goss, recently of the A. E. F., has talked of chemistry and chemical engineering in that organization. Lt. Col. W. D. Bancroft discussed the electrochemical industries at Niagara Falls. General A. A. Fries considered the A. E. F., laying stress on its organization, engineering and military values. Dr. C. L. Parsons has accepted an invitation to address the men on "The Methods and Devices Which May be Commercially Employed for the Fixation of Nitrogen." Invitations have been sent to Col. W. H. Walker to enlighten the students on the paper industry, and to Dr. L. H. Baekeland for a discussion of commercial research and developments.

After completing the course, the men will be taken on a trip of about 10 days to visit chemical industries in the East, including the cement factories in Pennsylvania, electrochemical and engineering industries at Buffalo and Niagara Falls. A second trip embracing the Philadelphia, New York and Boston districts, and a third to the industries of the South, such as Virginia, West Virginia, Tennessee, and Alabama have been recommended. The reasons for plant locations, adjacent sources of raw products, transportation facilities, and kindred matters will be emphasized as well as the actual manufacture of materials.

In the final examinations it is proposed to supplement the regular process by developing cooperation with the universities. A number of them throughout the country have been asked to supply sample copies of ordinary problems and examinations. The intent is to insure comprehensive as well as correct instruction of the students. While it is felt that the men are receiving such a foundation, it is proposed to improve, to modernize, and to strengthen the course at every opportunity.

In conclusion, it should be noted that, from the instructor's standpoint, West Point graduates are ideal students. The deep-rooted military lessons of obedience, correct discipline, and maintenance of the highest standards of honor have insured the implicit completion of every instruction. I have regarded my work as a great privilege.

L. T. SUTHERLAND,
Major, C. W. S., U. S. A.

AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.
March 11, 1919

MATHEMATICS AND SANITARY SCIENCE

There is a disposition among sundry workers in sanitary lines to make frequent use of mathematical forms with the result that their conclusions are stated with all the nicety and force of definite equations. Very naturally there creeps over one a feeling of confidence in results that have the backing of algebraic exactness. In November last a most painstaking demonstration was given of the usefulness of the following expression whereby to determine the probable error in the total count of bacteria per cubic centimeter of water

$$e(a_\mu) = \sqrt{\frac{a}{Nn}}$$

where N represented the number of water samples employed and n the cubic centimeters used per sample.

In another recent publication a sanitary deduction was given in the form of a curve which passed through but three of the forty-odd determining points and missed the others by distances which were often relatively great.

It is hard for some readers of sanitary papers to appreciate the value of applying mathematical expressions with stringency when dealing with a science which supplies so many variables. Astronomy naturally falls into the hands of the mathematician at once, while medicine seldom asks his aid, and sanitary science quite nearly approaches the position of the latter. Fancy a physician at the bedside of a typhoid patient counting the rose spots on the abdomen, squaring the number found, adding thereto one-half the pulse rate, subtracting the respirations per minute, dividing by the body temperature, and then concluding that the recovery of the patient was assured because the above calculation resulted in a number less than a certain predetermined constant.

We all remember how dogmatic Wanklyn was when he first brought out his book on Water Analysis. He went so far as to give the number 0.15 as the critical value in parts per million for albuminoid ammonia above which should condemn a water and below which should establish its purity. That is all ancient history now.

However little we may care to confess it, some of us are slightly tainted with heresy in the matter of unlimited belief in the value of knowing to a nicety the remote decimals in a water report. The writer now recalls with a feeling akin to a shiver the imposing array of figures he attached to a report written long ago; one that he is now disposed to classify as among his "early crimes."

In order to properly pass judgment upon the potability of a water supply we are prone to ask for somewhat rougher figures and more numerous analyses, and we are especially interested in the result of the "sanitary survey."

Basing sanitary decisions upon laboratory data alone, so far as water supply is concerned, is about equivalent to a physician treating by telephone a patient whom he has never seen.

TROY, NEW YORK
March 28, 1919

W. P. MASON

THE GERMAN DYE FACTORIES¹

Speaking at the annual dinner of the Society of Dyers and Colourists at Bradford on Friday of last week, Lord Moulton said that in his capacity as Director of Explosives Supply, he had to nominate a Commission to go out to see the great chemical factories of Germany which were situated in the occupied zones along the Rhine, and when the members came back he got their reports, and, what was much better, he discussed with them what they had seen; and he had a picture which filled him with dismay. He was told that those chemical factories had been working during the war solely for the purpose of the war.

¹ Reprinted from the *Chemical Trade Journal and Chemical Engineer* (London), for March 29, 1919.

They had made explosives in enormous quantities, but what, to him, was much more serious, he found they had been making those devilish poison gases in quantities as large as the Germans ever would want, and they had made them in the plant ordinarily used for chemical products often without changing one single item of plant. The operations which made the dyes, wonderful as the results were, could be classed under very few heads. The plant could be made on standard lines, and when they found that those plants intended to be used for peaceful purposes were capable of turning out the vilest of all offensive means without any change whatever, they realized what a terrible danger it was for England that those factories should exist on such an enormous scale, closely united one with the other, ready at any moment, should the evil intention come to them, of being the very fountain of all that was needed for the most ferocious methods. This had entirely resulted from the success of the Germans in dealing with the dye industry during the last 20, 30, or 40 years. If equal factories had existed with us, we should have been able at a moment's call to turn out for the defense of our country and for repelling the insidious attacks made by Germany more war material, and the period of the war would have been a trifle compared with what it had been. The consequence was that it was absolutely necessary that England should have a large and flourishing dye industry for the making of dyes. If there were a large and flourishing industry for the utilization of those dyes, it was through the work of dyers that our textile industries were freed from foreign control. It was idle to think that the mere production of those dyes would make us safe. If we wanted to back our textile industries, if we wanted to prevent Germany continuing to carry on the prosperity which our lack of enterprise and lack of competition had permitted them to have, we must certainly not be at their mercy in future years. We could only establish these industries if dyers took to heart this lesson, and if they, by their skill and by their mastery of the great color industry, not only made our textile industries in the point of dyeing which was vital to them, utterly independent of any foreign supplies, but also put them in the position they ought to take as the highest in quality and the lowest in price of all the world.

A BUREAU OF CHEMICAL INTELLIGENCE

Editor of the Journal of Industrial and Engineering Chemistry:

The very interesting report of the Patent Committee, printed in the March number of *THIS JOURNAL*, suggests a matter connected with the Patent Office about which, it seems to me, something ought to be done.

There is in the Patent Office a chemical card index of approximately 1,000,000 cards, on which the Government has spent to date about \$70,000. This index has been fully described in the *Journal of the American Chemical Society*, 32 (1900), 478-94; 29 (1907), 936-41; 34 (1912), 416-7; and also in the report made in 1912 by President Taft's Commission on Efficiency and Economy upon the Patent Office (62d Congress, 3rd Session, H. R. Document 1110, pp. 599-618), all written by Dr. Edwin A. Hill, who originated the index and was formerly in charge of it and is at present First Assistant Examiner of Division 34 of the Patent Office.

At present, owing to neglect, this index is little used and threatens to go rapidly from bad to worse. Two clerks who are not chemists and who have no chemical supervision have been left at work on it, and that for part time only. For several years no new drawer sections have been provided for housing the accumulated cards, so that there are over 100,000 finished cards in storage that cannot be put into the main index. This, in contrast with a former regular force of one chemist and four assistants provided with sufficient supplies.

Apparently the feeling of those in charge of the Patent Office is that the cost of maintenance of the index is greater than is

justified by the use which the Office can make of it, and this may be true, although chemists in the Office have told me that they frequently find things in the index that they cannot find elsewhere. Patent attorneys do not make much use of it; some have never taken the trouble to learn the simple system and many of them shy at chemical formulas. Probably they would use it if a competent person were in charge and the index itself were in proper condition.

Opinions may differ as to the value of the index but at least all will agree that the present policy should not be continued. If the project is of sufficient value to keep up, why not give it a justification for existence by greatly enlarging its field of use? Why not make it the nucleus of a bureau of chemical intelligence, which shall not only supply information to the Patent Office and patent attorneys but shall furnish chemical intelligence of all kinds to chemists and others interested, anywhere in the country? This is not my own idea, but is based on suggestions received during use of the index for the Chemical Warfare Service.

It has been suggested that this bureau might be created as a small, independent bureau of the Interior Department but remain housed in the Patent Office building, contributing its services to that office and receiving in return the advantages of the Patent Office library. Such a bureau would have a director who is an experienced chemist, assistants of various grades, photostat operator, etc. It would be prepared, as a part of its work, to furnish copies of cards and copies, translations, and abstracts of articles at a low price.

The Taft Commission commended the index and recommended that it be brought and kept up to date by a competent force, but this, like many other recommendations of the Commission, was not carried out. The present apathy of the Government is the result of the apathy of chemists, at least in part.

If American chemists think a bureau of chemical intelligence important enough, probably they can get one, and there is no doubt that it could make itself very useful. The Patent Office index is not an essential feature of such a bureau as has been proposed and the idea of the bureau should be considered on its own merits. But the index should also be given attention on its own account and if, on investigation, it promises to be useful to chemists, the AMERICAN CHEMICAL SOCIETY should urge that it be given adequate support.

XENIA, OHIO
April 5, 1919

AUSTIN M. PATTERSON

PLATINUM THEFT

Editor of the Journal of Industrial and Engineering Chemistry:

On April 1, between 12.30 and 3 o'clock, a thief entered our laboratory and stole 14 small platinum dishes weighing about 15 g. and having a capacity of about 25 cc. The dishes were numbered from 1 to 14 and had been considerably abused, that is, they were worn and bent, and several had holes in the bottom. This ware had been in use about 7 years.

So far we have absolutely no clue at all. We are writing all the dealers asking them to be on the lookout as the robber might endeavor to dispose of it in this way.

We ask for cooperation in this matter.

R. M. SIMPSON, *Chief Chemist*

STATE OF SOUTH CAROLINA
DEPARTMENT OF AGRICULTURE, COMMERCE, AND INDUSTRIES
COLUMBIA, S. C., April 4, 1919

STATISTICS REGARDING SOME IMPORTANT GERMAN INDUSTRIES

A member of the AMERICAN CHEMICAL SOCIETY sends from Coblenz the following statistics concerning some important German industries:

COAL, IRON AND STEEL PRODUCTION OF GERMAN DISTRICTS IN PEACE, IN WAR, AND AFTER THE REVOLUTION

	Aug.- Dec. 1913	Jan.- Sept. 1914	Oct. 1918	Nov. 1918	Dec. 1918	Aug.- Dec. 1913	Jan.- Sept. 1914	Oct. 1918	Nov. 1918	Dec. 1918
	Monthly Production—Tons					Percentage Compared with 1913 Taken as 100%				
Coal mined: Ruhr district.....	9,540,000	6,139,000	8,380,000	8,450,000	6,250,000	100.00	64.35	87.84	88.57	65.51
Raw iron production:										
Rhine Province and Westphalia.....	684,096	377,303	514,068	522,927	356,361	100.00	55.15	75.15	76.44	52.09
Silesia.....	82,884	55,006	62,284	57,459	43,624	100.00	66.37	75.15	69.33	52.63
Hesse-Nassau and Siegerland.....	82,911	39,281	83,359	83,864	55,255	100.00	47.38	100.54	101.35	66.64
North, East, and Middle Germany.....	83,443	39,924	67,954	67,956	50,510	100.00	47.85	81.44	81.44	60.53
South Germany.....	26,705	14,467	14,645	14,923	12,669	100.00	54.17	54.84	55.88	47.43
TOTAL.....	960,039	525,981	742,310	747,129	518,419	100.00	54.79	77.32	77.82	54.00
Raw steel production:										
Rhine Province and Westphalia.....	842,670	521,368	781,407	803,746	490,357	100.00	61.87	92.73	95.38	58.19
Silesia.....	117,275	73,544	123,807	111,911	77,755	100.00	62.63	105.57	95.43	66.30
Hesse-Nassau and Siegerland.....	32,358	17,733	25,642	24,685	12,665	100.00	54.80	79.24	76.29	39.14
North, East, and Middle Germany.....	61,738	34,598	80,930	82,823	51,219	100.00	56.04	131.09	134.15	82.96
Kingdom of Saxony.....	27,594	17,168	36,036	36,272	23,727	100.00	62.22	130.59	131.45	85.99
South Germany.....	21,085	7,326	18,755	17,109	10,660	100.00	34.75	88.95	81.14	50.56
TOTAL.....	1,102,720	671,647	1,066,577	1,076,546	666,383	100.00	60.91	96.72	97.63	60.43

¹ Exclusive of Saar district, Rhine Palatinate, Alsace-Lorraine, and Luxemburg.

In the above table, no figures for the steel production of Alsace-Lorraine, Luxemburg, the Saar district and Rhine Palatinate are given. From another source I have obtained the following:

	1918	Oct.	Nov.	Dec.
Saar district and Rhine Palatinate—Tons.....	95,453	59,008	47,370	

The only figures for Alsace-Lorraine and Luxemburg are that an average production of 6,000,000 tons a year were available, no specific year being mentioned however.

Germany formerly exported about 3,000,000 tons of steel per year from Sweden.

The average monthly production in 1913, including the Saar district and the Bavarian Rhine Palatinate, but excepting Alsace-Lorraine and Luxemburg, was 1,577,925 tons. The production for the year of 1913 was 18,953,089 tons; for 1917, 16,587,360 tons; for 1918, 14,992,904 tons.

PRICES PER TON IN MARKS¹

	Before War	1913/18	1919
Foundry pig iron No. 1 from Oberhausen.....	74.5	161.5	200.5
Hematite.....	79.5	223.0	314.5
Foundry pig iron No. 3.....	70.5	123.0	249.0
Unfinished tool iron in round bars.....	95.0	202.5	300.0
Beams, from Driedhofen.....	110.0	220.0	320.0
Wrought iron, Oberhausen.....	97.0	235.0	335.0
Iron strip.....	110.0	265.0	365.0
Rough sheet iron, 1 mm. thick, from Sieger.....	102.0	275.0	375.0
Smooth sheet iron, 1 mm. thick, from Sieger.....	120.0	310.0	460.0
Smooth sheet iron, under 1 mm. thick, from Sieger.....	335.0	485.0	635.0
Rolled wire, from works.....	117.5	250.0	350.0

¹ The value of the mark has decreased to less than one-half of its value in peace times. At present (March 6, 1919) it is worth 11 to 12 cents, but of course is not stable as yet.

METAL PRODUCTION OF AUSTRIA FOR 1918

	Kilograms
GOLD	
Total.....	283,5878
Bohemia.....	250,1672
Upper Austria.....	1,6000
Moravia.....	5,8854
Tyrol.....	9,2210
SILVER	
Total.....	54,433,487
Prague District.....	44,641,000
Galicia.....	3,400,000
COPPER	
Total.....	36,845
Salzburg.....	25,692
Moravia.....	9,993
PIE IRON	
Total.....	17,500,000
Steinmark.....	6,000,000
Moravia.....	5,200,000
Silesia.....	1,700,000
Salzburg.....	56,239
City District of Trieste.....	1,100,000
LEAD ORE	
Total.....	223,116
Prague District.....	38,329
Kärnten.....	113,571
Laibach.....	24,251
Galicia.....	26,965
ZINC	
Total.....	195,084
Galicia.....	151,651
Chili.....	43,433

Germany, during the war, the limit price on pure block silver was 175 marks per kg. This limit price was made in order to prevent manufacturers from melting up coin and using it for manufacturing purposes. Now, however, practically all the silver is stored in the Reichsbank or hoarded away by the people.

The limit price was lifted on January 1, 1919, and probably will go up to about 250 marks per kg.

COMPARATIVE FIGURES OF GERMANY'S AND CUBA'S SUGAR OUTPUT¹

	Germany Kg.	Cuba Kg.
1909-10.....	4,060,000,000	3,600,000,000
1910-11.....	5,200,000,000	2,960,000,000
1911-12.....	3,000,000,000	3,800,000,000
1912-13.....	5,400,000,000	4,850,000,000
1913-14.....	5,430,000,000	5,200,000,000
1914-15.....	5,130,000,000	5,180,000,000
1915-16.....	3,040,000,000	6,000,000,000
1916-17.....	5,100,000,000	6,050,000,000
1917-18.....	3,200,000,000	6,900,000,000
1918-19.....	2,800,000,000	8,000,000,000

¹ As given in the *Konditor Zeitung*.

² Estimated.

In Austria the sugar production in the last year of peace was 1,400,000,000 kg. and fell to 600,000,000 kg. during the war.

RUSSIAN SUGAR SUPPLY

In the governments of Kurak, Woronesch, Tambow, Orel and Tula, there are 40 sugar factories, against 232 in peace times. The amount of sugar on hand up to October 1918 was as follows:

Raw Sugar.....	290,000 kg.
Refined Sugar.....	38,000 kg.

The entire requirement of the people in Russia amounts to about 10 million kg. yearly. The above mentioned 40 factories produce about 3,377,000 kg. raw sugar, and 1,195,000 kg. refined sugar. The shortage, therefore, is about 5 1/2 million kg. yearly.

GRAIN PRODUCTION OF GERMANY IN TONS FOR 1913, 1917, 1918¹

	1913	1917	1918
Winter wheat.....	2,208,807	1,997,881	3,873,887
Summer wheat.....	251,611	228,204	542,021
Winter rye.....	7,914,027	6,893,607	11,968,865
Summer rye.....	95,063	83,584	160,640
Winter barley.....	193,667	135,820	
Summer barley.....	2,064,588	1,821,283	
Oats.....	4,680,755	3,628,753	9,504,002
Potatoes.....	29,469,718	34,410,982	52,754,683
Sugar beets.....	9,483,800	9,987,321	
Clover.....	6,385,816	7,999,451	10,929,926
Luzerne.....	1,111,120	1,305,988	1,461,077

¹ From the *Süddeutsche Schaeferi Zeitung* for February 15, 1919.

DISPOSITION OF STEEL IN 1918

	October Tons	November Tons	December Tons
Thomas blocks.....	423,296	281,563	219,350
Bessemer blocks.....	13,252	2,466	90
Siemens-Martin.....	576,683	360,735	236,837
Siemens-Sauer.....	15,327	7,812	4,370
Steel castings—basic proof.....	49,327	25,645	14,888
Steel castings—acid proof.....	68,198	32,481	14,939
Crucible steel.....	7,592	4,311	3,015
Electric steel.....	18,013	10,378	7,494

CONCERNING THE MANUFACTURE OF PHTHALIC ANHYDRIDE

On June 16, 1917, the Department of Agriculture announced that the Color Laboratory of the Bureau of Chemistry had developed, on a laboratory scale, a new process for the manufacture of phthalic anhydride and was ready to cooperate with manufacturers in the attempt to develop the process on a commercial scale. All of the cooperation that could be handled at that time was obtained and on November 1, 1917, the offer of cooperation was withdrawn.

Inasmuch as a number of manufacturers recently have expressed a desire to produce a phthalic anhydride and cooperate with this Department in the experimental work, the Department of Agriculture hereby announces that it is ready to assist manufacturers by reopening this offer of cooperation on the same terms and under the same form of agreement as originally made with other manufacturers.

This offer of additional cooperation is made possible by the release from war work of men of the Color Laboratory. It will not be held open indefinitely.

DECISION CONCERNING IMPORTATION OF GERMAN CHEMICAL PRODUCTS

The following decision was recently announced in a letter from Alien Property Custodian Garvan to Burwell S. Cutter, Chief of the Bureau of Foreign and Domestic Commerce:

All of the German dye and chemical patents (and in this classification there is included allied subjects, such as metallurgy, fertilizers, fixation of nitrogen, hydrogenation of oils, etc.) have been seized by the Alien Property Custodian and sold

to the Chemical Foundation. The Chemical Foundation will use the patents to prevent interference with the American industries to which they relate by Germans after the war, by issuing non-exclusive licenses to American manufacturers, and will also institute suits for infringement based upon the importation of the goods of German manufacturers.

It seems to me that it would be desirable to advise the trade in the United States that importation of German chemical products may result in infringement of patents owned by the Chemical Foundation and thereby lay the importer open to prosecution.

THE RESEARCH DIVISION, CHEMICAL WARFARE SERVICE, U. S. A.—CORRECTION

Editor of the Journal of Industrial and Engineering Chemistry:

In the article of the above title [This JOURNAL, 11 (1919), 93] I inadvertently neglected to mention the fact that Dr. M. Gomborg, of Michigan, with facilities turned over to him by the University of Michigan, did, gratis, some exceedingly important work for us on mustard gas and other toxic gas syntheses at a time when our staff was working feverishly, early and late, to make mustard and other gases. He had charge of one of our important laboratories.

Dr. James Withrow, of Ohio State University, also deserves especial notice and praise for his work on prussic acid, cyanogen chloride (both laboratory and plant), arsenic trichloride, and other substances. At one time he had charge of a group of 40 men.

PITTSBURGH, PA.
March 19, 1919

G. A. BURRELL

WORKS AND LABORATORY ACCIDENTS

In response to the editorial, "Am I My Brother's Keeper?" p. 183, of the March 1919 issue, THIS JOURNAL, the two following communications have been received. It is again urged that detailed information be sent to THIS JOURNAL whenever accidents in works or in laboratories occur, so that legitimate publicity may work for the common good.—[EDITOR.]

FIRE PROTECTION IN CHEMICAL PLANTS

Editor of the Journal of Industrial and Engineering Chemistry:

Recent severe fire losses in some of the newly established chemical plants have directed the attention of fire insurance underwriters and engineers to the general conditions surrounding the chemical industries to-day.

The event which prompted this letter was the destruction by fire of a large synthetic dye works in Massachusetts with a loss of some \$200,000. This fire occurred on March 6. This plant was engaged in making sulfur and azo colors and some nitrophenol had been made and stored in the building. The owners some 8 months previous to the fire had had trouble from the spontaneous heating of this material, but no actual fire had occurred. At the time of the fire, however, some 12 to 20 barrels of this material which were stored in the building were observed to be fuming, apparently from spontaneously generated heat. Before steps could be taken to remove the material from the main building the cloud of fumes which had collected under the roof of the building burst into flames. Although the building was equipped in part with automatic sprinklers, the nature of the fire was such that the sprinklers did not subdue it. The early breaking of an important water main crippled the sprinkler protection and the hose streams available were not sufficient to prevent the almost complete destruction of the plant. We believe this fire presents a very good example of one of the new hazards which are appearing in our industrial

plants. While the fire insurance interests are striving to keep abreast of the times in the matter of chemical hazards, it has proved very difficult to obtain satisfactory information along these lines.

It appears to be the general opinion of those in touch with industrial activities that the American chemical industries, particularly the coal-tar dye industry, are facing a critical period in their growth.

The clamor of the trade for the artificial protection of tariff and other legislation may fairly be construed as an admission of the unstable condition of these industries. It is to be hoped that as much energy is being devoted to the study of the means and methods of securing economy and efficiency in plants making our chemicals as is being given to the effort to stifle foreign competition by legislative means. It is quite evident that the lavish and wasteful methods, excusable or necessary in war time, must give way to rigid care and far-sighted economy, if these industries are to succeed to a stable and permanent position in our national life. There is no industry which presents such a wide field of opportunity to-day, and none more essential to the full and independent development of our other industries and our agriculture and medicine, and it is a national need that the chemical industries be put on a stable economic basis as soon as possible.

In considering the steps necessary to place any industry upon a sound economic basis, and a basis upon which it can meet foreign competition on favorable terms, the need for adequate protection of the material property on which it depends against severe fire loss should be given careful attention. Chemical plants of this country have, as a class, become notorious for their heavy fire loss record. The effects of this record are far-reaching. It is becoming increasingly difficult for such plants to secure the best indemnity against fire, and the cost of this indem-

nity, when secured, is relatively very high. Financial credit for a concern whose plants are not adequately protected by good indemnity against fire is secured with difficulty and consequently at relatively high cost. Through the interruption by fire of the production of goods, important markets may be lost.

An element in the cost of production of any commodity is the fire loss cost. That this country competes with foreign countries with the handicap of a high fire loss cost is apparent when it is remembered that the cost for the United States is some 15 times as great per capita as it is in Germany.

There are in this country, no doubt, a large number of chemical plants which have been built and equipped in accordance with modern practice of the science of fire protection, and which receive the care which their value and importance warrant, but as a class chemical plants appear to be of flimsy construction, poorly provided with means for extinguishment of fire, and poorly cared for as to discipline of employees and general cleanliness. Conditions of this sort, when compared with the favorable conditions existing in such long-established industries as, for instance, the cotton, woolen, or metal-working industries, leave the impression with the observer that the very efficiency of the management and of the production effort is similarly contrasted.

As in the erection and equipment of a modern chemical plant the best available supervision of design by engineers and architects should be afforded to the chemist, so should the services of the fire protection engineer be sought. It is high time that the industrial chemists of this country realize that the fire protection engineers stand ready to render them a much-needed service if coöperation is assured. It is also time for fire protection engineers generally to study the special problems of the protection of chemical plants in order that the service rendered may be efficient.

It is above all essential that the policy of concealment of the causes of fires, so often adopted by the managers of chemical plants, be quickly abandoned. A policy of concealment of hazard is not only unfair to insurance underwriters, but is short-sighted, if not stupid. The true experience of fires arising from special processes or materials should be made a part of the common fund of knowledge if safety, economy, and success are to be secured.

The writer feels that a realization of the need for improved conditions as to fire hazard on the part of the leaders of an industry is of much greater value in the long run than is the unappreciative acceptance of such requirements as the insurance interests may present. It would seem that a real benefit to the industry as a whole might be secured by arousing interest in these matters by a discussion of problems in the columns of the JOURNAL.

THE UNDERWRITERS' BUREAU OF NEW ENGLAND
BOSTON, MASS., March 24, 1919

W. D. MILNE

Editor of the Journal of Industrial and Engineering Chemistry:

My attention has been called to a letter written to you, under date of March 24, by Mr. William D. Milne, of Boston, who is a member of our committee.

It is our business to study the sources of development of all lines of manufacture and report annually to this Association. We endorse Mr. Milne's remarks and would emphasize the importance of the points he brings up as they relate to the future of the chemical industry. We ask your kind coöperation and if we can do anything to further present the results of our observations to those interested, we will be pleased to do so.

BENJ. RICHARDS, *Chairman*

Committee on Manufacturing Risks & Special Hazards

NATIONAL FIRE PROTECTION ASSOCIATION
175 W. JACKSON BLVD., CHICAGO
April 11, 1919

A FATAL ETHER FIRE

Editor of the Journal of Industrial and Engineering Chemistry:

On February 3 a fire started in one of the chemical laboratories of Colgate & Co., Jersey City, N. J., which resulted in the death of Dr. George Peirce and one of his assistants.

Dr. Peirce was engaged in a manufacturing process which involved the use of the Grignard reaction. This process had been carried out by him on numerous former occasions and both he and his assistants were quite familiar with the ordinary course which the reaction took. On this occasion when the reaction was well advanced and going smoothly a belt which drove the stirring apparatus slipped off and the reaction mixture, which could be controlled perfectly within narrow temperature limits by means of stirring and external cooling, began to develop immediately strong local action and quick overheating to the boiling point of ether and above. The first quick rush of vapor loosened a cork plug in the cover which supported a long, delicate thermometer and allowed a considerable amount of ether vapor to come out into the room. In trying to save this thermometer Dr. Peirce got some of the reaction mixture on his sleeves and possibly on other parts of his clothing. He sent one of his assistants to open the windows wide to improve the ventilation and at the same time stepped over and threw a switch which had controlled the stirring apparatus. This caused a spark which ignited the ether vapor in the room. The puff that followed vented itself at the window which had just been opened and the man who had opened it, still standing in front of the window, was blown through the opening and landed on a fence, suffering severe bruises but no burns of any consequence. He has since fully recovered. Dr. Peirce seems to have escaped serious injury from the first flash for he returned to the room and tried to extinguish the residual flame with a Pyrene extinguisher which was later found empty on the floor several paces from where it had hung near the door. A fresh rush of vapor from the reaction vessel, probably accompanied by some liquid, caused a second flash which set fire to Dr. Peirce's clothing and he was forced to run from the room, thus fanning the flames, so that by the time he reached the street the greater part of his clothing had burned from him, producing fatal burns.

It is not perfectly clear just what happened to his assistant, Robert Goedert, but his clothing caught fire to an extent that also resulted in fatal burns though over a very much more limited area. He did not realize the seriousness of his injuries and started off alone away from the factory, to walk to the hospital a mile or more away, and was later picked up by someone in an auto and taken to the hospital. Both Dr. Peirce and Goedert died early the next morning from the shock and from their burns.

Several other men who were at work in the building escaped with only slight burns from which they soon recovered.

Dr. Peirce was conscious for a number of hours and told of what happened at the start and of returning after having got out at first. Thinking of the welfare of other chemists he advised that men working with any quantity of ether should wear an outer suit of fire-retarding material, say material that had been soaked in alum solution. He said that if he had worn such a suit of fire-retarding material he would have escaped all right. Of course it is apparent that no electric switch of any kind is to be recommended for use anywhere in the vicinity of space that may become even partly charged with ether vapor.

The fire which followed was very hot and lasted for about 2 hrs., being fed by various oils and chemicals. The start was more in the nature of heavy puffs than explosions. Half an hour or so after the start there was a series of sharp reports, which, however, did no harm and which were probably caused by some sodium in 10-lb. cans located in one part of the building.

The building was practically a total loss.

The vessel used for the reaction above referred to stood through the fire unhurt except that the connections between the still and the condenser coils had melted. The rest of the apparatus was efficiently water-cooled and, after the fire was all out, the vessel contained its contents of ether, Grignard reagent, and unused magnesium practically untouched, very little ether, comparatively, having been lost. It seems probable that at times

ether vapor must have burned at the outlets and that some flashes probably entered the vessel, but the flashes leaving non-combustible gases were not repeated until fresh ether vapor had found its way to the outlets and on account of the cooling, the amount of ether vapor thus formed was not large.

COLGATE AND COMPANY
JERSEY CITY, N. J.
April 15, 1919

MARTIN H. ITTNER

WASHINGTON LETTER

By PAUL WOOTON, Union Trust Building, Washington, D. C.

A period of prosperity and expansion for the chemical industries is a prediction based upon the broad view of these activities which various government bureaus enjoy. The vision of these officials is not being obscured by the existing dullness in the industry. They recognize this as the natural result of the period of transition. It is the consensus of opinion that the chemical industries in this country are on the threshold of an era of activity which will eclipse any estimate made prior to the war.

The foregoing conclusion is based on several grounds. The domestic market in the future will be supplied almost entirely from American sources. This condition will be accelerated, it is held, by the practical certainty that a revision of the tariff will be made by the incoming Congress. Exports are certain to be on an unprecedented scale. The lessons of the war make possible greater efficiency in production. These constitute the main reasons back of the prediction but there is a multitude of minor circumstances which are combining to the interest of the chemical industries in the United States. In their aggregate, they will be potent. Just as America surprised the world in the development of automobile and rubber manufacture, for instance, the chemical industries are expected by some to take such a stride forward.

Friends of the domestic potash industry have not been idle during the interim between sessions of Congress. It is safe to say that everything that intelligent wide-awake men can do preparatory to safe-guarding their industry has been done. They have powerful aid, both from Republican and Democratic leaders. Despite the care with which the case has been prepared and the influence of its adherents, it is becoming increasingly evident that the influence of those who want cheap potash is likely to prevail. Until very recently it was expected that the changed conditions in Europe would tend to make the price of imported potash much higher than was the case before the war. Actual investigation of the situation in Germany, in Alsace, in Spain, and in Africa, tends to belie a condition which had been accepted with much comfort by American potash men. The prices being charged for German potash immediately before the war allowed a large profit to the German syndicate. At that time, the German product enjoyed a monopoly. As an outcome of the war, however, there will be real world-competition in potash. Alsace shortly will be a large producer. The Spanish deposits have been developed to a point where they will be factors in the situation. An even more formidable potential competitor will be the African deposits, the full possibilities of which were not recognized before the war. It is probable that these deposits will come under Italian suzerainty. Thus four powerful nations will be interested in marketing potash. That prices will reflect the keen competition which will develop is a foregone conclusion. It is predicted, therefore, by competent authorities here that as soon as the shipping situation eases up, potash will be laid down at our ports at a surprisingly low price.

While it is admitted that many American potash operations will be forced to close, it is not believed that this will apply to all of them. If a market can be developed for products other than potash, which is regarded as probable, it is thought the Seale Lake operations can continue. There also is the greatest faith in the production of potash as a blast furnace and cement mill by-product.

Much importance was attached to the initial hearing before the War Minerals Relief Commission, which was held in Washington April 15 and 16. This hearing brought out many points as to procedure and established precedents which will be followed in succeeding hearings. The hearing was on the claim of the Chester T. Pyrites and Chemical Company. The stock

in this company is held in equal amounts by George L. Pratt and N. T. Pratt. In 1916 the company undertook the development of a pyrites property near Gainesville, Ga. Preparations were made to operate the property on a small scale. After a visit from a representative of the Secretary of the Interior, and after an interview with Secretary Lane himself, the Messrs. Pratt yielded to their urgent importunings and entered upon the development of their property on a very much larger scale. Mining engineers in the service of the Government were dispatched to assist them, with the idea of securing the promptest possible production. The Secretary of Agriculture swept aside all technicalities and proceeded to assist in providing the best of highway facilities between the mine and the railroad.

As no clearer case could be had of loss incurred in an effort to comply with a government request, the case resolves itself more into a determination of the amount of the loss. The case is complicated greatly by the fact that the operation was begun as a personal venture, with the government responsibility resting only on the increased development. The claim is for \$900,000. The largest item of this expenditure was for an extension of the railroad. The value of this railroad line under present conditions is difficult to ascertain. The same is true in a more restricted sense of the mine and the plant erected on it.

At this writing, some 200 claims have been filed. The amounts are in excess of \$3,000,000. Some large claims are known still to be outstanding, as is the great bulk of the chrome claims. Probabilities are that claims will be filed for amounts greatly in excess of the \$8,500,000 appropriation.

After June 2, which is the last date on which claims may be filed, the Commission expects to visit various mining centers, at which hearings will be conducted.

The *Washington Times* is authority for the following: Extravagance in connection with expenditures for the government nitrate plant at Muscle Shoals, Ala., has been uncovered by agents of the Department of Justice in their investigations of the project, it was learned yesterday, but so far the department has not determined whether there is any criminal liability. The final report now is being prepared by investigating agents to be submitted within a month, and until then the department will not know whether criminal proceedings are to be instituted.

The Chemical Warfare Service is to be continued. Careful consideration of the whole situation pertaining to the use of noxious gases has led to the conclusion that the United States cannot afford at this time to abandon that branch of the military service any more than it can that of aviation or of ordnance.

Tentative arrangements for the disposition of the War Department's surplus stock of spelter were made at a conference held in the office of the Director of Sales, which was attended by War Department officials and a committee representing the American Zinc Institute.

A complete report was presented by the Government, the figures of surplus shown being considerably less than anticipated by the members of the committee, and it was arranged that the War Department would dispose of its surplus spelter through the zinc committee as representing the producers of zinc. This arrangement will tend to relieve any situation which might arise in the industry from the sale of this property by the War Department itself.

The members of the committee present at the meeting were: W. A. Ogg, President, American Zinc, Lead & Smelting Co.; Edgar Palmer, President, New Jersey Zinc Co.; C. M. Loeb, President, American Metal Co.; Edward Morshauser, Anaconda Copper Mining Company; and S. S. Tutthill, Secretary, American Zinc Institute. More definite arrangements will probably be made at another meeting to be held shortly.

By direction of the President, under the provisions of the Act of Congress approved July 9, 1916, the Distinguished Service Medal has been awarded to Colonel Bradley Dewey, Chemical Warfare Service, for exceptionally meritorious and conspicuous service as Chief of the Gas Defense Production Division in achieving under most trying circumstances remarkable results in supplying the American Expeditionary Forces with a sufficient number of gas masks of high grade and of improved design.

The Federal Trade Commission has issued five complaints alleging commercial bribery, naming three interstate soap manufacturing companies and two supply concerns, as follows:

F. Kenney Manufacturing Co., Boston, Mass.; Rome Soap Manufacturing Co., Rome, N. Y.; Standard Soap Manufacturing Co., Woonsocket, R. I.; Engineering Supply Co., Philadelphia, Pa.; and Wm. H. Swan & Sons, New York City, makers of ship supplies.

The Commission states in all complaints that it has reason to believe the concerns secretly paid money to employees of its customers and prospective customers to influence the purchase of supplies.

They were cited to appear before the Commission in Washington, respectively, May 9, May 8, May 7, May 12, and May 10.

Declaring it has reason to believe the concerns have conspired and federated together with the result that all competition has been eliminated and a monopoly established in the manufacture and sale of railway signal torches, the Federal Trade Commission has issued formal complaint against the Oldbury Electro-Chemical Co., Niagara Falls, N. Y.; J. L. & D. S. Riker, Inc., acting as sales agents for the Oldbury Company; and the Central Railway Signal Co., Pittsburgh, Pa.

INDUSTRIAL NOTES

The War Trade Board announced on April 14 that they had been informed that the general import license mentioned in their Ruling 621, issued March 6, authorizing the importation into Great Britain of dyestuffs of *bona fide* French, American, or Swiss origin, has been revoked, as of date of April 14, 1919. All consignments en route from the place of origin to Great Britain on through bills of lading, issued on or before April 9, will be admitted into Great Britain without special license, but in all other cases it will be necessary for British purchasers, prior to purchasing dyestuffs abroad, to obtain a permit for such purchase from the Trade and Licensing Subcommittee.

A three-story addition is planned to the chemical works of the Powers-Weightman-Rosengarten Company, Ninth and Parrish Streets, Philadelphia. The estimated cost is about \$30,000.

According to the *Oil, Paint and Drug Reporter* assurance that the chemical and dye industries of this country will be given adequate protection by the next Congress, which will revise the tariff, so that they may meet competition from Germany or any other source on an equal ground, is given by Representative Joseph W. Fordney, of Michigan, who will be chairman of the Ways and Means Committee. The infant domestic dye industry is singled out by Representative Fordney as the one particular war-born industry which must be preserved through government protection in the way of stiff import duties. He has always been a student of tariff questions, and has made the subject his particular hobby during the 20 years he has been in Congress. For 12 years he has been a member of the Ways and Means Committee, and he has helped to draft two tariff bills, the Payne and Underwood laws.

Pacific coast fish packers, operating canneries from Alaska to Magdalen Bay, are turning to cottonseed and peanut oils as a highly profitable and satisfactory dressing for canned tuna. With olives fluttering around \$500 a ton, and a shorter crop appearing certain each year, the canners have been virtually compelled to find a less expensive but equally palatable and wholesome dressing for their canned products. While vegetable oils have been increasing in favor among fish canners for some time, it is reasonable to assume that the popularity may be further increased by methods of education and good salesmanship on the coast.

The International Consolidated Chemical Corporation, Dover, Del., has been incorporated with a capital of \$5,000,000, to prepare compounds and generally deal in and with drugs. The incorporators are E. Virgil Neal, Elim L. Kinkaid, Paul S. Smith, New York.

The Oldbury Company, the complaint alleges, is the only concern in the United States manufacturing perchlorate of potash, essential to the manufacture of railway signal torches. By agreement, it is charged, the Oldbury Company restricts its output of perchlorate of potash to the amount needed and contracted for by the Central Railway Signal Company, and has refused for the past two years to manufacture for or supply competitors of the Central Railway Signal Company with this necessary ingredient.

The concerns were cited to appear before the Commission in Washington, May 6.

A conference was held March 24, 1919, in the office of the Director of Sales, War Department, between representatives of that office and members of the Alkali Section of the Chemical Alliance, in connection with the disposition of the government surplus stocks of caustic soda and soda ash.

Figures were presented by the representatives of the Director of Sales office showing the approximate quantity of surplus caustic soda to be 4,000 tons and of soda ash to be 2,500 tons. The Alkali Committee stated that these amounts were rather small in comparison with the total normal production and consumption of this country. However, arrangements will probably be made whereby the caustic soda will be disposed of through the manufacturers at manufacturers' current market prices. The details of such an agreement are not entirely complete, but a contract is being drawn to this effect. As a result, no surplus caustic soda will be placed on the market by any of the agencies of the War Department.

It was further decided at this meeting that the 2,500 tons of soda ash could be sold by the Government through the various selling bureaus at current market prices without any effect on the trade.

The U. S. Bureau of Mines announces that it has developed a novel method for giving a danger warning in mines, particularly metal mines, in which compressed air is used throughout the workings. An ill-smelling substance is injected into the compressed-air line, and within a few minutes the odor is spread through all parts of the mine. A technical paper is to be published on this subject.

Experiments have shown that hydro-naphthalenes, especially tetra-hydro-naphthalene, deca-hydro-naphthalene, and their intermediates may be used as substitutes for common lubricating oil. With fats or fat oils they may be used to lubricate machinery.

The General Electric Company is initiating a new plan whereby it will be able to engage a number of senior students in chemistry, physics, and engineering during summer months. These men will be placed on problems for which the facilities of working have already been somewhat prepared. Problems will be selected in such a way that the students will be allowed to publish an account of everything they may accomplish. In this way it is hoped to carry on much research work, mostly along the lines of pure science. It is believed that the introduction of these men to the laboratory at Schenectady, N. Y., will not only be beneficial to them, but also to the members of the regular research staff who will act as their directors during the period of their connection with the company.

Imports of cottonseed oil from August 1, 1918, to January 31, 1919, amounted to 9,626,307 lbs. The exports of cottonseed products consisted of 50,349,583 lbs. of oil, 22,401 tons of cake and meal, and 62,718 bales of linters.

Major F. M. Crossett, chief of the Relations Section, Chemical Warfare Service, U. S. A., 7th and B Streets, Washington, D. C., advises that his office is acting as a clearing house for chemists who are, or have been, in the service, and now seek civilian employment. Applications are being constantly received from reliable firms desiring to employ chemists. At present many are unfilled, owing to the meager information on file regarding applicants. Applicants are requested to give the following details regarding themselves: Name; age; address; position desired (1st and 2nd choice); locality desired (first and second choice); salary expected; technical schools, names, specialization, degrees, dates, etc.; and experience, places with dates.

The Pennsylvania Chemical Co., Dover, Del., has been incorporated with a capital of \$25,000 to manufacture chemicals of all kinds. The incorporators are F. R. Hansell, E. M. MacFarland, I. Vernon Pimm, Philadelphia, Pa.

LIST OF APPLICATIONS MADE TO THE FEDERAL TRADE COMMISSION FOR LICENSES UNDER THE "ENEMY ACT"					ENEMY-CONTROLLED PATENTS PURSUANT TO THE "TRADING WITH THE ENEMY ACT"	
Year	Pat. No.	Patentee	Assignee	Patent	Applicant	
1911	997,061	Wilhelm Herzberg, Schöneberg, near Berlin, and Werner Lange, of Treptow, near Berlin, Germany	Actien Gesellschaft für Anilin Fabrikation, Berlin, Germany	Tetrakisazo dye	E. I. du Pont de Nemours & Co., Wilmington, Del.	
1912	1,034,853	Adolf Winther, August Leopold Laska, and Arthur Zitscher, Offenbach-on-the-Main, Germany	Chemische Fabrik Griesheim-Elektron, Frankfurt-on-the-Main, Germany	Azo dyes for lakes	E. I. du Pont de Nemours & Co., Wilmington, Del.	
1912	1,034,898	Ernst Fussenegger, Ludwigshafen-on-the-Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Azo dyes and process of making the same	E. I. du Pont de Nemours & Co., Wilmington, Del.	
1912	1,049,109	August Leopold Laska, Offenbach-on-the-Main, Germany	Chemische Fabrik Griesheim-Elektron, Frankfurt-on-the-Main, Germany	Violet cotton dyes	E. I. du Pont de Nemours & Co., Wilmington, Del.	
1913	1,076,756	Ernst Fussenegger, Ludwigshafen-on-the-Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Azo dyes	E. I. du Pont de Nemours & Co., Wilmington, Del.	
1913	1,078,504	Wilhelm Herzberg, Wilmersdorf, and Werner Lange, Treptow, Germany	Actien Gesellschaft für Anilin Fabrikation, Berlin, Germany	Diazotizable disazo dyes for cotton	E. I. du Pont de Nemours & Co., Wilmington, Del.	
1912	1,028,006	Karl Elbel, Biebrich, Germany	Kalle & Company, Aktiengesellschaft, Biebrich, Germany	Manufacture and production of fast ortho-oxy-azo dyestuffs	E. I. du Pont de Nemours & Co., Wilmington, Del.	
1912	1,026,257	Karl Elbel, Biebrich, Germany	Kalle & Company, Aktiengesellschaft, Biebrich, Germany	Manufacture of a new pyrazolone-azo dye	E. I. du Pont de Nemours & Co., Wilmington, Del.	
1913	1,073,902	Paul Julius and Carl Immerheiser, Ludwigshafen-on-the-Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Azo dye	E. I. du Pont de Nemours & Co., Wilmington, Del.	
1913	1,073,905	Paul Julius and Carl Immerheiser, Ludwigshafen-on-the-Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Azo dye	E. I. du Pont de Nemours & Co., Wilmington, Del.	
1913	1,078,503	Wilhelm Herzberg, Wilmersdorf, and Werner Lange, Treptow, Germany	Actien Gesellschaft für Anilin Fabrikation, Berlin, Germany	Diazotizable disazo dyes for cotton	E. I. du Pont de Nemours & Co., Wilmington, Del.	
1913	1,082,719	Hermann Wagner, Höchst-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Monazo dyestuffs and process of making same	E. I. du Pont de Nemours & Co., Wilmington, Del.	
1914	1,084,363	Rudolf Reyher, Offenbach-on-the-Main, Germany	Chemische Fabrik Griesheim-Elektron, Frankfurt-on-the-Main, Germany	Yellow monazo dyes and process of making them	E. I. du Pont de Nemours & Co., Wilmington, Del.	
1915	1,126,656	Hans Reindel, Ludwigshafen-on-the-Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Azo dyes	E. I. du Pont de Nemours & Co., Wilmington, Del.	
1916	1,173,077	Fritz Ackermann, Berlin-Friedenau, Germany	Actien Gesellschaft für Anilin Fabrikation, Berlin, Germany	Disazo dye	E. I. du Pont de Nemours & Co., Wilmington, Del.	
1916	1,180,985	Jens Dedichen, Berlin-Halensee, and Werner Lange, Berlin-Friedenau, Germany	Actien Gesellschaft für Anilin Fabrikation, Berlin, Germany	Blue tetrakisazo dyes	E. I. du Pont de Nemours & Co., Wilmington, Del.	
1916	1,183,831	Jens Dedichen, Berlin-Halensee, and Werner Lange, Berlin-Friedenau, Germany	Actien Gesellschaft für Anilin Fabrikation, Berlin, Germany	Green substantive trisazo dyes	E. I. du Pont de Nemours & Co., Wilmington, Del.	
1918	1,266,896	Hugo Wolff and Filip Kacer, Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene dyes and process of making them	E. I. du Pont de Nemours & Co., Wilmington, Del.	
1910	971,501	Fritz Haber and Robert Le Rossignol, Karlsruhe, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Production of ammonia	Semet-Solvay Co., Solvay, N. Y.	
1911	1,006,206	Fritz Haber, of Karlsruhe, and Robert Le Rossignol, of Berlin, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Production of ammonia	Semet-Solvay Co., Solvay, N. Y.	
1913	1,053,951	Carl Bosch and Alwin Mittasch, of Ludwigshafen-on-the-Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Process of making ammonia	Semet-Solvay Co., Solvay, N. Y.	
1913	1,053,952	Carl Bosch and Alwin Mittasch, of Ludwigshafen-on-the-Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Process of manufacturing ammonia	Semet-Solvay Co., Solvay, N. Y.	
1913	1,068,966	Carl Bosch, Alwin Mittasch and Hans Wolf, of Ludwigshafen-on-the-Rhine, and Georg Stern, of Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Production of ammonia and catalytic agents for use therein	Semet-Solvay Co., Solvay, N. Y.	
1913	1,068,967	Carl Bosch, Alwin Mittasch, and Hans Wolf, of Ludwigshafen-on-the-Rhine, and Georg Stern, of Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Production of ammonia and catalytic agents for use therein	Semet-Solvay Co., Solvay, N. Y.	
1913	1,068,968	Carl Bosch, Alwin Mittasch, and Hans Wolf, of Ludwigshafen-on-the-Rhine, and Georg Stern, of Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Production of ammonia and catalytic agents for use therein	Semet-Solvay Co., Solvay, N. Y.	
1913	1,068,969	Carl Bosch, Alwin Mittasch, and Hans Wolf, of Ludwigshafen-on-the-Rhine, and Georg Stern, of Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Production of ammonia and catalytic agents for use therein	Semet-Solvay Co., Solvay, N. Y.	
1913	1,075,085	Carl Bosch and Franz Lappe, Ludwigshafen-on-the-Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Working with hydrogen under pressure	Semet-Solvay Co., Solvay, N. Y.	
1913	1,077,034	Carl Bosch, Ludwigshafen-on-the-Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Process of working with hydrogen under pressure	Semet-Solvay Co., Solvay, N. Y.	
1914	1,083,585	Carl Bosch and Alwin Mittasch, Ludwigshafen-on-the-Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Catalytic production of ammonia	Semet-Solvay Co., Solvay, N. Y.	
1914	1,089,185	Carl Bosch and Alwin Mittasch, Ludwigshafen-on-the-Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Producing ammonia	Semet-Solvay Co., Solvay, N. Y.	
1914	1,094,194	Carl Bosch, Alwin Mittasch, and Hans Wolf, Ludwigshafen-on-the-Rhine, and Georg Stern, Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Production of ammonia	Semet-Solvay Co., Solvay, N. Y.	
1914	1,118,628	Carl Bosch and Alwin Mittasch, Ludwigshafen-on-the-Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Producing ammonia	Semet-Solvay Co., Solvay, N. Y.	

During the war the Bureau of Mines, Department of Interior, made strenuous efforts to find a special fuel for airplanes that would be superior to others already in use. The Bureau was particularly interested in a special fuel, named "hecter," tested in cooperation with the research division of the Dayton Metal Products Company. This fuel, which was a mixture of cyclohexane and benzol, gave indications of marked superiority over any other product tested and should, unless unforeseen deficiencies appear, prove ideal for the military aviation service. It is not certain that the cost of production will ever be low enough to permit its use in peace times but it is planned to complete the work of obtaining comprehensive information regarding all of its possibilities and to publish reports on the subject in cooperation with the engineers of the research division of the Dayton Metal Products Company.

At the annual meeting of stockholders of the National Aniline & Chemical Co., Inc., and at the succeeding meeting of the directors two days later, the officers and board of directors were elected as follows: *President and Chairman of the Board*, William J. Matheson, New York; *Vice Presidents*, William Beckers, New York; Robert A. Shaw, New York, and L. C. Jones, Syracuse; *Acting Treasurer*, William H. West; *Assistant Treasurers*, H. S. Trott and T. S. Baines; *Secretary*, William T. Miller; *Assistant Secretary*, Walter E. Rowley; *Chairmen of Executive Committee*, Henry Wigglesworth, New York; H. H. S. Handy, Syracuse; Clinton S. Lutkins, New York; Eugene Meyer, Jr., New York; W. N. McIlravy, New York; F. M. Peters, New York; T. M. Rianhard, New York; I. Frank Stone, New York; R. C. Taggesell, Buffalo; Orlando F. Weber, New York.

Referring to the prohibition on the importation of dyestuffs into Great Britain, announced by proclamation on February 24, the British Board of Trade has given notice that the order will be administered by a trade and licensing commission, consisting of an equal number of representatives of the dye manufacturing and dye using industries. For the present, however, a general license has been given for the importation of all dyestuffs and other products covered by the prohibitive order which are of *bona fide* French, American, or Swiss origin. It will, therefore, not be necessary at present, it is announced, to obtain licenses for individual consignments coming from those countries. Any communications as to the import regulations applicable to dyestuffs should be addressed to the Secretary, Dyes Department, Board of Trade, 7 Whitehall Gardens, London.

Mr. Francis P. Garvan, of New York City, was recently appointed by President Wilson as Alien Property Custodian, to succeed A. Mitchell Palmer, who becomes Attorney General. Mr. Garvan has been director of the Bureau of Investigation in the Custodian's office, and has been largely instrumental in establishing enemy interest in many corporations in this country.

The Grasselli Chemical Company has sent out an announcement saying that they have acquired the dyestuff business of the Bayer Company, Inc., including its dyestuff factory at Rensselaer, N. Y., its sales organization, branch offices, and warehouses, including its stocks of finished and unfinished products; also all the American patent rights in the dyestuff and allied lines of both the Bayer Company and the Synthetic Patents Company. They have also acquired the property of the Williams & Crowell Company, of Providence, R. I. This branch of their business will hereafter be known as the dyestuff department of the Grasselli Chemical Company. The head office of the dyestuff department is located at 117 Hudson Street, New York City. The Grasselli Chemical Company has also purchased from George and William Bramwell of New York, the mill village of Packerville, Conn.

Plans for building a chemical laboratory for the University of Buffalo at Main Street and city line were considered at a meeting of the university council in Townsend Hall recently. The deed of the land to the university calls for use of the site for university purposes by June of this year. The committee has collected \$125,000 towards the cost of the building and the National Aniline & Chemical Company has contributed an additional \$25,000. Provision will be made to start building the laboratory before June 1.

The Rhodia Chemical Company has been organized by R. Pfister, M. Grillet, and J. Koeschet to manufacture medicinal chemicals in this country, as an American company founded on the methods followed by the Société Chimique des Usines in France. The capital of the American company is \$600,000. The products will include chloroform, salicylic acid, saccharin, antipyrine, phenolphthalein, acacia, amyl benzoate, beeswax, benzyl acetate, citronella, creosote, caffeine, salol, and synthetic perfumes.

The International Vegetable Oil Co., Atlanta, Ga., has been organized to engage in the production of vegetable oils. It is understood that the company has plans under consideration for the construction of a large brick, steel, and concrete plant, estimated to cost \$200,000. W. W. Banks, Atlanta, is president, and Gordon B. Nicholson, Savannah, manager.

The U. S. Civil Service Commission announces in Bulletin No. 2236, amended, open competitive examinations for associate chemist and junior chemist, for both men and women. Competitors will not report for examination, but will be rated upon the sworn statements made in their applications. For associate chemist, the form to be filled in is No. 2118, and for junior chemist, No. 1312.

The War Trade Board announced under date of March 27 that "hereafter all applications for licenses to import dyes or dyestuffs must be accompanied by a statement giving complete specifications of the character of the dyes or dyestuffs proposed to be imported." A supplemental information sheet, procurable from the Bureau of Imports, Washington, or from any branch office of the Board, should be used for this purpose. Added importance is given this announcement by the fact that it was made soon after the Chemical Foundation, which will obtain title to many of the German dye and chemical patents seized after the United States entered the war, sent a cablegram to President Wilson asking that he recommend steps which would protect the American dye industry.

The National Aniline and Chemical Co., Inc., has arranged to erect a four-story office building adjoining their present building, at 15-19 Burling Slip, New York City.

Chemical manufacturers having war claims against the Government are urged by the Federal Liquidating Association at Washington to file their claims before May 15. The Association calls attention to the fact that the disintegration of the existing War Department machinery or the organization of new machinery, or the remission of all claims to the Court of Claims will involve great delay and increase the difficulties of obtaining settlements.

The Texas Gulf Sulfur Company has begun operating its third well, which increases the daily output of raw sulfur to 1600 tons. Other wells are being sunk, and will be put in operation as rapidly as they are finished. The capital stock of the company was recently increased from \$1,000,000 to \$3,000,000.

The Heyden Chemical Works, Garfield, N. J., was sold by the Alien Property Custodian, on March 27, to Mr. Allen A. Ryan. The price paid was \$1,500,000. Since the signing of the armistice the Heyden Chemical Works has operated at full capacity, and it is believed that with careful management the company should show a profit for 1919 of between \$400,000 and \$500,000.

The Island Refining Corporation, a subsidiary of the Island Oil and Transportation Company, has been formed with authorized capitalization of \$10,000,000. Col. G. A. Burrell, of Pittsburgh, Pa., has been elected president of the new company.

The War Trade Board announces that the restrictions heretofore existing upon the importation of ferromanganese and spiegel-eisen have been removed, and importations from the United Kingdom, France, Italy, Belgium, or Japan, or from their possessions, may now be made under General Import License PBF No. 34.

The Ohio Metal Briquetting Co., Cleveland, Ohio, has placed a contract with the Crowell-Lundoff-Little Company for a new plant for manufacturing briquettes of scrap metal. Annealing furnaces and some other equipment will be required.

The National Aniline & Chemical Co., Inc., New York City, announces, as a new product of its factories in Niagara, blue BR. It is identical with diamine blue BX and benzo blue BX, which were formerly imported. These prototypes were some of the most widely used brands of direct blue, and were put to many special uses.

The Wright Chemical Corporation is enlarging its plant for the manufacture of dyes, intermediates, and other chemicals. Mr. A. A. Matheson, who recently resigned as general manager of the Union Dye & Chemical Corp., Kingsport, Tenn., has been elected president of the Wright concern, succeeding Mr. E. J. Wright, who is now vice president. Mr. A. E. Crocker continues as treasurer.

Certain Illinois coals instead of eastern coke can be used for the manufacture of water gas and at a considerably decreased cost, according to experiments that have been made in the city gas plant at Streator, Ill. This means the utilization of nearby coals at water-gas plants in the central states instead of having to depend upon the coke from eastern coals that have to be transported some distance. It will also save the eastern coking coals for other purposes.

Arthur D. Little, Inc., Cambridge, Mass., announces that Mr. Herbert L. Sherman, formerly president of the New England Bureau of Tests, Inc., and more recently in charge of inspection for the Construction Division of the United States Army, has joined the corporation, and will be in charge of the department for the testing and inspection of structural materials.

The British Chemical Trade Association has been registered at Somerset House as a company limited by guarantee, not formed for purpose of profit. The objects of the Association are to promote and assist trade in chemicals; to provide for the accurate sampling, analysis, and examination of the same; to establish in the trade uniformity in commercial usages, particularly with regard to forms of contract, charter parties, bills of lading, insurance policies and other documents, and to promote the voluntary (but not compulsory) adoption thereof; to obtain any provisional order or act of Parliament for enabling the Association to carry any of its objects into effect; to promote or oppose legislative or other measures affecting the trade, etc.

An exposition of the anhydrous food industry has recently appeared in a government bulletin entitled "Relation of Dehydration to Agriculture," written by Major S. C. Prescott. It is believed that the preparation of dried foods is destined to become a very important industry.

The Compagnie Nationale des Matières Colorantes et Produits Chimiques (France), with a share capital of \$8,000,000, has almost completed the erection of an entirely new plant for the production of synthetic indigo. The works are situated at Rieux, near Creil. Large deliveries of this product have already been made and it is estimated that the full output of 2,000 tons per year will be amply sufficient for home consumption.

A disappointing situation has developed in the domestic potash-from-kelp industry along the western coast. This has led to the closing down of certain plants. Already, the Hercules Powder Company has withdrawn from the business and is dismantling its plant at Chula Vista, near San Diego, Cal. This company has been making acetone and high-grade potash salts and other important chemicals. The whole operation marked a notable achievement in the application of chemical principles to kelp and products derived from it. The Diamond Match Co., Wilmington, Cal., is reported to have dismantled its plant. The Lorned Manufacturing Co., Sumnerland, Cal., and the Pacific Products Co., Long Beach, Cal., have closed their plants at what they consider the end of the period of profitable operation. Some kelp plants are still operating, for example, the Sea Products Company at Long Beach, and Swift & Company at San Diego.

It is reported that the Tennessee Manganese Company, owners and operators of the East Fork carbonate mine, in eastern Tennessee, are contemplating erecting a 10-ton electric furnace in the Cleveland district, Tennessee. By smelting the ores locally, not only is a saving made in freight rates, but the selling price of the manganese itself, owing to the high degree of concentration, is much increased. This may make it possible to continue the operation of the several manganese properties owned by the company.

It is claimed by government experts who have conducted an investigation of the probable supply of natural gas in the Petrolia field from which helium is obtained that the quantity is sufficient to keep in operation for at least 15 years the \$6,000,000 helium plant that is being erected at Fort Worth, Texas. At Petrolia another government experimental helium plant is in operation. It is stated that when this plant is finished it will have a daily output of 30,000 cu. ft. of the gas. The helium will be stored in steel cylinders and shipped wherever it may be needed, particularly for balloon-filling purposes. The gas is nonexplosive. At the time the armistice was signed the United States Government had on hand ready for use in balloons against the Germans 150,000 cu. ft. of helium. Although helium is found in the natural gas of some other fields of the country, the natural gas at Petrolia is the only one so far found that contains the product in commercial quantities.

The Tennessee Agricultural Chemical Corporation, a \$2,000,000 corporation with a Virginia charter, has bought the old Volunteer Phosphate Company property on Swan Creek, near Centerville, from the National Phosphate Fertilizer Company, and will erect a \$135,000 plant with the new dry cleaning process that eliminates the necessity for washing the rock.

The Capote Nitrate Company is making a thorough test of the large beds of nitrate situated near Valentine, Texas, which it acquired some time ago. It is stated that a large leaching plant will be installed if the tests now being made prove as successful as they promise to be.

The Columbia Chemical Company, a \$1,500,000 Ohio corporation, has bought a rich phosphate field of 178 acres on the Pulaski pike, Tennessee, four miles south of Columbia, and has already begun the construction of a spur track to it from the Louisville & Nashville Railroad. The plant to be erected there will cost \$135,000, and will prepare rock for use on the soil in its raw state as well as for commercial fertilizer. The company owns patent processes by which it expects to manufacture from phosphate rock a number of valuable chemicals in addition to using it as fertilizer.

The International Potash Corporation, composed of Omaha and Lincoln capitalists, has secured a lease from the Morse Brothers Machinery & Supply Company on the 6,000,000-ton dump at the dismantled mill of the United States Reduction & Refining Co., near Colorado Springs, Col. A new plant is being erected for the extraction of the potash salts from the residues. It is reported that the mill will be in commission by May 1.

Construction of a gravity railroad to cost about \$5,000,000 is planned by the Tennessee Coal, Iron & Railroad Company of the United States Steel Corporation, according to a report from Birmingham, Ala. It is designed to connect the Red Mountain ore mines near Ishkooda with the Ensley plant near Fairfield. Work has begun on Red Mountain. Huge steel piers will support the road.

The Canadian Council of Agriculture has given special consideration to the development of the potato-flour and hemp industries in Western Canada. The Western Committee of the Canadian Reconstruction Association, the Winnipeg Board of Trade, and the Western Canada Development Bureau have been very active in the matter, and the future progress of both these industries is well assured.

American exporters desiring to deal with European or other importers, will be greatly benefited by the plan of the War Finance Corporation to extend foreign trade credit. Sums up to \$50,000,000 will be loaned to responsible firms, corporations, or individuals by the War Finance Corporation to enable them to extend the foreign commerce of the United States. The corporation has formulated rules and regulations under which this program can be carried out.

The United States Geological Survey has recently issued a report, as Bulletin 680, which describes extensive phosphate deposits in the Big Hole district of Idaho and Wyoming. The existence of these deposits has been known for more than 10 years, but their extent was unknown until they were mapped in detail and sampled.

The object of an invention patented by Umata Okazaki, Kitaguchi, Japan, is to utilize for the manufacture of pulp the leaves of sugar cane, which are useless for any purpose and are wasted at present. The leaves are chopped into pieces and cleaned by air, and then boiled with caustic soda and lime for about 4 hrs., and then washed in a sieve-like vat, and beaten and washed in a beating machine. The separated fibers are then bleached by a solution of chloride of lime and sulfuric acid, the fiber remaining in this solution about 4 hrs. during which time it is steamed at a temperature of about 75° to 80° C., the steaming shortening the bleaching process. The bleached fiber is rinsed with clear water in an oscillating strainer, passing from which it is sized and made ready to go into the millboard machine. After going through a drying machine it comes out finished pulp ready to be made into paper.

According to information from Charleston, W. Va., the Pennsylvania Glass Company, which suspended operations at its plant there during the war, has resumed work, giving employment to more than 1,000 people, while the Dunbar Flint Glass Company whose plant was also shut down for some time, has resumed the production of window glass.

How virgin peanut oil is yielding a cold pressed product, with delicious flavor, made in America, winning favor as a substitute for olive oil, and having a distinct food value, is told in an official statement by the U. S. Department of Agriculture.

Water-resistant glues are of two general types: those made from blood albumen and those made from casein. All blood-albumen glues are made directly from the raw ingredients at the time the glue is to be used. The manufacturers using these glues make them by their own secret formulas, and there are no published formulas available. Casein glues can be obtained in the prepared state ready for mixing with water, or they can be made directly from the ingredients at the time the glue is to be used. The following prepared casein glues are now on the market: certus glue, napco glue, casco glue, and Perkins waterproof glue. Directions for mixing the prepared glues can be obtained from the Forest Products Laboratory, Madison, Wis.

PERSONAL NOTES

Dr. George Peirce who died February 4, 1919, was born at Bristol, Pa., May 7, 1883. He prepared for college at Germantown Academy and graduated from Haverford College with the degree of B.A. in 1903. He was holder of the Corporation Scholarship and a member of Phi Beta Kappa. He then attended the medical school of the Johns Hopkins University, graduating with the degree of M.D. in 1907. During the summer of 1907 he was in charge of Dr. Grenfel's hospital at St. Anthony, Newfoundland. Throughout the years of 1908 and 1909 he was resident physician at the Pennsylvania Hospital, at Philadelphia. In February 1910, he married Miss Ethel Girdwood, of West Orange, N. J. He and his wife then went to Germany, where Dr. Peirce continued his studies in chemistry at the University of Berlin, working under the direction of Emil Fischer and other celebrated chemists. Towards the end of 1912 he received the degree of Ph.D. in chemistry from the University of Berlin, having made a research in the chemistry of alkaloids in the brucin group. He then accepted an appointment at the University of Wisconsin as assistant in physiology. He demonstrated in physiological chemistry and carried out research work on ferments during the following year. Later as instructor in pharmacology he lectured and demonstrated in the laboratory and did research work on the configuration of some higher monosaccharides. In 1914 he became instructor in urology at the Johns Hopkins Medical School. He also did research work in the laboratory of physiological chemistry and in the James Buchanan Brady Urological Institute, on the configuration of the higher monosaccharides and on the excretion of sugar by the kidneys. After two years on the teaching and research staff of Johns Hopkins Medical School he came to the chemical department of Colgate & Company in September 1916. With Colgate & Company Dr. Peirce was largely busied in organic chemical research work in the terpene field and in related work. He displayed a wide, thorough knowledge of chemical subjects and had the ability to get the practical results that he started after. Dr. Peirce was a quiet man, of pleasing disposition. He was a conscientious worker and a scientist of great ability.

Dr. T. B. Wagner, long and prominently connected with the corn products industry, has resigned his office with the Corn Products Refining Company and has become associated with the U. S. Food Products Corporation, which is the new name of the company formerly known as the Distillers Securities Corporation. At the annual meeting of the latter Corporation held on March 19, Dr. Wagner was elected a director and vice president of the Corporation, and at once assumed charge of its new manufactures. Dr. Wagner will retain headquarters in New York City in the offices of the Corporation at 40 Exchange Place.

Mr. F. H. Lang, who served with the Research Division of the Chemical Warfare Service at the American University, Washington, D. C., has returned to his former position in the chemical division of the Western Electric Co., Hawthorne Plant, Chicago.

Mr. Paul Hayes, who, while in Washington, was in charge of the chemical inspection of leather used in the manufacture of leather equipment for the Army in connection with the Clothing and Equipage Division of the Quartermaster Corps, is now leather chemist with the Graton & Knight Manufacturing Co., Worcester, Mass., with whom he was associated prior to the war.

Dr. Jessie Y. Cann, formerly associate in chemistry at the University of Illinois and then assistant professor of analytical chemistry at Smith College, Northampton, Mass., has just been promoted to the associate professorship at Smith.

Mr. M. B. Crowe, for the past five years connected with the Riverside Acid Works at Warren, Pa., has severed connection with this firm and has accepted a position with the Crown Oil & Refining Co., Houston, Texas.

Mr. Herbert Kranich, who, until his discharge from the Army, was affiliated with the U. S. Supervisory and Control Laboratory of the Ordnance Department in Philadelphia, has returned to his former position as research chemist for S. Sternau & Co., Inc., N. Y.

Capt. P. E. Landolt, formerly chemical engineer with the Research Corporation, New York City, has resigned from the Nitrate Division, Ordnance Department, U. S. A., and has returned to the Research Corporation.

Mr. R. E. Stephenson, formerly of the Soils Department, Ames, Iowa, is now assistant soil chemist, Experiment Station, W. Va.

Mr. H. B. Weiser, who, while in Washington, on leave of absence from Rice Institute, served as Captain in the Research Division, Chemical Warfare Service, U. S. A., and held the position of Chief of the Catalytic Unit, stationed at the Catholic University Detachment of the American University Experiment Station, has returned to Rice Institute, Houston, Texas, where he is assistant professor of chemistry.

Mr. B. L. Hartz, who, during the war, served as Captain in Field Artillery, has resumed his connection with the Elyria Enameled Products Company, and will act as a dairy expert on practical application of Elyria equipment in the dairy and ice cream industries.

Mr. W. H. Jackson, formerly in the Aviation Corps at Payne Field, Miss., has recently been added to the technical force of the Elyria Enameled Products Co., Elyria, Ohio.

Mr. Max Donauer, who, during the war, was Administrative Officer in the Ordnance Department, Supervisory and Control Laboratories, in Philadelphia, has recently been added to the technical force of the Elyria Enameled Products Co., Elyria, Ohio.

Mr. Henry Odeen, recently chemist in the Chemical Warfare Service, stationed at Edgewood Arsenal for about nine months, is at present chief chemist with the Nucoa Butter Co., Bayonne, N. J.

Mr. Robert Hulme, formerly manager of the Phoenix Cotton Oil Company, is now with the California Products Co., Fresno, Cal., as vice president and general manager.

Mr. E. A. Dieterle, who has recently been associated with John S. Unger and had an appointment as consulting gas engineer for the U. S. Bureau of Standards, has joined the Koppers Company, of Pittsburgh, as assistant chief chemist.

Mr. R. B. Saylor, who, in April 1918, was granted leave of absence to take up work on gas masks with the Bureau of Mines, Washington, D. C., and was later commissioned 2nd Lieutenant in the Chemical Warfare Service and stationed at the American University Experiment Station in charge of laboratory operations of the Canister Testing Unit of Gas Mask Research Section, has resumed his former business relations with the American Sheet & Tin Plate Co., Vandergrift, Pa.

Mr. J. R. McConnell, who, prior to entering the service of the Oil Branch, U. S. Army, at 51 Chambers St., New York City, where he acted as chief chemist and member of the subcommittee for the standardization of petroleum specification, representing the U. S. Army, was chemical engineer for the Valvoline Oil Company, is now acting as chief chemist for the Conewango Refining Co., of Warren, Pa.

Mr. Norman Randal, who was recently connected with the Nitro Powder Co., Kingston, N. Y., and who was formerly superintendent of the TNT section of the explosives plant of Messrs. Curtiss & Harvey (Canada), Ltd., at Dragon, Quebec, which was wiped out by a disastrous fire on August 18, 1917, has joined the chemical division of Proctor & Gamble Co., Ivorydale, Ohio.

Dr. George H. A. Clowes has left the Grawtack Research Laboratory, Buffalo, N. Y., to take the position of Director of Biochemical Research of Eli Lilly & Co., Indianapolis, Ind. Dr. Clowes will have suitable laboratory facilities and personal assistants and the cooperation of the staff of the various scientific departments in carrying out research in this field. He will have entire freedom in regard to the nature and scope of the work to be undertaken and will be free to devote himself to the study of the fundamental problems on the border line between physics and chemistry on one hand, and biology and physiology on the other, in which he has long been interested. In order to study the relation between physical and biological systems to the best advantage, his work will be carried on during the summer months at Woods Hole where marine organisms will be available.

Mr. W. F. Brown, recently released from war service, has returned to his former position as chief chemist for Ball Brothers Glass Mfg. Co., Muncie, Ind.

Mr. Armin Seidenberg, who was recently released from the Research Division of the Chemical Warfare Service, Washington, D. C., has resumed his former position as chemist with the Department of Health, New York City.

Mr. Irving W. Hazard, formerly chemist with the National Cannery's Association at Washington, is now laboratory director for the Gibbs Preserving Co., Baltimore, Md.

Mr. Thomas R. Harrocks, formerly chief chemist of the Ordnance Department at the plant of the Aetna Explosives Co., Emporium, Pa., is now technical representative for H. Reeve Angel & Co., Inc., 7-11 Spruce St., New York City.

Mr. H. A. Schaffer, who, from October 1918 until March 1919, acted as advisory chemist and assistant to the Director of Building Materials Division, War Industries Board, Washington, D. C., has joined the staff of the Portland Cement Association as chemical engineer to conduct conservation studies.

Mr. Louis S. Deitz, Jr., recently discharged from the Ordnance Department, is now chief chemist of the Chemical Pigments Corporation, Philadelphia, Pa., and at present is located at their St. Helena, Md., plant.

Mr. Lloyd A. Hall, who was formerly chemist with the Department of Health, City of Chicago, then with the Ordnance Department for fourteen months, and more recently in research work at the Supervisory and Control Laboratory, Philadelphia, is now chief chemist for John Morrell and Co., Ottumwa, Iowa.

Mr. Gordon L. Cave, formerly on an editorial detail with the Pyrotechnic Section, Research Division, Chemical Warfare Service, has accepted a similar position with the research department, Brown Company, Berlin, N. H.

Mr. Milton W. Franklin, who was recently works manager for E. F. Houghton & Co., Philadelphia, has assumed the position of chief consulting engineer to the Remy Electric Division of the General Motors Corporation.

Mr. Frank Crossley, formerly chief chemist of the Curtiss Aeroplane and Motor Corp., Buffalo, N. Y., has been appointed chief chemist and metallurgist to the Curtiss Engineering Corp., Garden City, Long Island, N. Y.

Dr. William McPherson, who was recently discharged from the Chemical Warfare Service of the U. S. A., has returned to his former position at the Ohio State University.

Mr. R. C. Dabney has resumed his work in the research laboratories of the Miller Rubber Co., Akron, Ohio, after resigning his commission as 2nd Lieutenant in the Chemical Warfare Service.

Mr. Duncan MacRae, who has recently been discharged from the Chemical Warfare Service, has returned to the Westinghouse Lamp Company as research chemist in the Lamp Research Laboratory at East Pittsburgh.

Mr. K. M. Waddell, who, prior to his call for military service in 1917, was chemist and inspector for the Department of Timber Preservation for the Santa Fe R. R., has been discharged with rank of 2nd lieutenant from the Chemical Warfare Service, Washington, D. C., and is now in charge of the research laboratory of Jennison-Wright Co., Toledo, Ohio.

Mr. E. B. Peck, who, previous to the war, was instructor in the University of Minnesota, was recently discharged from the Army and has accepted a position with the Perth Amboy Chemical Works.

Mr. E. W. Guernsey, formerly with the Dispersoid Section, Research Division, Chemical Warfare Service, Washington, D. C., is now employed in the research department of the Brown Company, Berlin, N. H.

Mr. George Granger Brown, formerly chemical engineer with the Aluminum Company of America, at Massena, N. Y., and chemist for the Development Section, Research Division, Chemical Warfare Service, at American University, Washington, D. C., is now chief engineer for the Universal Aniline Dyes and Chemical Company of Milwaukee, Wis.

Mr. Allen Abrams, formerly chief of the Chemical Development Section, Research Division, Chemical Warfare Service, has resumed his former position as chemist for Bemis Brothers Bag Co., Indianapolis, Ind.

Mr. Horace C. Porter, who, during the war, served as Captain in the Ordnance Department, U. S. A., in Washington, and was engaged on the production of toluol and other raw materials for explosives, has entered into consulting practice as chemist and chemical engineer, specializing in fuels, gas, and by-products, and is associated with the Chemical Service Laboratories, Inc., West Conshohocken, Pa.

Sergt. Edwin F. Barnum, of the Chemical Warfare Service, died at Camp Merritt, N. J., February 12, of pneumonia. Sergt. Barnum sailed for France March 14, 1918, with the Laboratory Unit of the Chemical Warfare Service and was stationed with that unit until their return January 23, 1919. He had been recommended by his commanding officer for the Distinguished Service Medal for brilliant work. Before entering the service November 5, 1917, Sergt. Barnum was chemical superintendent of the Delaware Hard Fiber Co., Wilmington, Del.

Lt. Wilbur F. Kamm, who, before his enlistment in the Chemical Warfare Service, where he was stationed in Washington, D. C., was research chemist for Parke, Davis & Co., Detroit, Mich., has accepted the position of chief chemist for the Commonwealth Products Corporation of New York City and Chicago.

Mr. J. Arthur Durr recently resigned his position as first assistant to the chief chemist of the Metallurgical Section, Inspection Division, Ordnance Department, to take charge of the chemical and physical department of the Saginaw Malleable Iron Co., Saginaw, Mich.

Mr. R. P. Rose, formerly Major in the Chemical Warfare Service, Gas Defense Division, is now with the research staff of the general laboratories of the U. S. Rubber Co., New York City.

Mr. E. C. Pitman resigned his position as superintendent of the Lustron Co., South Boston, Mass., and is now associated with E. I. du Pont de Nemours & Company as research chemist.

Mr. Gurney O. Gutekunst, who was recently discharged from the Chemical Warfare Service, Washington, D. C., and who was formerly in the employ of O. J. Gutekunst Fruit Products Co., Gowanda, N. Y., is now chemist in the organic research department of the Eastman Kodak Company.

Mr. Alan P. Sullivan, who was recently in the Chemical Warfare Service, U. S. A., A. E. F., Hanlon Field Station, France, is now research chemist with the Carborundum Company, Niagara Falls, N. Y.

Mr. A. F. MacFarland formerly connected with the U. S. Ball Bearing Mfg. Co., Chicago, is now with the Vanadium-Alloys Steel Co., Latrobe, Pa., in the capacity of metallurgist.

Mr. W. C. Ricketts, who, since leaving the By-Products Coke Corp., Chicago, Ill., has been with the Bureau of Mines under Major Rowland, and later was furloughed to the Aetna Chemical Co., Carnegie, Pa., is at present employed as chemical engineer with the Rainey-Wood Coke Co., Swedeland, Pa.

Mr. Roscoe M. Gage, who, during the war, served as 1st Lieutenant in the Chemical Warfare Service, U. S. A., stationed at Akron, Ohio, supervising the manufacture of gas masks in the various rubber factories, and before the war was associated, for a number of years, with the Fisk Rubber Company and the New Jersey Car Spring & Rubber Company, recently joined the Portage Rubber Co., Akron, Ohio, as their chief chemist.

Mr. Scott Powell, who was formerly a private in the Ordnance Corps, and inspection chemist at the works of the King Powder Co., Kings Mills, Ohio, controlling black powder, is now chemist in charge of the laboratory of the Intravenous Products Co., Denver, Colo.

Mr. W. M. Lauer, formerly of the Explosives & Loading Branch of the Ordnance Department as chief army inspector at the plant of the Aetna Explosives Co., Inc., Emporium, Pa., and then transferred to the Central Supervisory & Control Laboratory, Philadelphia, Pa., in charge of control work, has returned to the University of Minnesota as Shevlin Fellow in chemistry.

Mr. A. E. Sidnell, who has recently been discharged from the Air Service, Bureau of Aircraft Production, Balloon Division, U. S. A., stationed at Akron, Ohio, has returned to the Gates Rubber Company as a rubber chemical engineer, in which capacity he has supervision over the development department, chemical laboratory, compounds and materials.

Dr. Wm. M. Bovard, formerly chief of the Paper Section, Research Division, Chemical Warfare Service, U. S. A., with headquarters at the American University, Washington, D. C., is now chief chemist with the Emerson Laboratory, Springfield, Mass.

Mr. A. T. McPherson, who recently resigned his position as assistant chemist in the gas section of the Bureau of Standards, has taken up graduate work in chemistry at the University of Illinois.

Mr. L. D. Ackerman, formerly with F. J. Maywald, consulting chemist in New York City, is now chief chemist with the Converse Rubber Shoe Co., Malden, Mass.

Mr. Paul D. Merica on April 1 resigned his position as physicist in metallurgy at the Bureau of Standards to become physical metallurgist in the research department of the International Nickel Co., Bayonne, N. J.

Mr. Alexander J. Wuertz, formerly in charge of the analytical and research work in the Supervisory & Control Laboratory, Philadelphia, Pa., which laboratory was under the chemical supervision group, Explosives Branch, Ordnance Department, U. S. A., is now engaged in research work in the Jackson Laboratory of E. I. du Pont de Nemours & Company.

Mr. Arthur C. Metcalf, formerly 2nd Lieutenant in the Sanitary Corps of the Army, has accepted an appointment as junior chemist, Bureau of Chemistry, United States Department of Agriculture, assigned to the Buffalo Station of the Bureau.

Mr. F. R. Georgia has been released from service as 1st Lieutenant in the Sanitary Corps with the A. E. F. and has returned to his old position as instructor in sanitary chemistry at Cornell University.

Mr. Hoyt D. Lucas, formerly with the Gas Defense Division, Chemical Warfare Service, as Sergeant-in-Charge of shift running routine control of gas mask carbon and granules at Astoria, L. I., serving part of the time on special detail at Springfield, Mass., and Edgewood Arsenal, Baltimore, Md., is now connected with the Nestlé Food Company as research and routine control chemist.

Captain C. A. Jennings has received his discharge from the Construction Division, Utilities Branch, U. S. A., and has returned to the technical staff of Wallace & Tiernan Co., Inc., in charge of the Chicago office.

Mr. William A. Hammond, recently discharged from the Chemical Warfare Service, is now with the Castalia Portland Cement Co., Pittsburgh, as chief chemist, having charge of the works laboratory at Castalia, Ohio. Mr. Hammond will do some research work on the recovery of potash.

Mr. L. J. Willien, formerly superintendent of the Offense Laboratory of the Development Division of the Chemical Warfare Service, Cleveland, Ohio, has returned to his former position as chemical engineer for Charles H. Tenney & Co., Boston, Mass.

Mr. H. W. Greider recently resigned his position in the Civil Service of the Government and is at present the holder of an Industrial Fellowship at the Mellon Institute of Industrial Research, with headquarters at Pittsburgh, Pa.

Mr. Harry E. Outcault who served as 2nd Lieutenant in the Gas Mask Research Division of the Chemical Warfare Service and was detailed on special duty as commanding officer of the Bureau of Standards detachment of the Chemical Warfare Service, is now employed in the engineering detachment of the Edison Lamp Works of the General Electric Company at Harrison, N. J.

Mr. R. L. Johnson, formerly Captain in the Gas Service at Edgewood Arsenal, Edgewood, Md., is now chemical engineer for the Midcontinent Iron and Chemical Co., Midco, Mo.

Mr. H. M. St. John, who served as Captain in the Chemical Warfare Service, Development Division, Cleveland, Ohio, has received his discharge and has taken the position of assistant manager for the Detroit Electric Furnace Co., Detroit, Mich.

Mr. Richard H. Catlett, who returned to the United States February 2, after a year's service in France with the 1st Gas Regiment (30th Engineers) as 1st Lieutenant, and who was wounded in the Argonne-Meuse offensive, has completely recovered from his wound and has been, since March 1, a member of the engineering staff of the International Coal Products Corp., Irvington, N. J.

Mr. Henry B. Faber, who is perhaps best known as a member of the Advisory Committee of the Chemical Exposition and as the technical man of the Industrial Filtration Corporation, was given a surprise dinner and loving cup on April 4 by the staff of nine of the School of Pyrotechnics at Columbia University of which he has been head. He has lately been appointed an associate in the department of chemical engineering at Columbia University.

Mr. Robert J. Anderson has resigned as research metallurgist with the Bureau of Aircraft Production, Detroit, and will join the staff of the Bureau of Mines, in which connection he will make special investigations in the metallurgy of aluminum and other nonferrous metals, at the experiment station at Pittsburgh.

Capt. C. L. Colburn has returned from service with the Corps of Engineers, and has resumed his former work as assistant metal mining engineer for the Bureau of Mines, stationed in Washington.

Mr. Walter Renton Ingalls, editor of the *Engineering and Mining Journal* for nearly 14 years, has resigned to re-enter professional practice as a consulting engineer, with offices at 115 Broadway, New York City, and Mr. H. C. Parmelee, editor of *Chemical and Metallurgical Engineering*, has been appointed acting editor of the *Engineering and Mining Journal*.

Dr. William C. Moore, for the past five and a half years research chemist at the Cleveland Plant of the National Carbon Co., Inc., has resigned, effective May 1, in order to take charge of the physico-chemical research in the department of immunology in the School of Public Health and Hygiene, recently established by the Rockefeller Foundation at Johns Hopkins University, Baltimore, Md.

Mr. H. Allison Webster has recently been made chief chemist of both the Columbia Chemical Company and the Tennessee Agricultural Chemical Corporation, of Tennessee.

Mr. Herbert A. Meyer has resigned as assistant to the Secretary of the Interior and has accepted an important position with the Prairie Oil and Gas Company in Texas.

Mr. Alexander D. Bell resigned March 1 from his position as assistant chemist, Bureau of Standards, Washington, to take a position as research chemist with the Aluminum Company of America, New Kensington, Pa.

GOVERNMENT PUBLICATIONS

By R. S. McBRIDE, Bureau of Standards, Washington

NOTICE—Publications for which price is indicated can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. Other publications can usually be supplied from the Bureau or Department from which they originate. Commerce Reports are received by all large libraries and may be consulted there, or single numbers can be secured by application to the Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington. The regular subscription rate for these Commerce Reports mailed daily is \$2.50 per year, payable in advance, to the Superintendent of Documents.

CONGRESSIONAL COMMITTEES

Mining Coal, Phosphate, Etc. Three reports on Senate Bill 2812 to authorize exploration for and disposition of coal, phosphate, sodium, oil, oil shale, gas, etc., have been submitted as follows: House Report 1138, 20 pp., dated February 25; House Report 1059, 21 pp., dated February 11; Senate Report 392, 17 pp., dated February 18.

Potash. Two reports on Senate Bill 5557 "to safeguard temporarily, by license control of imports of potash, interests of domestic potash producers until trade conditions are readjusted" are Senate Report from the Mines and Mining Committee No. 751, dated February 22, and a longer report of 177 pp. from the same committee giving the proceedings in hearings on this subject.

PUBLIC HEALTH SERVICE

Standards for Measuring the Efficiency of Exhaust Systems in Polishing Shops. C. E. A. WINSLOW, L. GREENBURG AND H. C. ANGERMYER. Public Health Reports, 34, 427-449 (March 7).

GEOLOGICAL SURVEY

Geology of the Lost Creek Coal Field Morgan County, Utah. F. R. CLARK. Bulletin 691-L. Contributions to Economic Geology, 1918, Part I. 12 pp. Issued February 26, 1919.

Gold, Silver, Copper, Lead, and Zinc in California and Oregon in 1917. C. G. YALE. Mines Report. Mineral Resources of the United States, 1917, Part I. 50 pp. Issued February 18, 1919.

Contributions to Economic Geology (Short Papers and Preliminary Reports) 1917. Part I—Metals and Nonmetals except Fuels. F. L. RANSOME, E. F. BURCHARD AND H. S. GALE. Bulletin 660. 304 pp.

Contributions to Economic Geology (Short Papers and Preliminary Reports) 1917. Part II—Mineral Fuels. D. WHITE. Bulletin 661. 328 pp.

Geology and Ore Deposits of the Tintic Mining District, Utah. W. LINDGREN AND G. F. LOUGHLIN. With a Historical Review. V. C. HEIKES. Professional Paper 107. 282 pp.

The Canning River Region Northern Alaska. E. DE K. LEFFINGWELL. Professional Paper 109. 251 pp.

A Geologic Reconnaissance of the Inyo Range and the Eastern Slope of the Southern Sierra Nevada, California. A. KNOPF. With a Section on the Stratigraphy of the Inyo Range. E. KIRK. Professional Paper 110. 130 pp.

Quicksilver in 1916. H. D. McCASKEY. Mineral Resources of the United States, 1916, Part I. 17 pp. Issued February 19, 1919.

The domestic quicksilver industry continued active throughout 1916, owing principally to conditions brought about by the war. These were, briefly, an increased demand for use in munitions, a market largely restricted to domestic output because of foreign embargoes on export, a consequent rise in prices, highly profitable current operations, and good prospects for future profits.

In February and March attempts to profiteer by speculators outside the industry, according to reports, brought the price to over \$300 a flask, but the effort proved abortive when supplies to complete domestic contracts for the British government were obtained from abroad. The market then became normal with strong demand at profitable but reasonable prices.

The mines and their reduction works were generally active throughout the year, and the outlook justified reopening of old properties and search for and development of new prospects. At some mines the richest ore was taken out to provide capital for further operations, and although this added material to the output in time of need and brought profitable returns at the moment, the effect was to lower the average grade of ore available for future treatment.

Although the industry enjoyed high prices and continuous demand, reserves have been heavily drawn upon, new ore bodies have not in the main been discovered to replace depleted resources, costs of operation have steadily climbed, and profits on the whole have not been equal to expectation. The domestic mines may continue to count upon a fair demand at favorable prices, but they must follow the best engineering practice and sound financial guidance to keep gross income above costs. The same war conditions that brought financial rewards also brought abnormal difficulties to be overcome.

Confidential returns to the Geological Survey from every producing district gave the output of quicksilver in the United States in 1916 as 29,932 flasks of 75 lbs. each, against 21,033 flasks in 1915. With high prices and in the absence of excessive burdens the production should be maintained at 30,000 to 35,000 flasks, at least until 1920.

At the average price of \$125.89 per flask quoted at San Francisco for domestic quicksilver, the output for 1916 was valued at \$3,768,139—a value exceeded only in 1875 (when it was \$4,228,538) in all the history of the domestic industry from 1850 to 1916, inclusive. In 1915 the value, based on the San Francisco quoted price of \$85.80, was \$1,804,631, against \$811,680 in 1914. Compared with 1915 the production for 1916 showed an increase of 42 per cent in quantity and of 109 per cent in value.

The production of California increased 47 per cent in quantity and 116 per cent in value in 1916, against 26 and 112 per cent in 1915. The output of Nevada decreased 6 per cent in quantity and increased 39 per cent in value, against increases of 11 and 105 per cent in 1915; and the output of the other states, Arizona, Oregon, Texas, and Washington combined, increased 51 per cent in quantity and 122 per cent in value over the output of Arizona, Texas, and Oregon combined in 1915.

The average recovery in 1916 was 0.45 per cent of metal in ore treated, or 9.0 lbs. of quicksilver per ton, against 0.497 per cent in 1915, or 9.9 lbs. per ton, and 0.505 per cent in 1914, or 10.1 lbs. per ton.

Prices of quicksilver in the United States may be studied from average quotations for domestic quicksilver at San Francisco,

the market in closest contact with the industry. From the low average of \$39.60 a flask in 1907 the price gradually climbed to \$46.51 a flask in 1910 and then declined to \$40.23 a flask in 1913. On the outbreak of the war, conditions of foreign embargoes and increased domestic demand brought the average up to \$125.89 a flask for 1916. The price in New York usually represents an increase commensurate with cost of freight from the mines to New York. The London prices (for Spanish and Italian, but principally the former) increased from the equivalent of \$39.61 a flask in 1912 to \$86.39 in 1916. Since 1913 the import tariff on quicksilver has been 10 per cent *ad valorem*, so that for comparison of cost of Spanish and Italian quicksilver at New York with domestic there should be added the tariff plus ocean freight.

Secondary Metals in 1917. J. P. DUNLOP. Mineral Resources of the United States, 1917, Part I. 32 pp. Issued February 19, 1919.

"Secondary metals" are those recovered from scrap metal, sweepings, skimmings, and drosses, and are so called to distinguish them from the metals derived directly from ores, which are termed "primary metals." The distinction does not imply that secondary metals are of inferior quality, for metals derived whether from ore or from waste material vary in purity and in adaptability for use in making certain products. The reports to the United States Geological Survey now include the secondary recoveries of copper, zinc, lead, tin, antimony, aluminum, and nickel. The figures obtained by the Survey are given as a supplement to the regular reports on primary metals in order to enable producers and consumers to form a more comprehensive idea of the quantities of metal available for consumption; in fact, they constitute an essential addition to the seven general reports on primary metals, though only a part of the recovery of waste metals is given.

Dealers in and refiners and smelters of scrap metals continued to do a large business in 1917, though it is doubtful if the business done was as profitable or as large as in 1916. Stocks of some new metals, such as copper, tin, and aluminum, were small and spot shipments were not always available. On the other hand, there were ample supplies of zinc and antimony and prices for these metals decreased. Generally there was an active demand for nearly all scrap metals throughout the year. Profits were less because prices were fixed during the year for certain metals and expenses were greater on account of higher costs of labor. Freight embargoes, restrictions of various kinds, and changing business conditions hampered the secondary metal trade. The active demand for scrap metals stimulated the collection of scrap metal from all sources, but the increased quantity of waste material was due mainly to the vast extension of industries connected with material for war purposes. The increase was confined mostly to clean new scrap, as the scarcity of labor and supplies and the clearly defined policy of the Government restricting construction of new buildings for nonessential purposes lessened the quantity of old metal derived from the demolition of structures which under ordinary conditions would have been replaced by new buildings and equipment. A smaller quantity of zinc was used for galvanizing, consequently less zinc dross was available for redistillation or remelting, and of this reduced output a considerable part was exported to Europe for treatment.

More scrap metals were sold directly from the producer to foundries, and there were fewer resales between dealers and brokers. One result of the fixed price of aluminum is that considerable quantities of scrap aluminum and aluminum alloy are purchased directly by consumers from the producers at prices which secondary smelters and refiners making ingot cannot afford to pay. New pig aluminum is barely sufficient in quantity to satisfy the requirements of priority consumers, so that the stocks available for nonessential industries are negligible. If

the consumers are purchasing only heavy scrap, the losses in remelting, though large, are not serious; but if large quantities of clippings, borings, and grindings are used by foundries, there is a very large loss in remelting, which would be avoided if the light scrap went to the large refineries that specialize in the treatment of such wastes.

The value of the secondary platinum, iridium, and palladium recovered in 1917 amounted to about \$6,650,000, and the value of old jewelry, dental waste, silver spoons, ornaments, and other material containing gold or silver, remelted and refined, was probably more than \$25,000,000. It is difficult to estimate the value of ferrous scrap remelted in 1917. Estimates of the quantity vary from 12,000,000 to 15,000,000 long tons, and the value from \$400,000,000 to \$450,000,000. Some of the scrap ferrous metal contained nickel, tungsten, manganese, chromium, vanadium, or other alloys, which made it many times more valuable than the more ordinary commercial products, though the market is limited and some knowledge is necessary to locate prospective purchasers. Old rails, car wheels, pipe, and other iron and steel shapes, were often sold at prices in excess of the original cost. Iron and steep scrap is used by all foundries and rolling mills, and hundreds of thousands of tons of it are collected, sorted, and shipped.

SECONDARY METALS RECOVERED IN THE UNITED STATES IN 1916 AND 1917

	1916		1917	
	Quantity Short Tons	Value Dollars	Quantity Short Tons	Value Dollars
Secondary copper, including that in alloys other than brass.....	140,000	68,880,000	159,400	87,032,400
Remelted brass.....	300,000	127,440,000	320,000	141,888,000
Secondary lead.....	56,700	13,289,400	45,100	16,082,000
Recovered lead in alloys.....	39,600		48,400	
Secondary spelter.....	50,700		31,400	
Recovered zinc in alloys other than brass.....	2,600	14,284,400	4,800	7,384,800
Secondary tin.....	7,600		6,000	
Recovered tin in alloys.....	9,800	15,131,040	13,400	23,920,200
Secondary antimony.....	80		6	
Recovered antimony in alloys.....	4,400	2,270,016	4,955	2,061,700
Secondary aluminum.....	12,900		6,660	
Recovered aluminum in alloys.....	6,400	23,430,200	9,440	16,711,800
Secondary nickel ¹	16		60	
Recovered nickel in alloys ¹	800	652,800	800	774,000
	265,377,856		295,854,900	

¹ Recoveries made by International Nickel Company from scrap nickel or alloys and from nickel in scrap ferrous alloys from any source are not included.

Sodium Salts in 1917. R. C. WELLS. Separate from Mineral Resources of the United States, 1917, Part II. 37 pp. Published January 27, 1919.

The following table summarizes the production in 1917 of the sodium salts included in this report and gives also for comparison certain figures for 1916 collected under the direction of H. S. Gale, of the United States Geological Survey.

It is obvious that there is some duplication in both the quantity and the value of the items of this table owing to the fact that a salt manufactured by one producer may be converted into another salt by another producer; for example, the sodium constituent in sodium fluoride made from soda ash purchased in the open market is reported and counted in both salts. The figures have, therefore, been recalculated as far as possible, with the particular aim of avoiding any such duplication and the result shows that in 1917 approximately 7,800,000 short tons of sodium salts were manufactured into compounds valued at \$128,000,000 at the point of shipment. These figures exclude any duplication in quantity of the sodium constituent, which, however, is all included and reckoned in the compounds having the highest values. Sodium chloride is the original source of most of the sodium in these salts, and the value added in manufacture represents interest, rents, profits, the cost of labor, power, and fuel, as well as the value of the other constituents of the salts, such as iodine, boron, chromium, cyanogen, and sulfur.

SODIUM SALTS PRODUCED IN THE UNITED STATES IN 1916 AND 1917

	1916		1917	
	Quantity Short Tons	Value	Quantity Short Tons	Value
Sodium acetate.....			1,049	\$22,828
Sodium bicarbonate.....	115,177	\$2,303,540	174,212	\$5,292,374
Sodium carbonate.....	1,324,208	18,283,866	1,578,889	38,374,199
Soda ash.....			77,399	1,698,520
Sodium chloride and sodium peroxide.....			4,522	2,119,626
Sodium chloride: Salt in brine.....	2,539,717	831,841	2,890,588	1,083,586
Rock salt.....	1,368,353	2,665,270	1,605,025	3,897,595
Evaporated salt.....	2,434,836	10,148,836	2,482,564	14,359,261
Sodium chromate and sodium bichromate.....			21,881	8,985,133
Sodium cyanide and sodium ferrocyanide.....			11,627	6,938,708
Sodium fluoride.....			1,424	397,305
Sodium hydroxide (caustic soda).....	391,597	17,426,066	495,744	29,733,673
Sodium iodide.....			7	490,000
Sodium nitrate.....			861	480,145
Sodium perchlorate and metallic sodium.....			4,594	2,119,100
Sodium phosphate (including all sodium phosphates).....			13,305	711,283
Sodium silicate.....			254,011	3,517,547
Sodium sulfate: Salt cake.....			183,909	2,987,641
Glauber's salt.....			47,757	732,403
Niter cake.....			387,821	780,278
Sodium sulfide.....			49,494	1,905,473
Sodium sulfate and sodium bisulfite.....			13,707	300,668
Sodium tetraborate (borax).....			32,089	4,717,532
Sodium thiosulfate ("hyposulfite").....			26,598	717,924
Miscellaneous sodium salts.....			49	
			10,359,666	\$132,965,802

The exports for 1917 are given as follows:

DOMESTIC SODA EXPORTED IN 1917

	Quantity Lbs.	Value
All soda ¹		\$ 9,322,233
Caustic soda ²	89,994,975	5,832,632
Salt soda ²	7,442,608	99,821
Sodium silicate ²	14,560,624	217,663
Soda ash ²	98,421,008	2,454,569
All other salts of sodium ²		4,030,196
		\$22,387,134

¹ Six months ending June 30, 1917.

² Six months ending Dec. 31, 1917

Besides these domestic exports, the exports of foreign sodium salts imported and re-exported were as follows:

FOREIGN SODIUM SALTS RE-EXPORTED, 1915-1917

	Sodium Cyanide	Sodium Nitrate	All Other Sodium Salts	Total
	Quantity Lbs.	Quantity Long Tons	Value	Value
1915	1,897,727	\$347,079	\$2,743	\$40,358
1916	222,916	58,265	53,553	\$3,432,273
1917	276,801	115,067	68,998	\$3,127,297
			4,145	\$4,546,509

SODIUM SALTS IMPORTED FOR DOMESTIC CONSUMPTION, 1916-1917

	1916		1917	
	Quantity Lbs.	Value	Quantity Lbs.	Value
Sodium arsenate.....	36,166	\$3,431	23,296	\$2,404
Sodium benzoate.....	72,268	241,429	42,561	197,284
Sodium bicarbonate.....	102,528	2,808	35,737	1,660
Sodium tetraborate or refined borax.....	703	135	110	7
Sodium carbonate or soda ash.....	1,015,010	29,134	2,063,571	70,080
Sodium chlorate.....			33,600	1,080
Sodium chromate and sodium bichromate.....	6,154	3,630	22,025	4,075
Crystalline sodium carbonate ²	62,768	1,316	45,650	1,179
Salt soda or soda crystals.....	22,400	21	100	5
Sodium cyanide.....	449,481	95,713	1,622,118	826,052
(yellow prussiate of soda).....				
Sodium hydroxide or caustic soda.....	397,800	175,089	22,048	13,454
Sodium nitrate or Chilean nitrate.....	154,223	24,606	146,236	17,773
Sodium nitrate.....	2,551,924,000	38,131,364	3,450,330,000	60,573,474
Sodium sulfate.....	3,630,074	255,755	8,767,415	349,111
Sodium phosphate.....	1,292	462	437	180
Sodium silicate.....	1,480,547	20,807	936,576	15,963
Sodium sulfate, crude, or salt cake, and niter cake.....	664,000	9,534	984,000	8,583
Sodium sulfate, crystallized or Glauber's salt.....	2,000	33		
Sodium sulfide.....	185,585	7,432	288,292	5,104
Sodium sulfite.....	68,547	1,272	1,268	30
Sodium thiosulfate or sodium hyposulfite.....	4,371	1,261	5,840	5,748

¹ 10% supercarbonate, or saleratus, and other alkalis containing 50 per cent or more of bicarbonate of soda.

² Monohydrate and sesquicarbonate.

Some Pliocene and Miocene Foraminifera of the Coastal Plain of the United States. J. A. CUSHMAN. Bulletin 676. 100 pp.

Geology and Mineral Deposits of the Colville Indian Reservation, Washington. J. T. PARDEE. Bulletin 677. 186 pp.

A Geologic Reconnaissance for Phosphate and Coal in South-eastern Idaho and Western Wyoming. A. R. SCHULTZ. Bulletin 680. 84 pp.

The Oxidized Zinc Ores of Leadville, Colorado. G. F. LOUGHLIN. Bulletin 681. 91 pp.

Structure and Oil and Gas Resources of the Osage Reservation, Oklahoma. Introduction. D. WHITE. Bulletin 686. 12 pp. Bulletins 686-A, F, H, I, J, K, L, M and N all relate to various districts. Other sections of the same report have already appeared or will follow.

Ground Water in Reese River Basin and Adjacent Parts of Humboldt River Basin, Nevada. G. A. WARING. Water-Supply Paper 425-D. Contributions to the hydrology of the United States, 1917. 45 pp. Issued December 26, 1918. This paper includes analyses.

Geology and Ore Deposits of the Yerington District, Nevada. A. KNOPP. Professional Paper 114. 68 pp.

Gold, Silver, Copper, Lead, and Zinc in Utah in 1917. V. C. HEIKES. Mines Report. Separate from Mineral Resources of the United States, 1917, Part I. 36 pp. Published February 8, 1919.

BUREAU OF THE CENSUS

Census of Manufactures, 1914. 677 pp. Issued February 1919. Reports by states with statistics for principal cities and metropolitan districts. Results of manufactures census for 1914 are contained in three volumes. Present volume contains statistics of manufacturing industries for states. These data were published as separate bulletins. Figures may be different in some unimportant details from those given in bulletins for the reason that certain minor errors discovered in bulletins as first published have been corrected. Volume 2 contains special reports relating to selected industries, which also have been published as series of separate bulletins. Volume 3 is Abstract of Census of Manufacturers, which contains in condensed form essential statistics collected at 1914 census.

Iron and Steel Products, Census of War Commodities. 16 pp. Issued February 1919. This paper contains tables presenting statistics for iron and steel products as reported by 10,494 establishments. Statistics were compiled by division of manufactures, Bureau of the Census, for use of various interested war boards of Government. Canvass included manufactures of specified classes of iron and steel products; wholesalers, dealers, jobbers, and supply houses carrying stocks; and manufacturers using products as material in further process of manufacture, including railroads and public-service corporations that operate construction and repair shops and carry stocks for upkeep of their properties, systems, and lines. Statistics include consumption by producers—that is, by rolling mills, wire-drawing mills, forging shops, etc.—of specified classes of products in further process of manufacture.

BUREAU OF MINES

A Preliminary Report on the Mining Districts of Idaho. T. VARLEY, C. A. WRIGHT, E. K. SOPER AND D. C. LIVINGSTON. Bulletin 166. 113 pp. Paper, 20 cents. Issued February 1919. This includes a preliminary report on the Horseshoe District of the Teton Coal Basin, Southeastern Idaho.

Mining and Milling of Lead and Zinc Ores in the Missouri-Kansas-Oklahoma Zinc District. C. A. WRIGHT. Bulletin 154. 134 pp. Paper, 30 cents. Issued August 1918.

This bulletin was published in cooperation with the Missouri

Bureau of Mines and Geology with the assistance of H. A. Buehler, State Geologist. The Missouri-Kansas-Oklahoma lead and zinc district, better known as the Joplin district, includes the mines in southwest Missouri and in those parts of Kansas and Oklahoma that are directly adjacent. This report of investigations carried on by the Bureau of Mines gives the methods used in mining and milling and indicates in some detail the conditions that affect the efficiency of those methods; it does not attempt to discuss the geology of the district, except incidentally, as this has been described in numerous reports by several geologists.

Central Station Heating, Its Economic Features with Reference to Community Service. J. C. WHITE. Technical Paper 191. 23 pp. Paper, 5 cents. Published October 1917.

Fume and Other Losses in Condensing Quicksilver from Furnace Gases. L. H. DUSCHAK AND C. N. SCHUETTE. Technical Paper 96. 29 pp. Paper, 5 cents. Published October 1918. The condenser losses that can be accurately measured represent at most only a few per cent of the plant output. One should not conclude from this, however, that the over-all efficiency of condensing systems now in use is of the order of 95 per cent. The losses mentioned in the last part of this report have undoubtedly been large at times. The point of fundamental importance established by this investigation is that there are no inherent difficulties that prevent the recovery of at least 96 to 99 per cent of the mercury vapor entering the condenser system.

Accidents at Metallurgical Works in the United States during the Calendar Year 1917. A. H. FAY. Technical Paper 215. 23 pp. Paper, 5 cents. Published January 1919.

Saving Coal in Steam Power Plants. Technical Paper 217. 7 pp. This is a reprint of Engineering Bulletin No. 2 prepared by the United States Fuel Administration in collaboration with the Bureau of Mines.

BUREAU OF STANDARDS

Manual of Inspection and Information for Weights and Measures Officials. F. S. HOLBROOK. Miscellaneous Publications No. 1. 246 pp. Issued November 14, 1918.

Preliminary Determination of the Thermal Expansion of Molybdenum. L. W. SCHAD AND P. HEDNERT. Scientific Paper No. 332. 9 pp. Paper, 5 cents. Issued January 29, 1919. Conclusions:

1—The thermal expansion of molybdenum has been determined between -142° and $+305^{\circ}$ C.

2—It is impossible to secure a second-degree equation which adequately represents the behavior of the material throughout this temperature range.

3—The most probable equation applicable between -142° and $+19^{\circ}$ C. is

$$L_t = L_0 (1 + 5.15t \times 10^{-6} + 0.00570t^2 \times 10^{-6})$$

4—The most probable equation applicable between 19° and $+305^{\circ}$ C. is

$$L_t = L_0 (1 + 5.01t \times 10^{-6} + 0.00138t^2 \times 10^{-6})$$

5—The instantaneous coefficient or rate of expansion increases with temperature.

Conservation of Tin in Bearing Metals, Bronzes, and Solders. G. K. BURGESS AND R. W. WOODWARD. Technologic Paper No. 109. 9 pp. Paper, 5 cents. Issued March 15, 1919. From a metallurgical standpoint there are several ways in which a reduction of the tin consumed in commercial nonferrous and white-metal alloys can be effected: First, a reduction of the tin content of the alloy; second, substitution of part or all of the tin content by some other metal; and third, a substitution of a different type of alloy, which in some cases also involves a change in mechanical design. The Bureau of Standards has been studying these methods of conservation for tin alloys, particularly in regard to Babbitt's and bearing metals, bronzes, and solders. Much of the information secured by the Bureau was obtained from answers to questionnaires sent to manu-

facturers and users of these materials, so that, in general, any suggestions or recommendations made can be considered as being practical and as having already been thoroughly tried.

Solders for Aluminum. Circular No. 78. 9 pp. Paper, 5 cents. Issued January 28, 1918. General conclusions concerning aluminum solders are:

1—All metals or combinations of metals used for aluminum soldering are electrolytically electronegative to aluminum. A soldered joint is therefore rapidly attacked when exposed to moisture and disintegrated. There is no solder for aluminum of which this is not true.

2—Joints should therefore never be made by soldering unless they are to be protected against corrosion by a paint or varnish, or unless they are quite heavy, such as repairs in castings, where corrosion and disintegration of the joint near the exposed surface would be of little consequence.

3—Solders are best applied without a flux, after preliminary cleaning and tinning of the surfaces to be soldered. The composition of the solder may be varied within wide limits. It should consist of a tin base with addition of zinc or of both zinc and aluminum, the chief function of which is to produce a semi-fluid mixture within the range of soldering temperatures.

SUGGESTED RANGES OF COMPOSITION

Tin-zinc solders	Remainder
Tin.....	15-50
Zinc, per cent.....	
Tin-zinc-aluminum solders	Remainder
Tin.....	8-15
Zinc, per cent.....	5-12
Aluminum, per cent.....	

4—The higher the temperature at which the "tinning" is done, the better the adhesion of the tinned layer. By using the higher values of the recommended zinc and aluminum percentages given above, the solder will be too stiff at lower temperatures to solder readily and the workman will be obliged to use a higher temperature, thus securing a better joint. A perfect union between solder and aluminum is very difficult to obtain.

5—The joint between previously tinned surfaces may be made by ordinary methods and with ordinary soft solder. Only the "tinning" mixture need be special for aluminum.

6—There is no reason why a good solder for aluminum need be brittle as several commercial varieties are, and it is very undesirable that it should be.

7—The tensile strength of a good aluminum solder is about 7000 lbs. per sq. in. The strength of a joint depends upon the type and upon the workmanship. Much dependence should not be placed on the strength of a joint.

Table of Unit Displacement of Commodities. Circular No. 77. 67 pp. Paper, 10 cents. Issued March 10, 1919.

DEPARTMENT OF AGRICULTURE

The Production and Conservation of Fats and Oils in the United States. H. S. BAILEY AND B. E. REUTER. Department Bulletin 769. Contributions from the Bureau of Chemistry. 48 pp. Paper, 10 cents. Issued February 10, 1919. This is a statement showing the possibilities of production and the necessity for same.

A Study of the Effect of Storage, Heat, and Moisture on Pyrethrum. W. S. ABBOTT. Department Bulletin 771. Contributions from the Bureau of Entomology. 7 pp. Paper, 5 cents. Issued February 21, 1919. This paper gives the results of experiments in the deterioration of pyrethrum under various conditions.

Articles from the Journal of Agricultural Research

Influence of Salts on the Nitric-Nitrogen Accumulation in the Soil. J. E. GRAVES, E. G. CARTER AND H. C. GOLDTHORPE. 16, 107-135 (January 27). Paper, 5 cents

Variations and Mode of Secretion of Milk Solids. J. W. GOWEN. 16, 79-103 (January 20). Paper, 5 cents.

Nitrates, Nitrification, and Bacterial Contents of Five Typical Acid Soils as Affected by Lime, Fertilizer, Crops, and Moisture. H. A. NOYES AND S. D. CONNER. 16, 27-43 (January 13). Paper, 25 cents.

COMMERCE REPORTS—MARCH 1919

Among the industries being especially developed in Sweden are artificial silk, tar and turpentine, rubber goods, peat fiber, textiles, and butter substitutes. (P. 962)

Efforts are being made to develop large-scale production of by-products of the salt industry in Madras, India, including magnesium and potassium salts and bromine. (P. 1049)

In a report of the British Engineering Trades Committee it is recommended that importation of scientific apparatus be prohibited for ten years; except for special licenses for articles not available in Great Britain. (P. 1094)

The demand for ferrotungsten for high speed steels has decreased so greatly in Great Britain that some sort of government relief is urged to prevent collapse of the industry. (P. 1106)

The formation in the United Kingdom of a Department of Mines is strongly urged for the purpose of developing mineral industries in Great Britain and the colonies. In the meantime a Bureau of Imperial Mineral Resources has been formed to collect and disseminate information regarding mineral resources. (P. 1147)

Among the important chemical industries of Holland represented at the 1918 Utrecht Fair were the manufacture of the following: sulfuric, hydrochloric, and nitric acids, ammonia and ammonium salts, potassium chlorate, copper sulfate, sodium silicate, potassium nitrate, sodium nitrate, white lead, red lead, lead acetate, zinc oxide, lithopone, ultramarine, chrome yellow, hydrogen, oxygen, nitrogen, alcohol, ether, acetic acid, acetates, lactic acid and lactates, coal-tar products, intermediates, drugs, etc. (Pp. 1185-8)

In the reclaiming of rubber in England niter cake was extensively employed to replace part of the sulfuric acid required. (P. 1251)

Large stocks of nitrate are on hand in Chili, where many of the mines are closed and the labor situation is very acute. (P. 1330)

SPECIAL SUPPLEMENTS ISSUED DURING THE MONTH

ITALY—8g	CUBA—25g
SPAIN—15g	ARGENTINA—38g
SPAIN—13g	BRAZIL—40g

STATISTICS OF EXPORTS TO THE UNITED STATES

BRADFORD, ENGLAND (P. 1191)	SPAIN—Sup. 15g	ARGENTINA—Sup. 38g
Drugs	Sphalerite	Beeswax
Dyes	Iron pyrites	Bones
Grease	Hides	Bismuth
Oils	Olive oil	Casein
Hides	Copper	Glycerin
Steel wire	Antimony	Argols
Leather	Antimony oxide	Copper
Artificial silk	Argols	Dye extracts
ALGOLERS (P. 1244)	Fusel oil	Fertilizer
Argols	Gentian root	Glue
Bones	Licorice	Gold
Cork	Calcium tartrate	Grease
Glue stock	Potassium carbonate	Hides
Kieselguhr	Thymol	Mica
Geranium oil	Glue	Castor oil
Zinc ore	Lithopone	Corn oil
Rags	Paper stock	Margarin oil
Skins	Mercury	Neat's-foot oil
SHANGHAI (P. 1478)	BRAZIL—Sup. 40g	Pettigrain oil
Hides	Carnauba wax	Steam oil
Tallow	Diamonds	Antimony ore
Tungsten	Gold	Tungsten ore
Antimony	Hides	Zinc ore
Cottonseed oil	Manganese ore	Quebracho extract
Peanut oil	Monazite sand	Silver
Wood oil	Rubber	Tallow
	Sugar	

NEW PUBLICATIONS

By CLARA M. GUPPY, Librarian Mellon Institute of Industrial Research, Pittsburgh

- Air Analysis: Methods of Air Analysis.** J. S. HALDANE. 2nd Ed. Revised and Enlarged. 8vo. 147 pp. Price, 6s. Charles Griffin & Co., London.
- Aluminum: L'Aluminium dans l'Industrie.** Métal pur, Alliages d'Aluminium. JEAN ESCARD. 272 pp. Price, 14 fr. 40c. H. Dunod et E. Pinat, Paris.
- Antimony, Graphite, Nickel, Potash, Strontium, Tin.** (Preliminary Report 5). 8vo. 44 pp. Price, Grátis. California State Mining Bureau, Ferry Building, San Francisco, Cal.
- Beverages and their Adulteration.** H. W. WILEY. 8vo. 421 pp. Price, \$3.50. P. Blakiston's Son & Co., Philadelphia.
- Casinghead Gas: Hand Book of Casinghead Gas.** H. P. WESTCOTT. 2nd Ed. 12mo. 577 pp. Price, \$3.50. Metric Metal Works, Erie Pa.
- Catalytic Hydrogenation and Reduction.** E. B. MAXTED. 8vo. 112 pp. Price, 4s. 6d. J. & A. Churchill, London.
- Chemical Calculations.** R. H. ASHLEY. 2nd Ed. Revised. 12mo. 276 pp. Price, \$2.00. D. Van Nostrand Co., New York.
- Chemistry: Introduction à la Chimie Générale.** Lois Fondamentales de l'Atomisme et de l'Affinité. H. COPAUX. 212 pp. Price 6 fr. Gauthier-Villars et Cie., Paris.
- Chemistry: Recent Advances in Physical and Inorganic Chemistry.** A. W. STEWART. 3rd Ed. 8vo. 278 pp. Price, \$4.00. Longmans, Green & Co., New York.
- Coal-Tar Dyes and Intermediates.** E. DE BARRY BARNETT. 213 pp. Price, 10s. 6d. Baillière, Tindall & Cox, London.
- Dyes: Natural Organic Coloring Matters.** A. G. PERKIN AND A. E. EVEREST. 8vo. 677 pp. Price, 28s. Longmans, Green & Co., London.
- Inorganic Chemistry: Recent Discoveries in Inorganic Chemistry.** J. H. SMITH. 8vo. 101 pp. Price, 4s. 6d. Cambridge University Press, London.
- Mechanics' and Machinists' Pocket Book, 1919.** W. H. FOWLER, Editor. 18mo. 507 pp. Price, 2s. 6d. Scientific Publishing Co., Manchester.
- Metalurgy of the Nonferrous Metals.** WILLIAM GOWLAND. 2nd Ed. Revised and Enlarged. 588 pp. Price, \$8.50. Charles Griffin & Co., London.
- Tungsten, Molybdenum, and Vanadium.** (Preliminary Report 4.) 8vo. 34 pp. Price, Grátis. California State Mining Bureau, Ferry Building, San Francisco, Cal.
- RECENT JOURNAL ARTICLES**
- Aluminum: Its Use in the Motor Industry in England; Application of the Metal in Replacing Steel and Other Metals.** E. C. HILL. *The Metal Industry*, Vol. 17 (1919), No. 3, pp. 125-127.
- Catalysis: Influence of Catalysts on the Chlorination of Hydrocarbons.** V. R. KOKATNUR. *The Chemical News*, Vol. 118 (1919), No. 3071, pp. 91-92.
- Chemical Engineering in Modern Gas Plants.** W. A. TWINE. *The Chemical Engineer*, Vol. 27 (1919), No. 2, pp. 31-33.
- Clays for Use in Paper-Making.** R. B. ROE. *Journal of the American Ceramic Society*, Vol. 2 (1919), No. 1, pp. 69-73.
- Clays: American Clays and the Paper Industry.** T. P. MAYNARD. *The Chemical Engineer*, Vol. 27 (1919), No. 3, pp. 59-62.
- Coal Ash: Fusibility of Coal Ash.** W. A. SELVIO, W. C. RATLIFF AND A. C. FIELDNER. *Chemical and Metallurgical Engineering*, Vol. 20 (1919), No. 6, pp. 274-276.
- Cyanogen Compounds: Estimation of Cyanogen Compounds in Concentrated Ammonia Liquor.** P. E. SPIELMANN AND HENRY WOOD. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 4, pp. 431-451.
- Dye-stuffs as Medicinal Agents.** G. HSYL. *Color Trade Journal*, Vol. 4 (1919), No. 4, pp. 73-76.
- Enamels: Relative Action of Acids on Enamels.** E. P. POSTER. *Journal of the American Ceramic Society*, Vol. 2 (1919), No. 1, pp. 32-43.
- Industrial Organic Chemistry: Future of Industrial Organic Chemistry; Brief Review of the Several Groups of Industries Depending on Organic Chemical Development, Such as Food, Clothing, Fuel, Drugs and Arts.** HAROLD HUBERT. *Chemical and Metallurgical Engineering*, Vol. 20 (1919), No. 7, pp. 335-341.
- Inorganic Constituents of Lobster Shells.** F. W. CLARKE AND GEORGE STENGER. *The Chemical News*, Vol. 118 (1919), No. 3074, p. 125.
- Leather: Theory and Practice of Leather Chemistry.** J. A. WILSON. *Journal of the American Leather Chemists Association*, Vol. 14 (1919), No. 3, pp. 93-102.
- Linoleum: History and Manufacture of Floorcloth and Linoleum.** M. W. JONES. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 3, pp. 261-311.
- Metals: Decomposition of Metals; A Critical Review of Various Theories which Have Been Advanced from Time to Time to Explain the So-Called "Disease of Metals."** A. I. KRYNITZKY. *Chemical and Metallurgical Engineering*, Vol. 20 (1919), No. 6, pp. 277-282.
- Minerals: International Control of Minerals.** C. K. LEITH. *Mining and Scientific Press*, Vol. 118 (1919), No. 11, pp. 357-361.
- Minerals: Two New Zircon Minerals—Orvilleite and Oliveiraite.** T. H. LEE. *The Chemical News*, Vol. 118 (1919), No. 3074, pp. 125-127.
- Molding Sand: The Practical Analysis of Molding Sand.** F. A. HAYES. *The Iron Age*, Vol. 103 (1919), No. 12, pp. 739-741.
- Mortar: Compressive Strength of Cement-Lime Mortars.** F. A. KIRKPATRICK AND W. B. ORANGE. *Journal of the American Ceramic Society*, Vol. 2 (1919), No. 1, pp. 44-64.
- Nitrates, Nitrification, and Bacterial Contents of Five Typical Acid Soils as Affected by Lime, Fertilizer, Crops, and Moisture.** H. A. NOYES AND S. D. CONNER. *Journal of Agricultural Research*, Vol. 16 (1919), No. 2, pp. 27-42.
- Paper: Testing Moisture in Pulp.** E. B. SLACK. *Pulp and Paper Magazine*, Vol. 17 (1919), No. 11, pp. 265-270.
- Petroleum of Benzene and Toluene in Petroleum.** F. B. THOLE. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 4, pp. 394-431.
- Phosphorites and Superphosphates from the Point of View of the Sulfur Industry.** LOUIS TRELLI. *The Chemical News*, Vol. 118 (1919), No. 3070, pp. 73-76.
- Phosphorus: Notes on the Determination of Phosphorus in Steel and Iron.** W. D. RIDSDALE. *The Chemical News*, Vol. 118 (1919), No. 3072, pp. 100-101.
- Potash in 1917.** H. S. GALE AND W. B. HICKS. *The American Fertiliser*, Vol. 50 (1919), No. 7, pp. 43-45.
- Pyrrhotite Ores: Magnetic Concentration of Pyrrhotite Ores.** J. P. BONARDI. *Chemical and Metallurgical Engineering*, Vol. 20 (1919), No. 6, pp. 266-270.
- Refractory Materials as a Field for Research; A Survey of the Scientific Aspects of the Subject.** E. W. WASHBURN. *Journal of the American Ceramic Society*, Vol. 2 (1919), No. 1, pp. 3-31.
- Rubber as a Colloid.** D. F. TWISS. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 5, pp. 471-501.
- Rubber: Solid Rubber Tires.** A. H. KINO. *Chemical and Metallurgical Engineering*, Vol. 20 (1919), No. 7, pp. 352-359.
- Safflower Oil as a Drying Oil.** H. H. MANN AND N. V. KANITKAR. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 3, pp. 364-381.
- Sheet Metal: Structural Characteristics of Rolled Sheet Brass.** H. A. EASTICK. *The Metal Industry*, Vol. 17 (1919), No. 3, pp. 121-124.
- Stains and Discolorations on Cotton Piece Goods.** O. H. FORSDALE. *Color Trade Journal*, Vol. 4 (1919), No. 4, pp. 77-78.
- Stannous Chloride: Estimation of Nitro-Groups in Organic Compounds by Means of Stannous Chloride.** J. C. F. DRUCE. *The Chemical News*, Vol. 118 (1919), No. 3075, p. 133.
- Stannous Chloride: The Interaction of Stannous and Arsenious Chlorides.** R. G. DURRANT. *Journal of the Chemical Society*, Vol. 115, (1919), No. 676, pp. 134-143.
- Steel: Observations on Flaky and Woody Steel.** FEDERICO GIOLITTI. *Chemical and Metallurgical Engineering*, Vol. 20 (1919), No. 6, pp. 271-273.
- Steel: Observations on So-Called "Flakes" in Steel; An Examination of Nickel Steel and Carbon Steel Transverse Test Bars.** HAAKON STREI. *Chemical and Metallurgical Engineering*, Vol. 20 (1919), No. 7, pp. 342-351.
- Sulfites: The Determination of Sulfites, and of Sulfur Dioxide in Gaseous Mixtures.** PERCY HALLER. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 5, pp. 521-561.
- Textiles: The Isolation and Examination of the Textile in Rubber-Proofed Cotton Fabrics.** B. D. FORRITT. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 5, pp. 501-521.
- Volumetric Determination of Reducing Sugars.** W. B. CLARK. *The Chemical News*, Vol. 118 (1919), No. 3075, pp. 140-142.
- Water: Effect of Some Simple Electrolytes on the Temperature of Maximum Density of Water.** ROBERT WRIGHT. *Journal of the Chemical Society*, Vol. 115 (1919), No. 676, pp. 119-126.
- Zirconia: Its Utilization as a Refractory Substance, an Opacifier, and an Abrasive.** M. A. GRANGER. *The Chemical News*, Vol. 118 (1919), No. 3073, pp. 115-118.

MARKET REPORT—APRIL, 1919

WHOLESALE PRICES PREVAILING IN THE NEW YORK MARKET ON APRIL 15, 1919

INORGANIC CHEMICALS

Acetate of Lime, Basis 80%.....	100 Lbs.	2.00	@	2.05
Alum, ammonia, lump, U. S. P.....	100 Lbs.	5.00		
Aluminum Sulfate, (iron free).....	Lb.	3	■	3 1/4
Ammonium Carbonate, domestic.....	Lb.	13	@	13 1/2
Ammonium Chloride, white.....	Lb.	19	@	20
Aqua Ammonia, 26°, drums.....	Lb.	6 1/2	■	7
Arsenic, white.....	Lb.	9	■	11
Barium Chloride.....	Ton	80.00	@	85.00
Barium Nitrate.....	Lb.	12	■	14
Barytes, prime white, foreign.....	Lb.	30.00	@	35.00
Bleaching Powder, 35 per cent.....	100 Lbs.	1.60	@	2.50
Blue Vitriol.....	Lb.	7 1/4	@	8
Borax, crystals, in bags.....	Lb.	7 1/4	@	10 1/4
Boric Acid, powdered crystals.....	Lb.	7 1/4	@	8 1/4
Bromine, crude, domestic.....	Long Ton	28.00	@	35.00
Bromine, technical, bulk.....	Lb.	75	@	
Calcium Chloride, lump, 70 to 75% fused.....	Ton	18.00	@	22.00
Caustic Soda, 76 per cent.....	100 Lbs.	2.60	@	2.90
Chalk, light precipitated.....	Ton	4 1/4	@	5
China Clay, imported.....	Ton	20.00	@	30.00
Feldspar.....	Ton	8.00	@	15.00
Fuller's Earth, foreign, powdered.....	Ton	nominal		
Fuller's Earth, domestic.....	Ton	20.00	@	30.00
Glauber's Salt, in bbls.....	100 Lbs.	2.10	■	3.00
Green Vitriol, bulk.....	100 Lbs.	2.00	@	2.25
Hydrochloric Acid, commercial, C. P.....	Lb.	8	■	8 1/4
Iodine, resublimed.....	Lb.	4.25	@	4.30
Lead Acetate, white crystals.....	Lb.	14	@	15
Lead Nitrate, C. P.....	Lb.	85		
Litharge, American.....	Lb.	9 1/2	@	10 1/2
Lithium Carbonate.....	Lb.	1.50		
Magnesium Carbonate, U. S. P.....	Lb.	25	@	30
Magnesite, "Calcedined".....	Ton	60.00	@	65.00
Nitric Acid, 40°.....	Lb.	7 1/4	@	
Nitric Acid, 42°.....	Lb.	8		
Phosphoric Acid, 48/50%.....	Lb.	26	@	30
Phosphorus, yellow.....	Lb.	45	@	55
Plaster of Paris.....	100 Lbs.	2.00	@	2.50
Potassium Bichromate.....	Lb.	34	@	35
Potassium Bromide, granular.....	Lb.	1.25	@	1.30
Potassium Carbonate, calcined, 80 @ 85%.....	Lb.	16	@	17
Potassium Chlorate, crystals, spot.....	Lb.	36	@	37
Potassium Cyanide, bulk, 98-99 per cent.....	Lb.	nominal		
Potassium Hydroxide, 88 @ 92%.....	Lb.	60	@	70
Potassium Iodide, bulk.....	Lb.	3.50	@	3.55
Potassium Nitrate.....	Lb.	27	@	30
Potassium Permanganate, bulk, U. S. P.....	Lb.	75	@	83
Quicksilver, flask.....	75 Lbs.	75.00	@	
Red Lead, American, dry.....	100 Lbs.	11.00	@	13.00
Salt Cake, glass makers'.....	Ton	17.50	@	22.00
Silver Nitrate.....	Oz.	63 1/4	@	65
Soapstone, in bags.....	10.00	@	12.50	
Soda Ash, 58%, in bags.....	100 Lbs.	1.60	@	1.65
Sodium Acetate, broken lump.....	Lb.	8 1/4	■	10 1/4
Sodium Bicarbonate, domestic.....	100 Lbs.	2.60	@	2.65
Sodium Bichromate.....	Lb.	10	@	11
Sodium Chlorate.....	Lb.	16	@	18
Sodium Cyanide.....	Lb.	30	@	32
Sodium Fluoride, commercial.....	Lb.	14	@	15
Sodium Hyposulfite.....	100 Lbs.	2.60	@	3.60
Sodium Nitrate, 95 per cent, spot.....	100 Lbs.	4.07 1/4	@	
Sodium Sulfate, liquid, 40° Bé.....	Lb.	2	@	2 1/2
Sodium Sulfate, 60%, fused in bbls.....	Lb.	3 1/2	@	3 3/4
Sodium Bisulfite, powdered.....	Lb.	5	@	7
Stroptium Nitrate.....	Lb.	25	@	30
Sulfur.....	100 Lbs.	2.25	@	4.60
Sulfuric Acid, chamber 66° Bé.....	Ton	18.00	@	20.00
Sulfuric Acid, oleum (fuming).....	Ton	23.00		
Talc, American, white.....	Ton	15.00		
Terra Alba, American, No. 1.....	100 Lbs.	1.17 1/4	@	
Tin Bichloride, 50°.....	Lb.	26	@	28
Tin Oxide.....	Lb.	65	@	70
White Lead, American, dry.....	Lb.	9	@	9 1/4
Zinc Carbonate.....	Lb.	18	@	20
Zinc Chloride, commercial.....	Lb.	14	@	14 1/4

ORGANIC CHEMICALS

Acetanilid, C. P., in bbls.....	Lb.	48	@	49
Acetic Acid, 56 per cent, in bbls.....	100 Lbs.	6.50	@	6.75
Acetic Acid, glacial, 99 1/2%.....	100 Lbs.	13.25	@	13.50
Acetone, drums.....	Lb.	15 1/4	@	16
Alcohol, denatured, 180 proof.....	Gal.	40	@	43

Alcohol, sugar cane, 188 proof.....	Gal.	4.90	@	4.95
Alcohol, wood, 95 per cent, refined.....	Gal.	1.22	@	1.24
Amyl Acetate.....	Gal.	4.20	■	4.50
Aniline Oil, drums extra.....	Lb.	23	@	24
Benzoic Acid, ex-toluol.....	Lb.	1.15	@	1.25
Benzene, pure.....	Gal.	22	@	22 1/2
Camphor, refined in bulk, bbls.....	Lb.	1.24 1/2	@	1.25
Carbolic Acid, U. S. P., crystals, drums.....	Lb.	10	@	15
Carbon Bisulfide.....	Lb.	9	@	10
Carbon Tetrachloride, drums, 100 gals.....	Lb.	143 1/2	@	151 1/2
Chloroform.....	Lb.	65	@	70
Citric Acid, domestic, crystals.....	Lb.	1.20	@	1.22
Cresosote, beechwood.....	Lb.	2.00	@	2.10
Cresol, U. S. P.....	Lb.	18	■	20
Dextrine, corn (carloads, bags).....	Lb.	8	@	9
Dextrine, imported potato.....	Lb.	nominal		
Ether, U. S. P. 1900.....	Lb.	23	@	24
Formaldehyde, 40 per cent.....	Lb.	22	■	22 1/2
Glycerin, dynamite, drums extra.....	Lb.	15	@	15 1/2
Oxalic Acid, in casks.....	Lb.	36	■	38
Pyrogallie Acid, resublimed, bulk.....	Lb.	2.75	@	2.95
Salicylic Acid, U. S. P.....	Lb.	30	@	40
Starch, corn (carloads, bags) pearl.....	100 Lbs.	6.00	@	7.00
Starch, potato, Japanese.....	Lb.	13	@	14
Starch, rice.....	Lb.	12 1/2	@	13
Starch, sago flour.....	Lb.	9 1/4	@	10 1/4
Starch, wheat.....	Lb.	nominal		
Tannic Acid, commercial.....	Lb.	65	@	80
Tartaric Acid, crystals.....	Lb.	84 1/2	@	85

OILS, WAXES, ETC.

Beeswax, pure, white.....	Lb.	50	@	55
Black Mineral Oil, 29 gravity.....	Gal.	24	@	25
Castor Oil, No. 3.....	Lb.	21	@	22
Ceresin, yellow.....	Lb.	16	@	17
Corn Oil, crude.....	100 Lbs.	—	@	18.00
Cottonseed Oil, crude, f. o. b. mill.....	Lb.	17 1/2	@	—
Cottonseed Oil, p. s. y.....	Lb.	21 1/2	@	22
Menhaden Oil, crude (southern).....	Gal.	90	@	1.00
Neat's-foot Oil, 20°.....	Gal.	2.00	@	
Paraffin, crude, 118 to 120 m. p.....	Lb.	8 1/2	@	9
Paraffin Oil, high viscosity.....	Gal.	40	@	41
Rosin, "F" Grade, 280 lbs.....	Bbl.	12.15	@	12.25
Rosin Oil, first run.....	Lb.	75	@	76
Shellac, T. N.....	Lb.	46	@	48
Spermaceti, cake.....	Lb.	31	@	33
Sperm Oil, bleached winter, 38°.....	Gal.	1.98	@	2.00
Spindle Oil, No. 200.....	Gal.	38	@	40
Stearic Acid, double-pressed.....	Lb.	18	@	18 1/2
Tallow, acidless.....	Gal.	1.15	@	1.20
Tar Oil, distilled.....	Gal.	36	@	38
Turpentine, spirits of.....	Gal.	79	@	80

METALS

Aluminum, No. 1, ingots.....	Lb.	31	@	
Antimony, ordinary.....	Lb.	7 1/4	@	8
Bismuth, N. Y.....	Lb.	nominal		
Copper, electrolytic.....	Lb.	23	@	nominal
Copper, lake.....	Lb.	20	@	23
Lead, N. Y.....	Lb.	@		5.25
Nickel, electrolytic.....	Lb.	55	@	56
Platinum, refined, soft.....	Oz.	nominal		
Silver.....	Oz.	1.01 1/2	@	
Tin, Straits.....	Lb.	nominal		
Tungsten (Wo).....	Per Unit	15.00	@	20.00
Zinc, N. Y.....	100 Lbs.	9.40	@	9.60

FERTILIZER MATERIALS

Ammonium Sulfate.....	100 Lbs.	4.75	@	—
Blood, dried, f. o. b. New York.....	Unit	6.00	@	6.25
Bone, 3 and 50, ground, raw.....	Ton	37.00	@	37.50
Calcium Cyanamide.....	Unit of Ammonia	nominal		
Calcium Nitrate, Norwegian.....	100 Lbs.	—		
Castor Meal.....	Unit	—		
Fish Scrap, domestic, dried, f. o. b. works.....	Unit	nominal		
Phosphate, acid, 16 per cent.....	Ton	17.00	@	18.00
Phosphate Rock, f. o. b. mine.....	Ton	nominal		
Florida land pebble, 68 per cent.....	Ton	5.00	@	6.00
Tennessee, 78-80 per cent.....	Ton	nominal		
Potassium "muriate," basis 80 per cent.....	Ton	265.00	@	275.00
Pyrites, furnace size, imported.....	Unit	nominal		
Tankage, high-grade, f. o. b. Chicago.....	Unit	5.00	@	5.50

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EDITORIALS

FUTURE ARMS

At last the peace terms have been delivered to Germany. That nation is now foaming, squirming, and writhing. At this writing you can interpret these symptoms according to your own predilections. It's a fifty-fifty guess as to whether or not they will sign the terms.

Press interviews with prominent Germans are extremely interesting. Prince Lichnowsky indulges in threats and says the treaty could only be signed "with the thought of beginning a new war soon." So, too, a proclamation by the government states, "Fresh hatred and killing would result from such a peace." President Ebert inclines toward the humorous when he says "It [the German people] still has a cultural mission to perform and ethical treasures to bestow." On the other hand, Ludendorff bluntly informs an American correspondent, "If these are the peace terms, then America can go to hell!"

There is something satisfactory about this genial remark of Ludendorff's. It gets us out of the atmosphere of propaganda, stage-play, and bluff, and makes the issue clear. If this sentiment had been predominant during the first week of last November we would have been in Berlin by this time with many matters permanently settled. On the other hand, if Lichnowsky and the government proclamation portray the true state of affairs, then very serious consideration should be given to the remarks of General Foch to the Paris correspondent of the *London Daily Mail*.

The Germans will have no arms for another attack, you say. Ho! Ho! How do you know? By the time you found out that they had got them it would be too late.

What will be the character of those arms? Not battleships, nor submarines, nor the usual army equipment characteristic of the first year of the war. The terms of the treaty guard these points with all severity and security. Moreover, such means of war making are now obsolete. If Germany is to have arms for a future war they will be developed in her chemical laboratories. The advance in chemical warfare will be so great as to be comparable to the difference between the fighting last October and that of the days before the invention of gunpowder. In the published summary of the treaty, Germany is forbidden to manufacture poisonous gases, but evidently no curb is placed upon the chemical industries or the possibilities of research. The way is open.

What are we to do? Briefly, first, keep the Chemical Warfare Service intact and efficient, particularly in its research and development divisions.

Second, create a new division in that Service, a division of tactics and strategy of chemical warfare.

Third, foster a highly diversified organic chemical industry, by means of import licenses, tariff, anti-dumping legislation, and any other means which may be suggested, so that more and more of our young chemists may be attracted to this field; so that superintendents, foremen, and workmen may be trained in the

technique of this industry, insuring through the channels of peace industries a personnel which can rapidly be expanded if the days of "fresh hatred and killing" do result from this treaty of peace.

General Foch says:

Remember that those 70,000,000 Germans will always be a menace to us. * * * * * Their natural characteristics have not changed in four years. Fifty years hence they will be what they are to-day.

He has been in pretty close touch with the Germans; he ought to know.

After the above editorial was written the President of the United States addressed by cable the Congress now convened in extra session. That portion of the address which is of intense interest to chemists is the section urging prompt and complete guarding of the newly created industry of dyestuffs and related chemicals. The President clearly sees the full significance of this industry to the national welfare, and his exposition of the subject is both comprehensive and emphatic:

Nevertheless, there are parts of our tariff system which need prompt attention. The experiences of the war have made it plain that in some cases too great reliance on foreign supply is dangerous, and that in determining certain parts of our tariff policy domestic considerations must be borne in mind which are political as well as economic.

Among the industries to which special consideration should be given is that of the manufacture of dyestuffs and related chemicals. Our complete dependence upon German supplies before the war made the interruption of trade a cause of exceptional economic disturbance. The close relation between the manufacture of dyestuffs, on the one hand, and of explosives and poisonous gases on the other, moreover, has given the industry an exceptional significance and value.

Although the United States will gladly and unhesitatingly join in the program of international disarmament, it will, nevertheless, be a policy of obvious prudence to make certain of the successful maintenance of many strong and well equipped chemical plants. German chemical industry, with which we will be brought into competition, was and may well be again a thoroughly knit monopoly, capable of exercising a competition of a peculiarly insidious and dangerous kind.

A NEW TRIPLE ALLIANCE

In an editorial entitled "The Soldier, the Sailor, the Chemist," in the March 1919 issue of *THIS JOURNAL*, a closer union between our future generals and admirals and our chemists was urged, through the medium of lectures at West Point and Annapolis by prominent members of the AMERICAN CHEMICAL SOCIETY.

The suggestion has met heartiest endorsement by the officials of the War and Navy Departments, as is shown by the following extracts from letters received:

I beg to advise you that in their report upon this matter the Professor of Chemistry and the Superintendent of the Military Academy are heartily in accord with this plan. * * * * * I desire to assure you that the Department is heartily in accord with this movement.—NEWTON D. BAKER, Secretary of War.

I think the suggestion contained in your March editorial as to lectures by eminent chemists at the West Point Military Academy is an excellent one.—BENEDICT CROWELL, Acting Secretary of War.

The suggestion is one that I will be glad to take under consideration; it strikes me most favorably.—JOSEPHUS DANIELS, Secretary of the Navy.

I desire to inform you that the suggestion meets with the approval of the Superintendent of the Naval Academy and those having immediate charge of the instruction in chemistry at the Academy.

The Superintendent would be delighted to cooperate with you in obtaining the lectures necessary to carry out your suggestions.—FRANKLIN D. ROOSEVELT, Acting Secretary of the Navy.

The idea of giving five or six general lectures, the first one at Annapolis, seems to me an excellent one, along the lines of making the importance and sphere of chemistry understood, and thus add to their interest and comprehension of the subject.—RALPH EARLE, Rear Admiral, United States Navy, Chief of Bureau of Ordnance.

The correspondence will be placed in the hands of President Nichols on his return from his western trip. Meanwhile it is safe to say that several members of the SOCIETY have delightful treats in store, for the cordial hospitality of both the Military and the Naval Academies is proverbial.

The seed planted through these lectures will bear abundant fruit.

CHANNEL BUOYS

Professor J. N. Swan, of the University of Mississippi, writes us, under date of May 9, 1919:

In the editorial "Rocks Ahead!" you report that a prominent member said he had been told by three professors representing state universities that they would buy from Kahlbaum as soon as trade relations were reestablished.

This statement brings all of us in state universities under suspicion. In justice to the real Americans among us I believe these men and institutions should be named. I know of no reason why all of us in state universities should thus be brought under suspicion because some states tolerate 23 per cent Americans. In the name of one state institution whose chemical department is 100 per cent American, I ask that the institutions containing such men in the chemical departments be named so that the really loyal people shall not be under suspicion.

We would like to conform to Professor Swan's very reasonable request, but we cannot for the simple reason that the best we could get out of our informant at the time the statement was made was a promise to give the names if the orders with Kahlbaum were placed. Frankly, we don't believe the names will ever be furnished, for we are confident that more mature consideration of the many arguments against the placing of foreign orders will lead to an abandonment of the regrettable intention.

While writing the editorial, we realized that it was hardly a square deal to many patriotic and far-sighted men. What was to be done? Keep quiet? Never! The matter was too far-reaching in its importance. After all, the injustice done is not very great. And certain it is that all honor is due the many who had already determined voluntarily to forego the duty-free privilege allowed by law, in order to aid the consummation of American independence and to make impossible among our students that opportunity for insidious propaganda which the Council, by unanimous vote, declared importations from Germany had offered.

To those who may be sorely perplexed as to how to make ends meet under the increased cost of strictly home supplies the following incident may be of interest. A professor of chemistry in a well-known institution recently made up his customary estimates for the next year on a basis of American products,

through and through. In his report he pointed out unhesitatingly the increased cost, explained thoroughly its significance from all points of view, and promptly received the full amount of the appropriation asked.

There is still another party at interest in the question—the student. Several times the statement has been made that duty-free importation is necessary in order not to tax too severely the chemistry students. Pshaw! We don't believe these men know their students. They are of the same blood as the men who sleep beneath the soil of France. They are to be the leaders of the future. Are we not willing to give them the opportunity to do their share in the effort to gain independence; to carry into life that spirit of self-reliance which is the real American spirit? If there is doubt about the students' attitude, put the matter to a test. Give them every side of the question, the increased cost to them on the one hand—the price of the saving on the other: the price in dependence, in opportunity for propaganda, in the destruction of plants which have been established during the war period to supply our needs. Can there be a doubt as to the character of the vote which any body of our students would register, following a vigorous presentation of this matter?

THE CENSUS OF CHEMICAL IMPORTS

Congratulations to the Department of Commerce, its Bureau of Foreign and Domestic Commerce. Dr. E. R. Pickrell, and Dr. B. C. Hesse, upon the appearance on May 26, 1919, of Miscellaneous Series No. 82, entitled, "Chemicals and Allied Products Used in the United States, Imports by Quantities, Values, and Countries of Origin during the Fiscal Year 1913-1914 and Statistics of Domestic Production." As is shown on its cover, the book has been prepared in collaboration with the AMERICAN CHEMICAL SOCIETY. In this volume and that of the Norton Dyestuff Census, Special Agents' Series No. 121, there has been covered the entire chemical field of the pre-war year 1913-1914.

A brief introduction gives the history of the movement, the scope of the publication, sources of information, definition of terms, and classification of products. Then follows a summary of imports in general classes, and a comparison of imports, domestic production, and exports. These preliminary matters lead to the main body of the work, which consists of an itemized list of all material by quantity and by value, wherever this value exceeds \$100. Of particular interest is the final column of this statistical material, showing the per cent of each article as to country of origin. Items amounting to less than \$100 are brought together in a separate section. The volume concludes with an interesting appendix on the domestic manufacture of chemicals, and a most valuable index which enables the quick finding of any article of interest.

It is interesting to note that commercial names are used in the classification, followed in many cases by the scientific name or by a very brief description

of the product. In this respect alone the work furnishes a ready reference book of great value. This is especially true of coal-tar medicinal preparations.

For the first time in the history of this good land of ours a government department has given to the chemical industries detailed statistics covering the whole field of chemicals in such a specific way as will appeal to the individual manufacturer and to all who are interested in learning the extent of our economic dependence in chemicals prior to the war. The volume is to be considered as the forerunner of other government publications which will eventually build up a valuable stock of information which will serve as a sure guide in the development of our chemical industries.

In the compilation of this material the full reports of the United States Treasury Department at each port of entry have been made available. In the preparation of these records a large corps of assistants has been required, and the work has been thoroughly and carefully done. It is to be expected that in handling so vast a mass of material some mistakes would creep in. It is therefore urged that any suggestions as to defects in this present volume be promptly mailed to Chairman of the Import Statistics Committee, AMERICAN CHEMICAL SOCIETY, 35 East 41st Street, New York City. These suggestions will receive the prompt consideration of the Committee and will be forwarded to the Bureau of Foreign and Domestic Commerce.

This volume will prove of value not only to manufacturers but to every student looking forward to chemistry as a profession. It is sold by the Superintendent of Documents, Government Printing Office, Washington, D. C., for \$0.25, and can be obtained likewise at the district offices of the Bureau of Foreign and Domestic Commerce:

New York: 734 Customhouse	New Orleans: 1020 Hibernia Bank Building
Boston: 1801 Customhouse	San Francisco: 307 Customhouse
Chicago: 504 Federal Building	Seattle: 848 Henry Building
St. Louis: 402 Third Nat'l Bank Bldg.	

The path to the final issue of this new volume has been roundabout, beset with many difficulties and discouragements, but the first station on the road to better things has been reached. Now let us study carefully the facts presented and see how quickly our chemical dependence can be completely eliminated.

FIRST AID TO THE INJURED

An unfortunate accident has befallen the AMERICAN CHEMICAL SOCIETY. In the face of what was considered ample provision the onrush of new members this year has been so great (more than 1400) that the supply of copies of the *Journal of the American Chemical Society* for January and February 1919, and of *Chemical Abstracts* for the same months (Nos. 1, 2, 3 and 4) has been smashed into smithereens by this sixteen-inch shell. Meanwhile new members continue to come in, as well as subscriptions from educational institutions and libraries, many of which desire full volumes for binding.

A call for volunteers is therefore issued. There are some members of the SOCIETY who do not bind their journals, and who because of nearby library facilities do not preserve them. Will not such members help the situation by contributing these volumes which are now so much needed? To all such it is requested that these be forwarded to Harvey F. Mack, Publications Manager, 207 Church St., Easton, Pa.

Reprinting individual numbers is a heavy tax on the finances of the SOCIETY. In view of the fact that each member of the SOCIETY is now receiving by actual cold calculation \$11.50 worth of material for the ten dollars he pays in dues, it can be readily seen that such contributions will prove the verity of the old adage, "A friend in need is a friend indeed."

On to Easton!

NOTES

Madam Sklodowska Curie was decorated by King Alphonso with the Grand Cross of the Civilian Order of Alphonso XIII in Madrid on May 5, 1919.

Another step toward independence—word has just been received that in a short while quantitative filter paper, of strictly American make and superior to former importations, will be on the market.

Congratulations to Col. Bradley Dewey, to whom the War Department awarded recently its Distinguished Service Medal, in recognition of his effective work in providing gas masks for the Army.

The women chemists of the Illinois Steel Company not only made good as chemists but showed their fine spirit by resigning in order to make places for the men returning from war work.

Lt. Robert A. Hall has been transferred from the Camp Upton Hospital to General Hospital No. 9 at Lakewood, N. J. Good speed to his recovery! He wears a Croix de Guerre with palm and four stars, and carries on his right sleeve four golden emblems of wounds received while doing his duty.

Some of the papers are discussing the question of whether Hugo Schweitzer is dead or at present sojourning in Mexico, directing propaganda. The matter is at least of doubtful importance, for after all the recent revelations of his traitorous conduct he is certainly dead to this country.

Francis P. Garvan, Alien Property Custodian and president of the Chemical Foundation, Inc., insists that the German spy is still in our midst. By way of confirming his statements: *Chemie*, a German chemical trade daily, published on March 1, 1919, an article purporting to have been sent from New York, describing the steps leading up to the organization of the Foundation and the rôle it is intended to perform, eighteen days before it was published in any American newspaper.

AMERICAN OFFICERS IN GERMAN CHEMICAL PLANTS

THE DYESTUFF PLANTS AND THEIR WAR ACTIVITIES

By THORODRE W. SELL, Major, C. W. S., U. S. A.

During the month of February 1919, I had the opportunity, as a member of the Inter-Allied Commission, of visiting most of the principal plants in the various occupied areas of Germany which were devoted to the manufacture of dyestuffs, medicinal products, and standard chemicals.

Before going through these various plants one has many ideas, developed from newspaper reports and other sources of information, concerning Germany's war-time conditions, which are considerably changed after observing actual conditions. We had often heard of the great destruction resulting from air raids, of the lack of workers and great labor unrest, of the run-down conditions of the plants—and, in short, one was quite prepared to find them in a disordered state through the lack of operating personnel. However, one discovers very soon that the contrary is quite true. To-day finds these great German plants, probably the greatest of the potential possibilities for war material production, in splendid condition, with a large, highly-trained force of employees, and, moreover, with additional opportunities for increasing their production by utilizing the extra equipment added for war materials production.

Owing to the great foresight and efficiency of the German pre-war system, that is, efficiency from a military standpoint in particular, all of their man power was registered and so classified that when the call to battle came they kept a large proportion of their trained workmen within these plants. Consequently, they still have the majority of them ready to take part in a new battle for commercial supremacy.

At the present time the plants are operating at about 10 per cent of their productive capacity for peace-time products, but nevertheless they are keeping most of their labor to avoid their becoming mixed up in agitation or possible Bolshevism which may be nourished by lack of employment. Most of these men are utilized in cleaning up the plants every day. Consequently, one finds the plants in quite perfect condition. The only apparent handicap they have at present is the lack of oil and greases for lubrication of machinery, which, however, they have partially overcome by using artificial substitutes.

The important point is that the American people, in particular, should realize that this important portion of Germany's industries is not crippled but intact and ready to operate, and is consequently a dangerous factor in the struggle for commercial supremacy and also as a potential source of war material production unless properly controlled. Moreover, I do not think the German people, as a whole, realize completely the magnitude of their defeat; they count upon the Americans in particular very soon forgetting the horrors of the war, resuming their trade with them, utilizing their products, and allowing their industry to thrive once more. At present the only things they lack are raw materials and coal for the opera-

tion of the plants, which fortunately the Allies can control, unless the peace terms are lenient enough to allow them to operate on full scale as before. Let us hope that the American people and consumers of chemicals and dyestuffs will back up the American manufacturer so that this previous condition cannot be restored.

It was our good fortune to pass through the devastated sections of France and some in Belgium on our way to Germany. One cannot see this terrible destruction of land, factories, and cities, so complete and terrible that neither word nor picture can describe adequately, without being impressed by the contrast you see upon entering Germany, where all is serene, quiet, clean, and orderly, and scarcely any sign of destruction such as has been visited on the French.

Arriving in Cologne, we made our headquarters there while making a tour of investigation through the plant of the *Farbenfabriken vorm. Friedrich Bayer and Company* at *Leverkusen*, and also the plant of *Weiler-ter-Meer* at *Uerdingen* on the Rhine.

The plant of the Bayer Company stands out pre-eminently as the best and most modern of German chemical plants. It is a veritable city in itself, well laid out, with excellently constructed streets and brick buildings. Their office building and recreation buildings for the employees are luxurious palaces. This plant has expanded considerably during the war, and, despite the contrary assertions of its directors, was widely engaged in the manufacture of war products, particularly poison gases. We had the opportunity of meeting Dr. Duisberg, the chief director, and, incidentally, one of the ex-Kaiser's right-hand men in the development of the war. Many will remember him from his visit to this country at the time of the Chemical Congress in 1912. Incidentally, he hopes to be over here again very soon to see his "old-time friends."

The plant of *Weiler-ter-Meer* at *Uerdingen* is also an excellent development, kept up in very good condition. Despite the high cost of living in war times, this concern was able to erect within the last year a large, expensively-equipped recreation building for their men, and is apparently in good condition, just marking time while awaiting resumption of activities and thankful that the Belgians are there to protect them from the Bolsheviki across the river.

Of all the men whom we met in the various plants in Germany, the head of this plant was the most cordial and open in all his dealings with us. It was, of course, a difficult and humiliating position for men to be in, and in many cases we encountered sullen indifference, particularly among the plant directors, but among the lower classes of foremen and workmen there does seem to be a general recognition of the fact that the war has been lost and also that the cause was wrong to start with. Of course a good deal of this is propaganda and an effort to pass responsibility on to a government which has been discredited and broken up, but I believe that there is really a large number of the poorer class of Germans who have now come to realize the wrong done by Germany in this war.

After spending a few days in Coblenz, the American headquarters, where we had the opportunity of seeing the American flag proudly waving over the great German fortress of Ehrenbreitstein, we journeyed up the Rhine to Mayence, the headquarters of the French area. Within this area we were privileged to visit the Kalle plant at Biebrich. Very little war work had been done at this place, and the plant was probably the poorest of all we saw, being old, dirty, and in a run-down condition.

At Hoechst-on-the-Main we went through the great plant of Meister Lucius and Brüning, who were pioneers in the development of German poison gases, and had done considerable work in all kinds of war materials. They, too, had a large, very fine plant, well laid out, and in good operating condition, extending for many acres along the river. They are quite progressive and have developed on a large scale.

A little later we went up to the greatest of all plants, the Badische Anilin und Soda Fabrik at Ludwigshafen. This plant employs about 16,000 men, and covers many acres of ground. They have the plant for dyestuffs, intermediates, etc., at Ludwigshafen and a little further up the river, at Oppau, is located the plant for the Haber process. Considerable work on war products was done at Ludwigshafen, but they also were able to make dyestuffs on an appreciable scale during the war. At the present time they have a large stock on hand ready to turn loose on the markets when permission is granted. They, too, had done considerable work on poison gases and explosive intermediates, but not to an extent which would at all interfere with their resumption of dyestuff manufacture on a large scale.

At Oppau we saw what is probably the most phenomenal scientific development up to date, namely, the practical realization on an operating basis of the Haber process for ammonia production. The buildings are all quite new and well constructed, and the vast amount of detail has been studiously and carefully worked out on a practical operating basis producing upward of 100,000 tons of ammonia per year. This plant was a large factor in enabling Germany to stay in the war as long as she did, by means of producing large quantities of nitrates. The Germans have also another plant, a duplicate of this, which they are operating in the unoccupied area of Germany, so that it is really a great practical possibility at the present time.

Incidentally, it came to our attention that Haber, to whom Germany owes so much of her development in chemical products in warfare, had never attained a higher rank than Captain in the German chemical warfare service, despite the responsibility and immensity of his job.

Looking at our inspection of the German plants from a general viewpoint, it is my opinion that, considering the advantage gained in America by the last four years of experience in chemical manufacturing and the lessons learned by our equipment manufacturers, the German plants at the present time from an equipment standpoint and general layout are not superior to the existing American development, their ad-

vantage being that they have an experienced and long-trained personnel schooled and willing to carry on the laborious details; but if our people here at home will encourage our new, rapidly growing industries, there is no reason why our own personnel cannot equal or, in fact, surpass that of the Germans.

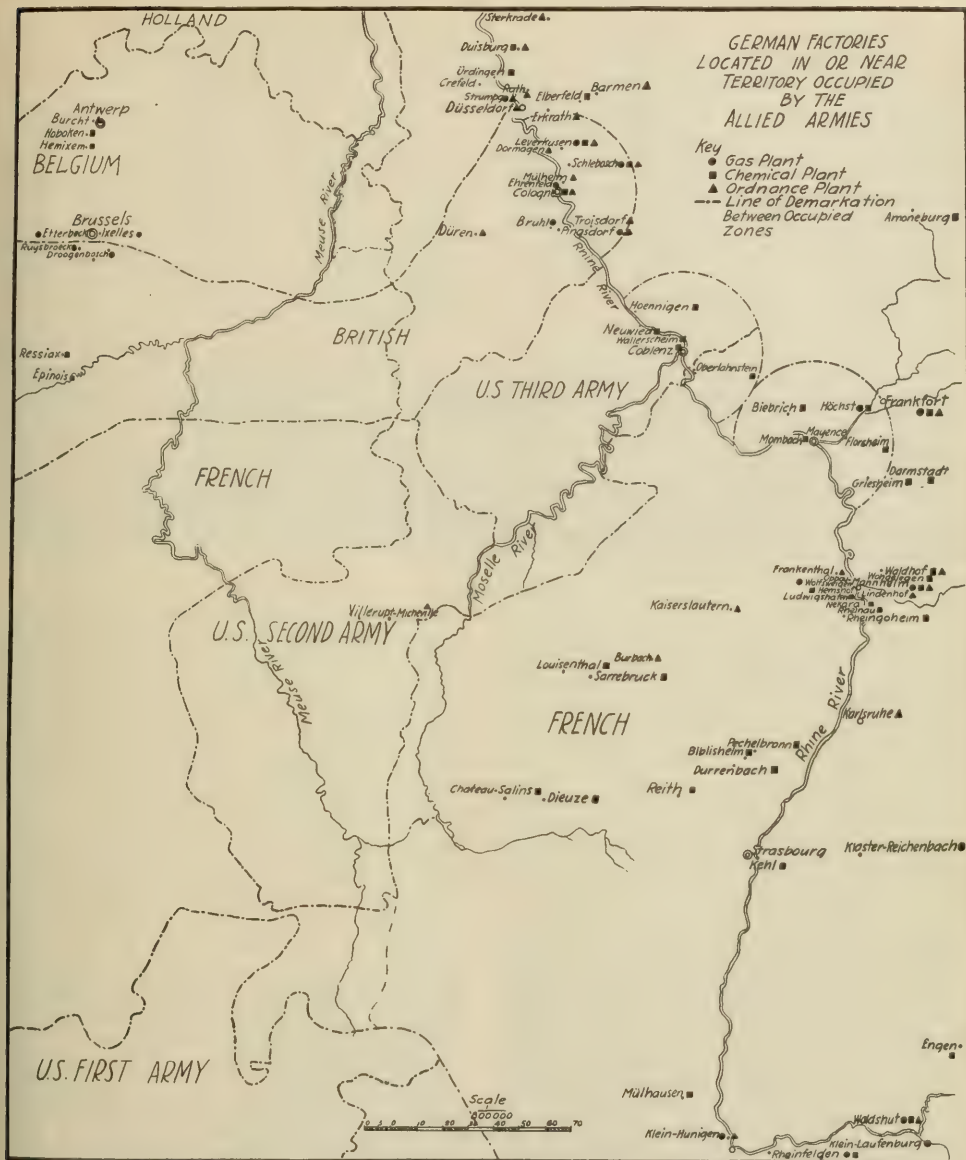
There are but few distinctive features to be observed which might advantageously be adopted in some American plants. For instance, (1) the Germans have a very clever method of building their water towers around the power house chimneys or stacks, thus utilizing the waste heat and keeping their water from freezing; (2) they have a method of distributing the pressure in the filter presses so that it is not only applied at the center by a large screw, as in most of our presses, but also horizontally along the sides of the press; (3) at one place we saw an excellent automatic nitration system, based upon the alternate filling and refilling of a small tank with a measured quantity of water, which in turn was connected with valves releasing definite amounts of acid and benzol; (4) the Germans have in practically all of their plants a very high grade of lead fittings, in which art they have advanced remarkably well; (5) in many cases it was also noted they used square flanges on the elbows for their high-pressure piping connections.

On the other hand, one notices considerable lack of conveying equipment, such as bucket elevators and belt conveyors through these plants, the probability being that they utilize man power much more than we do, and do not rely upon mechanical equipment so much. Moreover, despite the aggravated condition of transport during war times there were several instances where they made products in these various plants in successive steps, making one part at this plant, conveying it perhaps to a considerable distance up the Rhine to another plant, where it would be converted into an intermediate, and, perhaps, bring it back almost to its original starting point to be finished, and then carrying it over as far as Berlin, perhaps, to be put into shells. Despite the much-vaunted efficiency of German operations this seemed to be a glaring refutation of their claim, particularly in view of the fact that the type of apparatus was very simple and practically the same for all steps of the operation.

Although in most cases, particularly in connection with war problems, the Germans were quite liberal with information in answer to our questions, they did on many occasions fall back on Berlin as an alibi, emphasizing the fact that all plants were controlled by the War Minister in Berlin, that all papers were there, and that they were but pawns to do as he directed—the old government, now discredited, being to blame for all their war production.

Among the developments to be noted during the war in Germany, which are of special interest, was the production of synthetic rubber on a large scale and a practical basis. This was done at the Bayer plant in Leverkusen, and the production, though very expensive, was of material assistance in meeting their great shortage of rubber.

Another interesting phenomenon was their practical manufacture of washable paper cloth. This was



utilized in the manufacture of shirts and of various articles of clothing, as well as towels, tablecloths, etc. It was very successful, and was a considerable factor in meeting their shortage of linen, cotton, and such materials, aside from being exceptionally cheap.

At the present time in the occupied areas of Germany conditions are quiet and orderly, and the people are really thankful to have the Allied armies there to occupy those areas of Germany, as it means order and quiet in considerable contrast with what transpires

in other portions of Germany. The inhabitants have a fear that the Allies, particularly the French, are going to occupy the land permanently, but otherwise are quite satisfied. One sees store windows well filled with luxuries—optical goods, cameras, etc.—but the grocery stores are practically empty, and the quality of food is quite inferior. However, there are very few signs of any suffering, which has been so widely exaggerated in the press reports, but there is of course much inconvenience.

At the present time it is my understanding that the Allies occupying the various areas plan to keep a qualified corps of representatives to participate in the control of operations of the factories in their area. They will thus have command over the raw materials utilized and required, the methods of operation and the export of the materials produced. It is my strong conviction that America, too, despite the fact that there are no particularly large chemical plants in the area which the American army occupies, should, in consideration of being an ally and a much needed and valuable participant in the victory gained, also have representatives in each of these factories for a long period of time, to gain the valuable information which our Allies are obtaining. This information should be utilized by our Government for the disposal of the requirements of American manufacturers, so that our industries now just getting on their feet may have equal chance in competing in the world market.

EAST ORANGE
NEW JERSEY

CONDITION OF CHEMICAL PLANTS IN GERMANY

By FREDERICK POPE, Major, C. W. S., U. S. A.

If asked, any chemist or chemical engineer in the United States would say that he knew how much importance industrial Germany attaches to her chemical industry, but as a matter of fact, it is impossible for any one who has not been in Germany to realize her iron determination to regain the place she had before the war, or to realize the sacrifices that have been made towards accomplishing this.

On two occasions, immediately following the armistice, I was ordered to Germany for a purpose which involved investigating chemical plants in the occupied territory.

The physical condition of the chemical plants in the occupied territory is good. All the plants not in use have been shut down and cared for in such a way as to make them immediately available when the time comes when it is possible for them to resume. The machinery is in good repair.

Many new plants have been built for explosives and poison gas, and existing ones enlarged; all these plants have been designed and built with the idea of being modified to enable them to make peace-time products. This is one important element in this phase of German preparedness.

In one of the large chemical plants there is a building for the employees, containing restaurants, baths, gymnasiums, recreation rooms, etc., all as well conceived and as well built as any in the world. This was completed in the latter part of 1918.

Most of the personnel of these chemical factories is immediately available as soon as the plants can start up. Germany did not send her chemists and chemical workmen along with her cannon fodder. Most of these men not engaged in their pre-war occupation were used for making poison gases or explosives, and such as were not were used elsewhere than in the trenches.

At the present time most of these men are at the factories, some of them doing inconsequential work and employed ostensibly to keep them off the streets, but

really this is another phase of German preparedness.

While it is true that most of these plants are in a condition of comparative idleness, some of them not running over 10 per cent of their capacity, there exist in Germany and several neutral countries considerable stocks of German dyes available for immediate shipment.

It is well known that England and France forbid the entry of these dyes. Germany is looking to the United States with hungry eyes as her best market. She believed Bernstoff when he named us "idiotic Yankees." I have talked with managers and chemists in German chemical plants, many of whom have expressed the greatest contempt for our chemical industry, giving a variety of reasons for their contempt, the reasons ranging from the opinion that we were temperamentally unfitted for the chemical industry to saying that we had not the schools to turn out the chemists, or the brains to learn the necessary lessons.

I hope that Germany will again find her psychology is wrong—probably she will, but at the same time it is absolutely necessary that the American nation should know three things: First, the determination of Germany to get back her business. This is evidenced, in addition to the things I have seen, by the well-known financial arrangements that have been made for the purpose. Second, that Germany has the necessary plants and the necessary personnel to recover her former position if we permit her to do it. Third, the importance of chemical plants in the life of a nation. It is by this time pretty generally understood that chemical plants can be rapidly turned into plants for the manufacture of munitions and poisonous gases. Furthermore, the nation that is great chemically is also great commercially—a leader in world commerce.

It was with considerable astonishment that I learned after a 16 months' absence in France, associating with the A. E. F., that one of the large users of dyes in the United States said that he was looking forward to the time when he could get back to "good old German dyes." Now, this man was either stupid, mistaken, or something worse, for every chemist in this country knows that we are making at the present time as good dyes as Germany ever made. It is of course perfectly true that we are not making all the dyes that were made in Germany, but the American manufacturer has not yet had sufficient time. The industry is expanding, and expanding rapidly.

As soon as the American people realize the danger of allowing our chemical industry to be killed, and decide to give it the necessary protection to enable it to get on its feet, one of the important steps in national defense will have been taken.

I have had perhaps a unique experience in having visited the most important dye plants in the United States, England, France, Switzerland, and Germany, and as a result am able to say that if America is willing to do it, she cannot only hold her own in the chemical industry, but can lead the world. With proper protection for a comparatively short time, our chemical industry will be in such a position that it will fear competition of no other people.

NEW YORK CITY

CONTRIBUTIONS FROM THE CHEMICAL WARFARE SERVICE, U. S. A.

THE PROVING DIVISION, CHEMICAL WARFARE SERVICE, U. S. A.

By W. S. Bacon, Lieutenant Colonel, C. W. S., Chief, Proving Division

Received April 19, 1919

Tucked away deep in a barren pine belt in New Jersey, near Lakehurst, there was located what was possibly the most secret and interesting army camp in America. The purpose of this camp was to test, in actual large-scale field trials, new gases, which from laboratory tests looked promising.

charge be worked out to a very fine point as a difference of one or two grams would seriously affect the concentration. A charge too small would allow a cup to be formed by the base and attached sides of the shell which would carry a considerable portion of the liquid into the ground where it would be lost. On the other hand, too great an amount of explosive in the booster would throw the gas high in the air. After the bursting charge had been determined large numbers of the shell were repeatedly fired on trenches, wooded areas, rolling and level ground, etc., in the same numbers as used in actual warfare.



FIG. 1—VIEW ON THE GROUNDS OF THE CAMP

Havens, Official Photographer

It is evident that the greatest possible secrecy was necessary. The personnel, both enlisted and commissioned, was chosen with great care. The accompanying photographs of the laboratories, barracks, ranges, etc., will give an idea of the extent of the camp. In addition, there were several other ranges, permanent gun positions, magazines, railroad sidings, etc., which are not shown.

To make clear to the reader the trials and tests necessary before a substance was finally recommended let us take as an example substance X, which has been found in the research laboratory to be promising, both as to toxicity and ease of manufacture. Enough of this substance was made to fill several hundred shell of various calibers. The first step towards making a recommendation was to determine a proper bursting charge for the substance. It is obvious that a gas such as phosgene, which has a low boiling point, would require less bursting charge to open the shell and allow the substance to

Animals were placed in these areas and samples of the gas taken by a method which will be described later. After a number of such experiments, very accurate and constant results were obtained, upon which, if the substance proved satisfactory, data could be given to the artillery as regards how many shell of this particular gas should be used, with corrections for size of area, wind velocities, temperatures, ground conditions, etc. Trials were continually held to determine how many high explosive shell could be fired with gas shell on the same area without affecting the concentrations.

The use of the high explosive shell in combination with gas shell was highly important in order to disguise the gas bombardment. The bursting of gas shell fired alone can be distinguished by the small detonation.

The Proving Division also conducted tests for the Gas Defense Division. When a new type mask was developed several hundred of them were sent to the grounds. Companies of infantry fully



Havens, Official Photographer

FIG. 2—75 MM. GOOD BURST, CLOUD KEEPING CLOSE TO THE GROUND
RANGE 5000 YDS.

vaporize than a gas, such as mustard, which has a high boiling point. In the latter case the bursting charge must not be only sufficient to fragment the shell, but to scatter the liquid so finely that it would be atomized over the largest possible area. In the case of the low-boiling liquids it was necessary that the



Havens, Official Photographer

FIG. 3—4.7 IN. GOOD BURST. NOT THROWN HIGH IN THE AIR

equipped for the field would wear a mask for hours at a time digging trenches, cutting timber, drilling, etc., and imitating in every way, as far as possible, actual field conditions. During these activities tons of gas in cylinders were released in such a way that the men working were enveloped in a far higher



FIG. 4—VIEW A MOMENT AFTER BURST NOTE HOW LOW THE CLOUD HANGS

Havens, Official Photographer

concentration than would ever be the case in practice. Valuable data were compiled in these tests.

For field concentration work two complete and separate lines of trenches were used and also several impact grounds. The trenches were built to simulate the trenches actually used in warfare. Each line of trench contained several concrete shell-proof dugouts and were equipped with shelves on which the sample boxes could be placed for holding the sample bottles. At intervals of one yard throughout both trenches there were electrical connections available for electrical sampling purposes. The various impact grounds were used for cloud gas attacks, and experiments with mustard gas (either in firing trials or in connection with the so-called mustard gardens or patches, used for determination of persistency), or in many cases for static trials.

Sampling during firing of shell was made possible by the automatic electrical sampling apparatus. This apparatus consisted of a wooden box into which an evacuated bottle fitted snugly. Above this was an adjustable electromagnet support equipped with a small electromagnet with attached hook. A weight, (about 0.5 kg.) was hung over this hook and the small copper tip, attached to the weight by a chain, was slipped over the end of the bottle. When the sample was ready to be taken the electrical connection was made which threw the weight off the hook, and in falling, the copper tip would break off the end of the evacuated glass sample bottle, permitting the air-gas mixture existing in that immediate vicinity at the moment to be drawn into the bottle. The bottle was then closed by tightening a screw clamp and its contents were ready for analysis. During a firing trial the sampling apparatus was placed in the

trenches, dugouts, and on the surface of the ground, and the necessary electrical connections made. Any sample could be taken at any given time by merely pushing a button on the keyboard in the observation tower. By this method samples of the gas were obtained at various intervals throughout an entire firing trial. The average number of samples taken during a firing trial was about 125-150.

The tank samplers for average concentrations consisted of three copper tanks (varying in capacity from 2-20 liters each) enclosed in a large wooden box. Each tank was equipped with an electrical tripping attachment which opened the bottom of the tank and permitted the water that was contained in the tank to escape, thus causing a vacuum above the liquid. The tops of the tanks were each connected to a series of aspirating bottles containing absorbents which absorbed the gas out of the air-gas mixture while passing through. The tank samplers were set out on the field, the tanks filled with water, and absorption bottles connected. At any given time the sampling could be started by merely making an electrical connection at the observation tower. The water flowing out would cause air to be drawn through the absorption bottles with the consequent absorption of the gas. A special gravity valve was also designed which permitted the aspiration of the air from all three tanks through one series of absorption bottles only.

A great deal of research work was done to obtain methods of analysis for the gases used. The methods were especially applied to concentrations such as would be obtained under actual field conditions. The limits of accuracy of volumetric analytical methods were supplemented by colorimetric methods wherever possible and those methods proved very rapid, accurate, and efficient. The problem of field paper detectors was given a good deal of attention and experiments on persistency of various gases were performed.

The chemical laboratory was also charged with the filling of shell with gases to be used for experimental work. For the sake of economy, salt solutions of the same specific gravity as a particular gas were made up and used as the shell filling for these experiments. In order to do away with the inconvenience of having mustard gas distributed over the impact grounds after booster and fragmentation tests, a mustard gas substitute was conceived. This substitute (benzal chloride) has physical properties almost identical with those of mustard and hence could be used in tests of this character.

Shell were received at the laboratory daily, being selected from a certain lot of the daily production of the loading plant. The filling of the shell was analyzed to determine whether or not specifications were met. The percentage void or air space in all shell was determined as a part of the regular proof data.

Experiments were performed to determine the decomposition of various gases on detonation. The shell were fired at a large wooden screen and burst on impact. Samples of the gas were taken immediately and analyzed for the decomposition

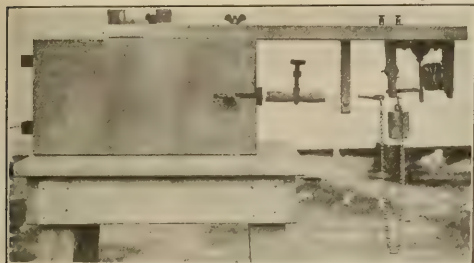


Havens, Official Photographer

FIG. 5 47 IN FOOT BURST, CLOUD BEING THROWN HIGH IN THE AIR BY FORCE OF EXPLOSIVE CHARGE

products. This decomposition was tested, using booster loadings of various kinds and weights.

The department of pathology of the Proving Division confined its activities to animal experimentation designed to demonstrate and estimate the offensive value of various proposed war gases.



Havens, Official Photographer

FIG. 6—ELECTRICAL SAMPLING APPARATUS

The animals available for use in field experiments included goats, dogs, guinea pigs, and monkeys. Two thousand goats in all were purchased.

It was considered advisable, because of the marked difference in the susceptibility of different animals and of individuals of the same species, to use more than one species and a large number of individuals in each test, or, in case this was not possible, to repeat tests in which small numbers were used. The use of guinea pigs in tests of mustard gas was discontinued after the discovery that the guinea pig shows no lesions following exposure to mustard gas vapors. The guinea pig develops burns after direct application of the liquid mustard, and frequently dies after exposure to high concentrations of the gas, but it is not affected by concentrations such as are obtained in the usual field tests.

In preparation for experiments in which gas shell were to be fired upon trenches (the sector of trench to be used having been selected with reference to the wind direction), animals were placed in the trench and tied to staples at intervals of 3 to 5 yds., some on the firing step, some on the floor and several more in dug-outs. It was the usual practice to place animals on the surface also, tying them to stakes or confining them in cages at distances varying from 10 to 100 yds. to the leeward of the trench sector.

For tests in which gas shell were to be fired at a target in an open field, animals were placed 10 yds. apart in a series of rows parallel with the battery front, covering rectangular areas varying in extent from 1200 to 2800 sq. yds. Goats and dogs were fastened to stakes by means of collars and chains or ropes. Guinea pigs were confined in small cages (7 in. \times 7 in. \times 10 in.) made with wooden frames covered with wire netting, the cages being placed at stakes at heights varying from 2 to 5 ft. above the surface.

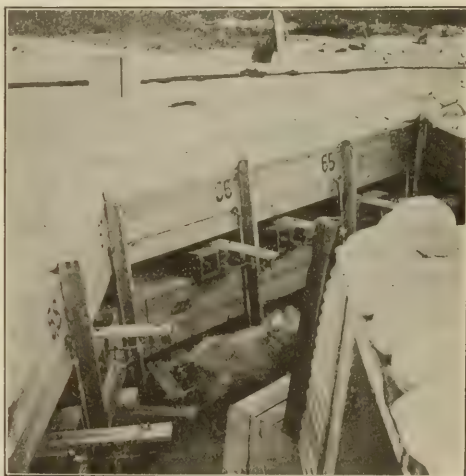
For tests in which the gas was to be liberated from shell or drums, fired statically, the animals were grouped at various intervals along radii centering at the shell or drum position, extending to the leeward for distances of 100 or 400 yds. and covering sectors of about 45°.

A series of tests were made on the range for the purpose of determining the relative effectiveness and persistency of various samples of mustard in which the liquid mustard was distributed uniformly upon the surface of grassy zones 1 ft. to 3 ft. in width, which formed the periphery of circular areas 14 to 21 ft. in diameter, the central part of each circle being occupied by animals.

By this method the animals were continuously exposed to the same quantity of gas no matter how much the wind direction might change during tests which were continued in several cases for as long as 3 days, a different set of animals being exposed each day.

All animals were removed from the trenches or surface areas following tests with volatile gases within a few minutes of the liberation of the gas and were immediately transported by train or truck to the animal hospitals for clinical observation, but all animals used in tests of mustard were allowed to remain in the gassed areas for periods varying from 1 to 10 hrs. and, in those cases in which the mustard was liberated from exploding shell, the animals were taken to shelters located near the impact ground, where they were kept for a period of 2 days, or until the gas with which they had possibly been sprayed had hydrolyzed or evaporated.

Animals exposed to gas during field tests were under observation in the animal hospitals or shelters for at least 3 days after exposure and in the case of affected animals, record was made on blanks provided for the purpose, of abnormal systems which developed. Observations on pulse and respiratory rates were discontinued after it had been shown by several series of counts on normal and gassed animals extending over 24-hr. periods, that such observations on goats and dogs have little or no value in estimating the degree of injury sustained from exposure to gas. The following symptoms, found to be significant, were covered by the clinical records: discharge at the eyes, conjunctiva, clouded cornea, reddened eyelids, secretion at the nose, dry or loose cough, burns, and other general symptoms such as depressed condition, prostrate, salivated, retching, vomiting, convulsions, the urine, and feces.



Havens, Official Photographer

FIG. 7—SECTION OF TRENCH SHOWING POSITION OF SAMPLING APPARATUS AND ELECTRICAL CONNECTIONS

The meteorological section was of very great importance. This department was under the direction of trained meteorologists from the weather bureau of Washington. For assistance in forecasting the weather, arrangements were made with the weather bureau to furnish complete telegraphic code reports from sixty stations both morning and evening.

The artillery detachment was composed of a full company of artillery which had charge of several batteries of various cali-

bers. This department was under the direction of officers sent from the Fort Sill School of Fire.

To determine the practicability of building up a given concentration of gas with artillery fire, to test the persistency of a concentration, or to learn its actual effect upon animals, a large number of shell were thrown on a given area in a very short period of time. The preliminary adjustment was usually accurately made by the percussion-precision method on some point near the zone to be attacked. Fire was then shifted to the zone and the desired number of rounds fired. As the observation point was well forward of the flank of the zone attacked, very accurate conduct of fire was possible.

With the cessation of hostilities on November 11, 1918, the work of the Division was abruptly terminated. By the end of that month all experimental work had been concluded and by January 1, 1919, three-fourths of the commissioned and enlisted personnel had been released from the service.

PROVING DIVISION
CHEMICAL WARFARE SERVICE, U. S. A.
LAKEHURST, N. J.

THE PERSONNEL SECTION, CHEMICAL WARFARE SERVICE, U. S. A.¹

By FREDERICK E. BREITHUT, Major, Chemical Warfare Service, U. S. A.

Received March 24, 1919

Previous issues of This JOURNAL have contained accounts of the work of the various divisions of the Chemical Warfare Service. The remarkable output of research, the development of promising ideas, and the production of gas offense and gas defense materials on a hitherto unheard-of scale were naturally paralleled with a corresponding growth in personnel, and it is of this phase of the activities of the Chemical Warfare Service that this article treats.

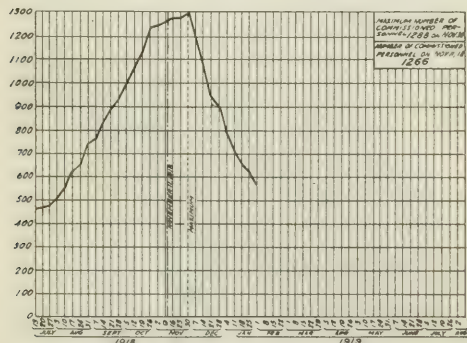


FIG. 1.—SHOWING NUMBER OF COMMISSIONED PERSONNEL EXCLUSIVE OF EUROPEAN DIVISION

On the day the armistice was signed, the Personnel Section of the Administration Division of the Chemical Warfare Service had seven branches. The names and functions of these branches appear on the organization chart. An examination of this chart shows that the Personnel Section of the Chemical Warfare Service performed all of the functions of the Personnel Sections of the other staff corps of the Army and was also charged with two additional responsibilities: (1) the control of the chemists entering the Army, and (2) a census of chemists, both military and civilian, of the whole country. Chemists are naturally most interested in these latter phases of the work.

¹ Publication approved by the Director of the Chemical Warfare Service, U. S. A.

The assignment of chemists entering the Army was part of the work of the Enlisted Branch. All chemists who were drafted into the Army were reported to this branch upon reaching their cantonments. These men were held at the cantonments pending the investigation by the Chemical Warfare Service of their qualifications as chemists. Those who had adequate training were then transferred to chemical work, military or civilian, by the Adjutant General's Office, upon the recommendation of the Chemical Warfare Service. The following table shows what was accomplished along these lines up to November 1, 1918:

Total number of men reported by camps to Chemical Warfare Service as chemists.....	3,814
DISPOSITION	
Proved (on investigation) not to be chemists.....	641
Ordered to remain with organizations for chemical duty.....	318
Unavailable for transfer from organizations for military reasons, etc.....	430
Furloughed to essential industries.....	107
Furloughed to universities as teachers.....	53
Transfer requested to Chemical Warfare Service.....	1,726
Transfer requested to Ordnance Department.....	333
Transfer requested to Medical Department.....	24
Transfer requested to Quartermaster Corps.....	6
Transfer requested to Air Service.....	12
Held for investigations of qualifications.....	164
TOTAL.....	3,814

The fear had frequently been expressed that the United States would repeat the error of both England and France of sending her chemists to the line instead of utilizing their technical training in chemical work. The facts show that this fear was unjustified. Chemists not needed for chemical work in the American Expeditionary Force were kept on this side of the Atlantic and were placed either on chemical work or some work in close relation thereto. At the worst there were errors in the assign-

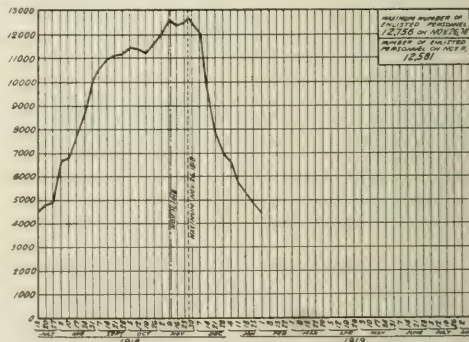


FIG. 2.—SHOWING NUMBER OF ENLISTED PERSONNEL EXCLUSIVE OF EUROPEAN DIVISION

ment of men to particular chemical tasks. This was due in the main to the discrepancy between the demand of the Army for chemists and the supply procurable from the draft. This discrepancy forced a hurried distribution of men to fill the most urgent need at the time when reported by the camps. At times there was dissatisfaction among some of the men affected and considerable anxiety was felt by those who had the best interest of American chemistry and America's success in the war at heart. Happily the danger of wasted man power in this direction was foreseen, and it may be stated that within the limitations just given the chemical man power of the country was conserved. Measures had just been taken when the armistice was signed to utilize this man power at its maximum of

PERSONNEL SECTION, ADMINISTRATION DIVISION, CHEMICAL WARFARE SERVICE

AP	PERSONNEL SECTION
<p>Function: Administrators, under the direction of the Director of Chemical Warfare Service, the procurement, assignment, and control of commissioned, enlisted, and civilian personnel. Arranges for promotions, transfers, travel, etc. Maintains proficiency in personnel records.</p> <p>Location: Control covers all personnel branches and units of the Chemical Warfare Service.</p> <p>Controls a census of all chemists in the United States.</p> <p>Location: War Relocation Authority, San Francisco, California.</p> <p>Controls the assignment, transfer, and movement of chemists to industries, universities, and government departments.</p>	
<p>MAJ. F. E. BREITHUT CHIEF OF PERSONNEL</p>	

Lt A. F Sprino
Assistant

APR. RECORDS BR.	FUNCTION: Maintains records of enlisted and discharged personnel under the control of the Director of Chemical Warfare Service.
APL ADJUSTMENT BR.	FUNCTION: Cooperates with the Relations Section (APR) in the United States, both military and civilian, to advise military and government departments and agencies adjusting conflicting claims.
APA. CENSUS BR.	FUNCTION: Controls a census of all chemists in the United States, both military and civilian, maintains a record of their qualifications, occupation, availability, nationality, etc.
APC. CIVILIAN BR.	FUNCTION: Procures appointments and assigns duties to civilian chemists. Arranges for and records the changes in Civilian Chemical Warfare Service.
APF. ENTERED BR.	FUNCTION: Requisition, procure, inspect, transport, and maintain general supplies over enlisted personnel.
APQ. COMMISSIONED BR.	FUNCTION: Procures, examines, assigns, and controls the commissioned personnel of the Operations Division, Commanded Personnel Section, and the various routes, methods, and procedures pertaining to Development and Organization.
APS. EXECUTIVE BR.	FUNCTION: Supervises office management of Personnel Section under the control of the Chief of Personnel.

MAJ. H. S. KIMBERLY HEAD OF BRANCH	Lt. J. A. SCHWETZER HEAD OF BRANCH	Lt. H. B. BRAMHART HEAD OF BRANCH	CAPT. C. A. MUZZY HEAD OF BRANCH	Lt. A. E. CASE HEAD OF BRANCH	Lt. C. F. ROTH HEAD OF BRANCH	Lt. W. F. KUNLE HEAD OF BRANCH
APSE EFFICIENCY APSS STATISTICAL ASDD DRAFTING ASDM METHODS ASPS OFFICE MANAGEMENT	APOA ASSIGNMENT APOP PROMOTION APOT TRAVEL APOR PROCUREMENT APOB TRANSPORT	APEL INDICTION APET TRANSPORT APER FORGIVEN APER REQUISITION APEP PROCUREMENT APES PROMOTION APEA ALLOTMENT	APCP PROCUREMENT APCA ASSIGNMENT APCO PROMOTION APCL LEAVE APCR RECORDS APCE EFFICIENCY APCS CIVIL SERVICE LAW	APAC CLASSIFICATION APAD QUESTIONNAIRE APAR RECORD APAI INFORMATION	APLP PRIORITIES APLA ALLOTMENT APLC CLAIM APLF FOLLOW-UP	APRC COMMISSIONED APRE ENLISTED APRF QUALIFICATION APRM MILITARY HISTORY

efficiency. The Adjustment Branch of the Personnel Section, in charge of Lt. Charles F. Roth, had begun an investigation of the duties of the Army's chemists with a view to giving each one a task commensurate with his qualifications. It was expected that, barring a small percentage of men whose transfer could not be accomplished for military reasons, errors incident to the necessarily hurried assignment of chemists during the period of almost unbelievably rapid expansion of our Army would be corrected to the manifest advantage of the Government and the chemists. In this phase of the work the advice and help of the Relations Section, in charge of Colonel Marston T. Bogert, were cheerfully given and availed of.

The Census Branch of the Personnel Section took a census of American chemists. This census was designed as an aid to the Government in its problem of the allocation of chemists in military and industrial work during the war, and especially in industrial work upon the demobilization of the Army. It is a pleasure to be able to state that 16,000 American chemists responded to the call and returned the 4-page questionnaire giving full details of their training, past experience, and equipment. The information thus given was transcribed on cards which were classified and cross-indexed so that the most available man might be located in the shortest possible time. The classification was made in two ways. The chemists were first listed under the following classification headings:

1—Acids and alkalis	22—Laboratory assistant
2—Bacteriological	23—Leather
3—Biochemist	24—Metallurgist—ferrous metals and alloys
4—Cement, classed as chemist or tester	25—Metallurgist, non-ferrous metals and alloys
5—Chemical engineer	26—Organic chemist (not otherwise listed)
6—Chemical worker, skilled	27—Paint and varnish
7—Coal-tar products (not otherwise listed)	28—Pharmaceutical and photographic chemicals
8—Dairy	29—War gases
9—Dyes	30—Professor or instructor
10—Electrochemistry	31—Pyrotechnics
11—Explosives, high	32—Rubber
12—Explosives, black powder	33—Sanitary
13—Fatty oils, waxes, soaps	34—Sugar, starch, and gum
14—Fertilizers	35—Textiles
15—Foods	36—Miscellaneous
16—Fuels	37—Executive
17—Gases, other than war gases	38—General analyst
18—Glass	39—Physiologist
19—Glass blower	40—Pharmacist
20—Iron and steel analyst	
21—Junior chemist	

Secondly, the chemists were classified according to the function which they usually performed, that is to say, a man with experience in operations work in a rubber factory, for example, would be of greater utility as an operations man in another kind of factory rather than as an analytical rubber chemist.

COMPARISON OF NUMBER OF COMMISSIONED PERSONNEL

DIVISION	August 1	October 31	Increase Per cent
Administration.....	32	69	115
Training.....	63	318	402
Research.....	89	243	173
Medical.....	6	24	300
Development.....	9	47	422
Proving.....	19	34	79
Gas Defense Production.....	172	265	54
Gas Offense Production.....	150	329	119
TOTAL.....	540	1,329	146

COMPARISON OF NUMBER OF ENLISTED PERSONNEL

DIVISION	August 1	October 31	Increase Per cent
Administration.....	52	109	109
Training.....	3	214	7,033
Research.....	794	1,068	34
Medical.....	35	93	165
Development.....	104	819	687
Proving.....	284	627	121
Gas Defense Production.....	1,270	2,067	63
Gas Offense Production.....	4,339	6,884	58
TOTAL.....	6,881	11,881	72

A new set of specifications for chemists, in harmony with the census classification, was furnished the Committee on the Classification of Personnel in the Army, and the set of specifications thus worked out was published as an appendix to the Trade Specifications and Index of the Occupations of the United States Army.

On November 1, 1918, the Personnel Section rendered a report to Major General Wm. L. Sibert, Director of the Chemical Warfare Service, reviewing its past work and presenting a program for the future. The preceding tables taken from that report show the enormous increase in all divisions of the Chemical Warfare Service (exclusive of the European division) during the last 3 months of mobilization.

A glance at the tables reveals the fact that among the officers the increase in this 3-month period fell below 100 per cent in only two of the divisions, while in two of them it ran over 400 per cent. Among the enlisted men three divisions have an increase of less than 100 per cent, but these divisions already had a large personnel and even in these cases the increase is considerable, running well over 50 per cent in all but one division, namely, the Research Division. The Research Division was largely a complete organization when it was brought under the jurisdiction of the War Department. It is also interesting to note that the largest increases were in the Training and Development Divisions, the two divisions which most needed to be pushed in order to enable every soldier who sailed from America to go fully equipped, offensively and defensively, for gas warfare.

The joyful news of November 11 necessitated a complete reversal of the administrative machinery, and the work of demobilization was carried on with a vigor almost equal to that of mobilization. In this connection the wise vision of Major General Sibert was reflected in the following order sent to all his division chiefs:

It is desired that the enlisted and commissioned personnel of the Chemical Warfare Service be discharged as rapidly as is consistent with the efficient maintenance of the integrity of the organization. In case a man is needed by a civilian company every effort should be made to secure his return to his normal civilian activity with the least possible delay.

So long as the war was in progress it was necessary to subordinate the individual's wishes to the country's good. The war being ended, it is advantageous both from personal and economic standpoints that officers and enlisted men be given opportunity to return promptly to remunerative positions in civil life.

The rate of mobilization and demobilization is graphically shown in Figs. 1 and 2. The lag from the middle of September to the middle of October was due to the influenza epidemic which prevented the removal of men from the camps. The continued growth for a short period after the signing of the armistice was due to the execution of orders already in transit before the issuance of new orders adjusting the Army program to the new status quo.

In addition to the numbers given in these charts there should be added the personnel of the European Division. On November 30, 1918, the numbers were 572 commissioned officers and 5,257 enlisted men. The maximum number of commissioned personnel for the whole Chemical Warfare Service was reached on November 30, 1918—1,860 officers. By February 1, 1919, this number had been reduced to 894, that is to say, 52 per cent of the commissioned personnel had been discharged. Similarly, the maximum number of enlisted men for the whole Chemical Warfare Service was reached on November 26, 1918—18,013 men. By February 1, 1919, this number had been reduced to 8,266, that is to say, 54 per cent of the enlisted personnel had been discharged.

In conclusion, the author wishes to express his sincere appreciation of the service of those with whom he was associated in this work.

ADMINISTRATION DIVISION, C W S U S A
WASHINGTON, D. C.

METHODS OF TESTING GAS MASKS AND ABSORBENTS¹By A. C. FIELDNER,² G. G. OBERFELL, M. C. TRAGUE AND J. N. LAWRENCE

Received March 17, 1919

INTRODUCTION

The development and manufacture of gas masks and absorbents depend to a large degree upon accurate and properly designed tests which simulate, as far as possible, actual conditions under which the mask is to be used. These tests are subdivided into three groups:

1—Absorbent tests, which are used in the development and control of absorbent production.

2—Machine canister tests, used in the development of canisters and in controlling the uniformity of filling the canisters at the factory.

3—Actual man tests, in which men wear the masks in gas chambers to determine the life of the canister, maximum protection, leakage, comfort and fit of the facepiece.

ABSORBENT TESTING

The ultimate test of the value of an absorbent is, of course, the actual man test of the complete mask. However, for the development and control of absorbents a much more precise test is made by placing a definite quantity of absorbent in a glass tube at approximately the same depth as that used in the final canister and at a rate of flow equal to that of a man doing moderate work. For the present army canisters these fixed dimensions of the standard tube test are:

- 10 cm. depth of layer
- 2 cm. diameter of tube
- Rate of flow of 500 cc. per min. per sq. cm. cross-sectional area
- 8–14 mesh material
- 50 per cent relative humidity
- As nearly as possible a room temperature of 25° C.

In general, the gas concentrations are 1000 p. p. m. by volume, assuming the material to be a perfect gas at 25° C. and 760 mm.

The service time is taken as the time in minutes to 99 per cent efficiency.

The absorption value of any material may be considered under two heads: 1—Activity; 2—Capacity.

The tube test can be varied to throw emphasis upon either one of these factors, although it does not in any case completely separate them. The capacity of the absorbent is usually measured by making the tube test against a rather dilute mixture of gas and air, so that the service time is long. For soda lime, capacity is measured by testing against 1000 p. p. m. of trichloromethylchloroformate, whereas activity is measured by testing it against 10,000 p. p. m. phosgene, activity being measured by the ability of an absorbent to take up high concentrations of gas. It is also possible to secure relative figures on activity and capacity by considering the 99 per cent point as a measure of activity and a comparison at a lower point, say 80 per cent, as a measure of capacity. In the production of absorbents for industrial purposes, it is, of course, advisable to test the material against two or three representative gases such as may be met with in the industries. One of these should be a weak

sulfur dioxide; another, a rather stronger acid gas such as chlorine or phosgene; and for materials that depend entirely upon adsorption, such as charcoal, the gas should be one that is taken up by adsorption only, such as chlorpicrin or carbon tetrachloride.

Another important property of absorbents that are used in masks which are subject to considerable handling and rough usage, is hardness. A special method will be described for making this test as well as the more important tube tests.

STANDARD METHODS FOR TESTING ABSORBENTS**DETERMINATION OF MOISTURE**

A 5-g. sample of the material is heated 2 hrs. at 150° C. in a Freas electric oven. The covered capsule or dish is cooled in a desiccator and weighed to the nearest milligram. The loss in weight is moisture.

SCREEN ANALYSIS

All screen analyses are made with 10-in. Tyler standard screen-scale screens, shaken in nests on the Ro-tap shaker.

Soda lime is screened by placing a 400-g. representative sample in the top screen and shaking 5 min.

Charcoal is screened by placing a 500-g. sample on the top screen and shaking 10 min.

DETERMINATION OF HARDNESS OR RESISTANCE TO ABRASION¹

A 70-g. sample of the material is screened on 8- and 14-mesh screens for 5 min. on a standard Ro-tap machine. Tyler standard screen-scale screens of 10 in. diameter are used.

Fifty grams of this material which have passed through the 8-mesh and are retained on the 14-mesh screen, are weighed out and placed in the bottom pan of the Ro-tap machine. Fifteen steel ball bearings, 1/2 in. in diameter, and 15 balls of 3/8 in. diameter are then placed carefully on top of the absorbent material and the pan is covered and shaken for exactly 30 min. on the Ro-tap machine, at a speed of 1750 r. p. m. of the driving shaft. The bottom of the pan should be slightly concave upward and have no dents or irregularities.

At the end of 30 min. the contents of the pan are carefully brushed into a 20-mesh screen, the ball bearings dusted off and removed, and the screen shaken for 3 min. on the Ro-tap machine. The weight of absorbent remaining on the screen multiplied by two gives the hardness number.

The test with steel balls of the number and size given above is best adapted to materials ranging between 50 and 80 hardness. If the hardness is above 80, the dispersion is not sufficient to distinguish adequately between different degrees of hardness, and likewise where more than 50 per cent of the material passes through a 20-mesh screen, the cushioning effect of the large amount of fines decreases the severity of the test. Hence, in new types of absorbents a different scale may be required, which is preferably ob-

¹ Published by permission of the Director of the Chemical Warfare Service, U. S. A.

² In charge Gas Mask Research Section, Research Division, Chemical Warfare Service, U. S. A.

¹ Method devised by Major Robert E. Wilson of Defense Chemical Research Section.

tained by changing the size of the balls so that the average material of that type passing through the screen will be approximately 60 or 70 per cent.

A second hardness scale used in this laboratory for softer material consists in using 30 steel balls of $\frac{3}{8}$ in. diameter.

DETERMINATION OF THE EFFICIENCY OF ABSORBENTS AGAINST VARIOUS GASES

The standard tube test methods described herein were developed at the American University Experiment Station for determining the absorption value of charcoal and soda lime under conditions closely approximating the actual service conditions of their use in gas mask canisters.

These methods have been in constant use in a number of different laboratories of the Chemical Warfare Service, and, when carefully followed, give closely comparable results.

Acknowledgment is due to a great many persons for improvements in various details of the test and especially to Capt. J. B. Dickson and the Coördinating Committee on Analytical and Research Methods,¹ for carefully standardizing the apparatus and methods.

PRINCIPLE OF THE TEST—The absorbent under test is filled into a sample tube of specified diameter (2 cm.) to a depth of 10 cm. by the standard method for filling tubes, and a standard concentration (usually 1000 or 10,000 p. p. m. by volume) of the gas in air of definite (50 per cent) humidity is passed through the absorbent at a rate of 500 cc. per sq. cm. per min. The concentration of the entering gas is determined by analysis. The length of time is noted from the instant the gas-air mixture is started through the absorbent to the time the gas or some toxic or irritating reaction product of the gas begins to come through the absorbent, as determined by some qualitative test. Quantitative samples of the outflowing gas are then taken at known intervals and from the amount of gas found in the sample the per cent efficiency of the absorbent at the corresponding time is calculated.

Per cent efficiency =

$$\frac{\text{P. p. m. entering gas} - \text{p. p. m. effluent gas}}{\text{P. p. m. entering gas}} \times 100$$

These efficiencies are plotted against the minutes elapsed from the beginning of the test to the middle of the sampling period corresponding to that efficiency point. A smooth curve is drawn through these points and the efficiency of the absorbent is reported as so many minutes to the 100, 99, 95, 90, 80, etc., per cent efficiency points.

APPARATUS—Like most gas analysis apparatus, tube testing boards are susceptible of infinite variation in detail, and may combine any number of absorption tubes on one board. Unless a laboratory has a very large volume of work a two-tube board furnishes sufficient testing capacity for a single operator. The one described is the result of much experience in de-

signing tube test units and embodies the best features of the various boards at this station.¹

The board unit itself, as shown in Fig. 1, may be used for any gas or vapor by simply attaching to the gas supply line a tank of the compressed gas in question, or, if the gas cannot be stored under sufficient pressure, by attaching one of the three types of gas supply devices shown in Fig. II.

DESCRIPTION OF STANDARD TWO-TUBE BOARD AS USED FOR LIQUEFIED GASES IN CYLINDERS—The standard two-tube board shown in Fig. 1 is 31 in. wide and 30 in. high. It is made of 1 in. soft pine lumber and has a base of the same material projecting 8 in. at the front and rear and 6 in. to the left. The glass tubing is 6 to 8 mm. outside diameter, and the stopcocks are of liberal bore, in order to reduce resistance to flow to a minimum. Stopcocks T, T' should have a bore of at least 3 mm.

This apparatus is operated entirely under pressure. Air from a pressure line enters the apparatus through the cock W, and bubbles through the humidifying bottles, 2, 3, and 4, containing sulfuric acid and water of the proper specific gravity to give the desired humidity (usually 50 per cent). Bottles 1 and 5, containing glass wool, serve as traps. From the humidifiers the air is conducted to the mixing chamber M at the top of the board, where it is mixed with the toxic gas from supply tank A, and then passes through a glass tube and T to the two sample tubes, P, P', and out through the effluent analyzing bottles to waste. The rate of flow of the gas-air mixture through each sample tube is accurately regulated to 500 cc. per sq. cm. per min., by the stopcock U, and the flow meter Q. The concentration of the entering gas is taken by directing the gas mixture into gas washing bottles, 8 and 9, by proper adjustment of stopcocks V and S. The gas mixture can also be directed into the waste line on the back of the board by reversing stopcock S. The effluent gas from the sample tubes P may be passed alternately to analyzing bottles, 6 or 7 on the left, and 10 or 11 on the right, by the large bore (3 mm.) three-way stopcocks T, T'. R and R' are water manometers for measuring the pressure drop through the absorbent.

Fluctuations in the air pressure line are controlled by the constant pressure water column N, which is connected to the air line between the humidifying bottles and the mixing chamber.

The toxic gas flow from cylinder A to the mixing chamber M is automatically controlled and maintained constant by a very ingenious automatic compensating flow meter, designed by R. P. Mase, of this laboratory.² This flow meter, when once set for a given concentration, as for example 10,000 p. p. m., will automatically deliver this concentration in the mixing chamber M to within 0.5 per cent, regardless of any pressure fluctuations that may take place in the mixing chamber due to increase of resistance in the absorbent tube or in the gas washing bottles.

¹ This board does not include temperature control which may be required if the room temperature cannot be kept fairly constant.

² THIS JOURNAL, 11 (1919), 294.

³ Maj. A. C. Fieldner, Maj. R. P. Rose, Maj. R. E. Wilson, Capt. John B. Dickson, Lt. W. N. Watson, and Lt. J. F. Walsh.

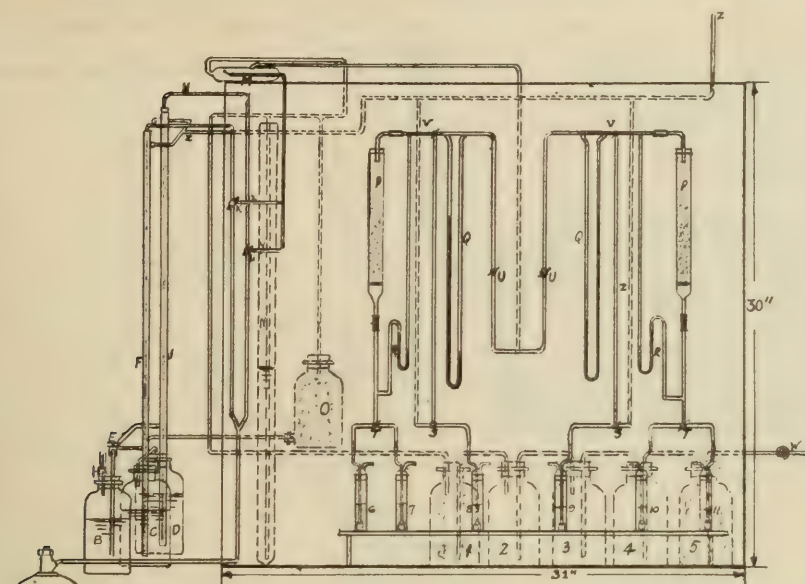


FIG. 1—STANDARD TWO-TUBE APPARATUS FOR TESTING ABSORBENTS, SHOWING ARRANGEMENT FOR GASES STORED IN CYLINDERS

- | | |
|---|--|
| A—Gas reservoir | O—Charcoal scrubber |
| B—Water reservoir | P—Absorbent tubes |
| C—1st concentration leveling bottles | Q—Flow meter |
| D—2nd concentration leveling bottles | R—Manometer |
| E—Control stopcock for leveling bottles | S—3-way stopcocks |
| F—Concentration water column | T—3-way stopcocks |
| G—Pure gas overflow line | U—Stopcocks for flow meter control |
| H—Pure gas overflow line | V—3-way stopcocks |
| I—Concentration water column | W—Air pressure line |
| J—3-way stopcock | X—Capillary-pure gas |
| K—3-way stopcock | Y—Capillary-pure gas |
| L—Gas-air mixing chamber | Z—Exhaust |
| M—Constant pressure device | 1, 2, 3, 4, 5—Humidifying bottles (1 and 5, traps) |
| | 6, 7, 8, 9, 10, 11—Gas washing absorption bottles |

In the apparatus shown in Fig. 1, there are two automatic flow meters arranged in parallel between gas supply tank A and mixing chamber M, (1) the system C, F, G, K, X, for concentrations of 1000 p. p. m., and (2) the system D, J, H, L, Y, for concentrations of 10,000 p. p. m. By this double arrangement the concentration can be instantly changed from one to the other, or the combination may be used for binary gas mixtures. Since the operation of the pair of flow meters is identical it will be sufficient to describe the D, J, H, L, Y system.

PRINCIPLE AND DESCRIPTION OF AUTOMATIC COMPENSATING FLOW METER—A constant flow of toxic gas is maintained through the very small constricted capillary tube Y, by imposing a constant differential pressure on the inlet and outlet. This differential pressure is the height of water column from bottom end of tube H to water level in bottle D. The cross section of bottle D is chosen sufficiently large in comparison to cross section of tube J so that no rise of water in tube J will change height of water level in D appreciably.

The quantity of gas transmitted by the automatic flow meter is determined by the size of the constricted

capillary Y and the water level in bottle C. These two factors must be determined by actual trials of concentration by analysis. The final exact adjustment of concentration is made by changing the water level in bottle C by applying suction or air pressure to reservoir bottle B and allowing the liquid to flow through stopcock E in the proper direction to give the desired level.

When the board is in operation, 3-way stopcock, L, is turned so that the gas flows through the constricted capillary Y and at the same time an excess of toxic gas passes through tube H and bubbles out against the column of liquid in J and passes off to waste through the tube Z.

The column of water in J is held by the pressure of the air over the liquid in the level bottle D. This air space communicates with the main air line just ahead of the mixing chamber and, therefore, has the same pressure, practically, as at the outlet end of the constricted capillary Y. Hence, any change in pressure on the outlet of Y is immediately compensated by an equal change in pressure on the inlet end due to change in level of water column J which governs the inlet pressure; thus all pressure fluctuations in the

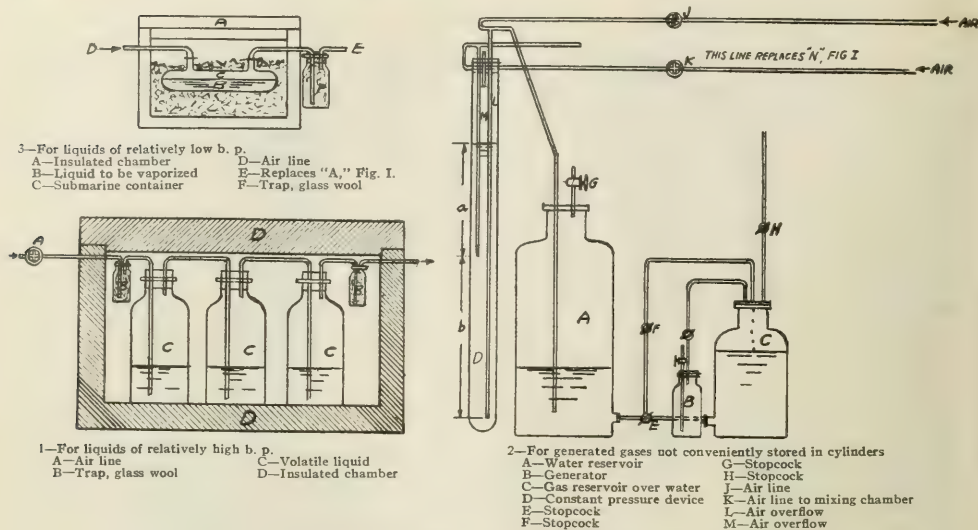


FIG. II—ACCESSORIES FOR FEEDING VARIOUS TYPES OF GASES AND VAPORS

line are instantly compensated and a constant and steady differential pressure is maintained over capillary Y, insuring a definite and uniform concentration. Charcoal bottle O prevents diffusion of gas into the main air line.

MODIFICATION FOR LOW-BOILING LIQUIDS—Liquids such as hydrocyanic acid are most conveniently vaporized by passing a slow stream of dry air over the surface, the container being packed in cracked ice and water at 0° C. A convenient form of such apparatus is shown in Fig. II-3. This container simply takes the place of the compressed gas tank. The air-vapor flow is regulated by the same automatic compensating flow meter shown in Fig. I.

MODIFICATION FOR HIGH-BOILING LIQUIDS—Vaporizing apparatus for liquids such as chlorpicrin, carbon tetrachloride, and trichloromethylchloroformate is shown in Fig. II-1. It differs from the previous apparatus only in that the liquid is placed in a five-bottle train. The three middle bottles contain the liquid and the two end bottles serve as traps. The entire train is packed in ice. The air, previously dried, is bubbled through the liquid and then through the automatic flow meter.

METHOD OF FILLING TUBES—The absorption tube and funnel (Fig. III-1) are supported in a vertical position with the funnel stem "centered" in the tube. The distance from the apex of the funnel to the upper layer of absorbent when the absorption tube is filled to the desired height should be 15 cm.

The entire sample of absorbent is poured on a large sheet of rubberized fabric and thoroughly mixed by rolling the sample. This may be done by lifting opposite corners of the fabric alternately. Smooth out the sample on the fabric and take portions with a spoon at regular intervals of space over the entire

surface of the sample so as to insure having a representative portion for test.

The absorbent is poured from the spoon, a few grains at a time, so that no grains have a free fall through the orifice of the funnel. The time for filling a 2.00 cm. tube to a height of 10 cm. should be not less than 1½ min. The tube should not be tapped at any time. Connect the tube to a strong suction and draw air through it at least 5 times to remove dust. In removing dust from the absorbent the stopcock C is turned on quickly for 1 or 2 sec. and quickly closed.

PROCEDURE IN MAKING TESTS—Having obtained the desired concentration and diverted the flow of gas-air mixture through the stopcocks V and S to the waste, the absorption tube, filled as previously described, is placed in position, the time noted, and the gas-air mixture passed through the absorbent by proper adjustment of stopcocks V and T. The proper amount of gas-air flow is regulated by the stopcock T. The bottle 6 or 7 may contain the solution or reagent to be used as the qualitative test. Upon noting a qualitative test the time is again recorded and the gas-air flow diverted alternately, generally for 5-min. intervals through bottles 6 and 7, which now contain solutions for quantitative analysis of the effluent gas. The efficiency of the absorbent is calculated as follows:

Percentage efficiency =

$$\frac{\text{P. p. m. entering gas} - \text{p. p. m. effluent gas}}{\text{P. p. m. entering gas}} \times 100$$

The time elapsed to any efficiency point is recorded as time in minutes from the beginning of the test to the middle of the sampling period corresponding to that efficiency point. A time efficiency curve with time in minutes as abscissa and percentage efficiency

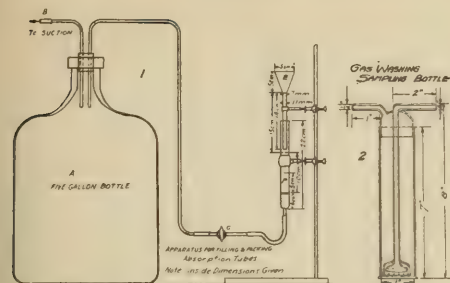


FIG. III—APPARATUS FOR FILLING SAMPLE TUBES

as ordinate is drawn as a smooth curve through the points whose values were obtained by analysis of the effluent gas. The time in minutes read from this curve and corrected to the nominal concentration is reported for the 100, 99, 95, 90, and 80 per cent efficiency points.

METHODS OF ANALYSIS

Concentrations of entering and effluent gas are determined by directing the entire gas-air stream (1571 cc. per min.) through 1 or 2 gas washing bottles in series, each containing 25 or 50 cc. of the proper absorbing solution, for an exact period of time—2 min. for entering gas and 5 or 10 min. for effluent gas. Since the gas-air stream has a volume of exactly 1571 cc. per min., the total sample volume becomes 1571 multiplied by the number of minutes that the gas stream was passed through the absorption bottle. The standard solutions are usually made up to an exact normality, so that 1 cc. of the solution is equal to exactly 100 or 1000 p. p. m. of the gas at 25° C. and 760 mm. for a 1-min. sample, *i. e.*, 1571 cc. Actually, the sampling time is usually 2, 5, or 10 min., and the result is then divided by the number of minutes of sampling. The absorbent solutions used for various gases are briefly described below.

CHLORINE

QUALITATIVE—Two per cent potassium iodide solution to which starch has been added.

QUANTITATIVE—A 4 per cent potassium iodide solution is used for entering concentrations and a 2 per cent potassium iodide solution for effluent concentrations. The gas-air mixture is aspirated through the potassium iodide solution and the iodine thus liberated is titrated with 0.1286 *N* sodium thiosulfate. 1 cc. of 0.1286 *N* sodium thiosulfate equals 1000 p. p. m. chlorine (by volume 25° C. and 760 mm.) for a 1-min. sample.

PHOSGENE

QUALITATIVE—The use of moist Congo-red paper as an indicator depends upon the presence of hydrochloric acid (resulting from hydrolysis of carbonyl chloride) in the effluent gas and the consequent change in color of the paper from red to blue. The phosgene test paper, which also responds to chlorine and hydrochloric acid, is prepared as follows:

Dissolve 5 g. of *p*-dimethylaminobenzaldehyde and 5 g. of diphenylamine in 100 cc. 95 per cent alcohol. Dip filter paper in the solution and dry in the air. When dry, keep the test paper away from light. These papers thus preserved do not deteriorate and will detect readily one part per million of phosgene. Both chlorine and hydrochloric acid act on the papers so that in testing for phosgene one must take precautions first to remove any chlorine or hydrochloric acid which may be present.

Another qualitative test solution which responds to both hydrochloric acid and phosgene is prepared by adding a few drops of potassium chromate and a few drops of neutral silver nitrate to alcohol. A salmon colored solution is obtained which is changed to yellow by presence of hydrochloric acid or phosgene.

QUANTITATIVE—The gas samples are absorbed in 50 cc. of alcoholic sodium hydroxide, prepared by dissolving 40 g. sodium hydroxide in 125 cc. of distilled water and adding this solution to 875 cc. of 95 per cent ethyl alcohol. The absorbent solution is neutralized with nitric acid (approximately normal), using phenolphthalein as an indicator, and the chloride-ion is determined by titration with 0.1286 *N* silver nitrate, using sodium chromate as an indicator. 1 cc. 0.1286 *N* silver nitrate equals 1000 p. p. m. phosgene (by volume at 25° C. and 760 mm.) for a 1-min. sample.

SULFUR DIOXIDE

QUALITATIVE—A 2 per cent potassium iodide solution to which a few drops of starch-0.01286 *N* iodine has been added.

QUANTITATIVE—Entering concentrations are determined by passing the gas through two absorption bottles, the first of which contains an accurately measured amount (approximately 30 cc.) of 0.1 *N* iodine solution, and the second, 25 cc. of 2 per cent potassium iodide solution, and titrating the liberated iodine with 0.1286 *N* thiosulfate solution (1 cc. = 1000 p. p. m. sulfur trioxide).

Effluent concentrations are determined by absorbing the gas in 25 cc. of 3 per cent aqueous sodium hydroxide. This solution is first neutralized with hydrochloric or sulfuric acid, using phenolphthalein as indicator, then titrated with 0.01286 *N* iodine (1 cc. = 100 p. p. m. sulfur dioxide), using starch as indicator.

CARBON DIOXIDE

QUALITATIVE—Approximately 0.2 *N* barium hydroxide solution.

QUANTITATIVE—The gas is absorbed in 0.1286 *N* barium hydroxide solution. Titrations are made with 0.1286 *N* hydrochloric acid or oxalic acid of the same normality, using phenolphthalein as an indicator. 1 cc. equals 1000 p. p. m. (by volume at 25° C. and 760 mm.) for a 1-min. sample.

TRICHLOROMETHYLCHLOROFORMATE

QUALITATIVE—Methyl red has given the most satisfactory qualitative test. The color change is from yellow to red. The solution is prepared by adding 10 drops of a 5 per cent solution to 100 cc. of alcohol and then adding 1 cc. 0.2 *N* sodium hydroxide solution.

QUANTITATIVE—The gas is absorbed in 50 cc. of alcoholic sodium hydroxide solution. This solution is prepared by dissolving 40 g. of sodium hydroxide in 125 cc. of distilled water which is then added to 875 cc. of 95 per cent alcohol. 1 cc. 0.0257 *N* silver nitrate = 100 p. p. m. (by volume at 25° C. and 760 mm.) for a 1-min. sample.

CHLORPICRIN

QUALITATIVE—The gas is decomposed by passing it through a quartz tube heated to about 400° C. Chlorine, one of the decomposition products, is detected by means of a 2 per cent potassium iodide solution to which starch has been added.

QUANTITATIVE—The gas is absorbed in 50 cc. of a 1 per cent solution of sodium peroxide in 50 per cent alcohol. This solution is made up daily by adding sodium peroxide to ice water in the ratio of 2 g. of the peroxide per 100 cc. of water. Just prior to use, 25 cc. of this solution are diluted with 25 cc. of 95 per cent alcohol. The chloride-ion resulting from decomposition of chlorpicrin is titrated with 0.01929 *N* silver nitrate in the neutral solution by using sodium chromate as an indicator. 1 cc. of 0.01929 *N* silver nitrate equals 100 p. p. m. (by volume at 25° C. and 760 mm.) for a 1-min. sample.

HYDROCYANIC ACID

QUALITATIVE—The gas is passed through a 2 per cent sodium bicarbonate solution to which starch and enough iodine have been added to produce a visible blue. Decolorization of this solution shows the break point.

QUANTITATIVE—Samples of the gas are absorbed in a 2 per cent sodium bicarbonate solution and titrated with 0.01286 *N* iodine solution, using starch as an indicator. 1 cc. 0.0129 *N* iodine solution equals 100 p. p. m. (by volume at 25° C. and 760 mm.).

ACCELERATED TEST FOR CHARCOAL

The accelerated test differs from the standard long test only in concentration, rate, and relative humidity of the gas-air mixture and in end-point of test. The rate of 1000 cc. per min. is obtained by using with the standard two-tube apparatus a 1.41 cm. internal diameter absorption tube instead of a 2.00 cm. tube. The relative humidity of the gas-air mixture which is zero and the concentration which is about 7500 p. p. m. are obtained by drying the entire air supply to the apparatus with concentrated sulfuric acid and then passing it through chlorpicrin maintained at 0° C. by an ice-water mixture. The effluent gas is passed into the air supply of a gas burner which contains a copper wire spiral or coil so situated that the copper wire is subjected to all gradations of temperature. A new multiple opening type of burner has been developed. It consists of a flat top burner with a ring of small holes near the outside. A piece of No. 18 copper wire bent into the form of a ring is laid over these holes. A green coloration of the flame is taken as the qualitative test for chlorpicrin in the effluent gas mixture. The green flame appears at a concentration somewhat less than 35 p. p. m. The time in minutes (recorded to the nearest tenth of a minute)

from the beginning of the test until a green coloration of the flame is noted is taken as the service time (or activity) of the charcoal. The green color of the flame is enhanced by use of a dark background.

An accelerated test of charcoals against carbon tetrachloride has also been used. It differs from the accelerated chlorpicrin test only in rate and concentration. The rate, which is 500 cc. per min., is obtained by using the standard two-tube apparatus. The concentration, which is about 40,000 (theoretical about 44,000 p. p. m. at 760 mm. pressure), and the relative humidity, which is zero, are obtained by drying the entire air supply to the apparatus with concentrated sulfuric acid and then passing it through carbon tetrachloride maintained at 0° C. by an ice-water mixture. The break point is sharper than that of the accelerated chlorpicrin test, due to the fact that there are more chlorine atoms in the carbon tetrachloride molecule and to the fact that the test time is shorter.

STANDARD METHODS FOR TESTING CANISTERS

LEAKAGE TEST

The canister filled with chemicals and completely assembled is subjected to an air pressure of 15 in. of mercury; leaks are detected by immersing the canister in water.

RESISTANCE TO FLOW TEST

The resistance to flow of the completely assembled canister is determined at a standard rate of flow of 85 l. per min. The canister is attached to A (Fig. IV)

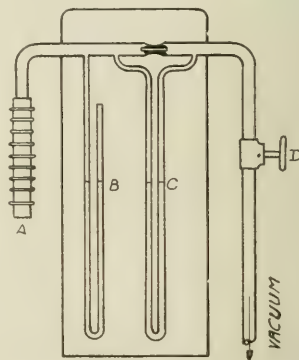


FIG. IV—APPARATUS FOR MEASUREMENT OF PRESSURE DROP

and the flow of air is adjusted by valve D to a rate of 85 l. per min. as indicated by flow meter C. The pressure drop or resistance is measured in inches or millimeters by the water column in manometer B. The resistance should not exceed 3 in. of water.

DETERMINATION OF EFFICIENCY OR LIFE OF CANISTERS AGAINST VARIOUS GASES

The efficiency or "life" of a canister in "gas" may be determined by an actual man test or by machine test; experience has shown that both methods are absolutely essential in development work. Each new design of canister must be submitted to exhaustive man tests in a gas chamber against all gases for which it is proposed, and, furthermore, these tests should be made in

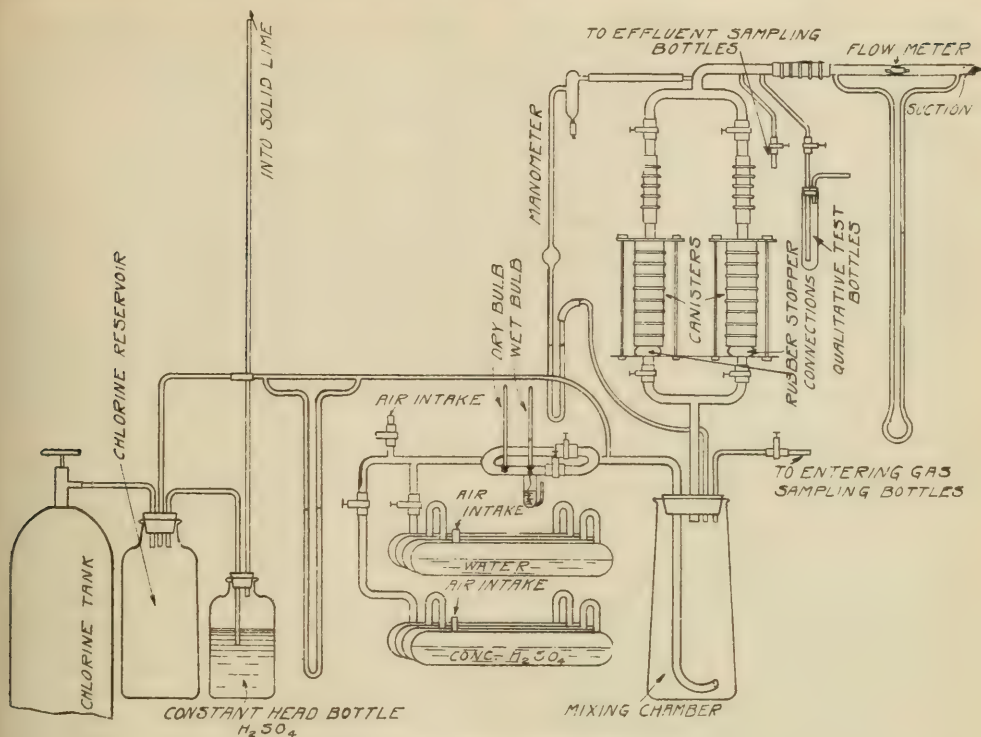


FIG. V.—APPARATUS FOR TESTING CANISTERS AGAINST CHLORINE

several different concentrations including the maximum concentration that is likely to be encountered in using the mask. Deep breathing or maximum work tests must also be made to insure adequate protection under all conditions of use.

Owing to the variable breathing rates of men, and to their different degrees of sensitivity to gas, man tests are too variable to be of much use in control testing such as is required in the factory where the canisters are filled with absorbents. For this purpose machine tests are used in which a constant flow of gas at a definite concentration is maintained through the canister by suitable suction and pressure pumps. The first trace of gas penetrating the canister is detected by chemical means and the amount penetrating is determined at definite intervals of time.

The particular gases used in the machine test will depend upon the absorbents: charcoal fillings are tested against chlorpicrin; soda-lime fillings against chlorine and hydrocyanic acid; and combinations of these two fillings against chlorine (or phosgene), chlorpicrin, and hydrocyanic acid. Other gases of the same general types may, of course, be substituted, especially if the canister is to be used against them, *e. g.*, sulfur dioxide instead of hydrocyanic acid. Methods for such other gases will suggest themselves from the four standard methods described below.

METHOD OF TESTING CANISTERS AGAINST CHLORINE SOLUTIONS—(1) 0.00818 *N* sodium thiosulfate. Make up a solution of approximately 1.3 g. per l. Allow it to stand for a week and dilute to required strength as shown by its action against standard 0.0100 *N* iodine solution.

(2) Two per cent potassium iodide solution. Dissolve 20 g. potassium iodide in 1 l. water.

(3) Starch solution. Bring 1 l. of water to boiling and add 5 g. starch. Filter hot, bring again to boiling, and pour into flask. Insert stopper containing one long tube and one short one having a pinchcock attachment. Invert, and use by drawing off solution through short tube.

APPARATUS—The apparatus is shown in Fig. V. Pure chlorine gas from a tank of liquid chlorine is supplied to a reservoir bottle which is connected to a constant pressure bottle containing sulfuric acid. From the constant pressure bottle the chlorine passes through a flow meter to a mixing jar. At the same time, air of 50 per cent relative humidity is drawn into the mixing jar, and the air-gas mixture is then drawn through the canister to be tested and a large flow meter on which can be read the total volume.

The stand is built to hold two canisters which are connected into the line in parallel between the mixing jar and flow meter. Stopcocks or pinchcocks on soft

rubber tubing placed on either side of each canister permit changing the air stream from one to the other without stopping the flow. The canisters rest on large rubber stoppers (No. 12) fitted on to the tubes from the mixing jar clamped in place by bolts passing through the iron stand. The connection from the top of the canisters to the $\frac{3}{4}$ in. glass manifold leading to the main flow meter is made by means of a piece of heavy-wall flexible tubing such as is used in making connection between the canister and face-piece of the completed gas mask. There are three small side tubes in this glass tube which leads from the canister. One of these is used for drawing off effluent samples; from the second, the gas for the qualitative test is aspirated; and the third is connected to the other side of the manometer which measures the pressure drop across the canister.

The samples for the determination of the concentration of chlorine in the entering and effluent air are drawn through absorption bottles by means of a large water-filled aspirator from which is run, into a calibrated flask, a volume of water equal to the volume of the sample required.

A three-canister apparatus, such as that used for chlorpicrin, can be substituted for the two-canister type described if it is desired to run a greater number of tests. Such an apparatus permits the testing of two canisters simultaneously. (See Method of Testing the Efficiency of Canisters against Chlorpicrin.)

PROCEDURE—The canister is first examined for leaks according to the method already described.

The pressure drop, in inches of water across the canister at 85 l. per min., is then determined.

With an old canister in position on the stand the apparatus is started. The air flow is adjusted to 32 l. per min., as shown by the main flow meter, and the relative humidity of the entering air is brought to 50 per cent by governing the relative amounts drawn over the sulfuric acid and the water tubes, the resulting value being determined from the wet and dry bulb hygrometer. (The humidity is frequently checked.) Next, the concentration of the air-gas mixture is brought to the desired value (5000 p. p. m. by volume for routine tests) by varying the rate of flow of the chlorine as shown by the small flow meter, the concentrations being actually determined by analyzing samples of the entering mixture.

When the relative humidity and concentration have been adjusted to the desired values, the canister to be tested, and which has been placed in the vacant position is quickly connected into the line and the old one cut out by means of the stopcocks above and below each canister, without interrupting the air flow. This causes the least possible dislocation of the concentration and makes the testing continuous.

The time of starting the test is recorded. Effluent gas at 500 cc. per min. is immediately started through the qualitative test bottle containing about 50 cc. of 2 per cent potassium iodide solution and a little starch solution. During the time which this qualitative test is running, the main flow should show 31.5 l. per min.,

making a total of 32 l. per min. Samples of entering air, 500 cc. in volume, are taken every 20 min. throughout the run. The pressure drop across the canister at 32 l. per min. is observed from the manometer about three times during the run and for any increase noted.

After the qualitative test has indicated a break, the concentration of chlorine in the effluent mixture is determined, 2-l. samples being taken successively until the efficiency of the canister has dropped below 90 per cent. The efficiency is calculated on the basis of the nearest entering concentration.

The time from the beginning of the test to the first appearance of blue in the qualitative test bottle is recorded as the time at 100 per cent efficiency, and the time in minutes from the beginning of the test to the middle of the sampling period of each effluent sample is plotted against the per cent efficiency.

Per cent efficiency =

$$\frac{\text{P. p. m. entering gas} - \text{p. p. m. effluent gas}}{\text{P. p. m. entering gas}} \times 100$$

A smooth curve is drawn through these points and the corrected times to such efficiency points as 100, 99, 95, 90, and 80 per cent are read from the curve.

In comparing the results of canister tests it is most convenient to use these specified points. The elapsed times must be corrected to the nominal concentration at which the test is being run, as the actual average concentration may fluctuate up to plus or minus 5 per cent. This correction is made according to the linear inverse proportion:

Corrected time =

$$\text{Observed time} \times \frac{\text{Actual average concentration}}{\text{Nominal concentration}}$$

The average temperature of the entering gas mixture is recorded and also the pressure drop through the canister at 85 l. per min. at the beginning and end of the test.

The machine is checked on alternate days by testing a canister of a previous packing date and comparing the result with the average tests of that date.

ANALYSIS—The concentration of chlorine in both the entering and effluent mixture is determined by aspirating samples through about 50 cc. of 2 per cent potassium iodide solution. By making use of a "petticoat" bubbler (shown in Fig. 1) one absorption bottle is sufficient to recover all of the chlorine in the entering gas sample. Half-liter samples of entering gas and 2-l. samples of effluent gas are used; these are taken at the rate of about 1 l. per min. The iodine thus liberated is titrated with 0.00818 *N* sodium thio-sulfate solution and the results calculated to parts (volume) per million at 25° C. and 760 mm.

CALCULATIONS—Standard solutions are made of such strength that 1 cc. of solution is equivalent to 100 p. p. m. of chlorine at 25° C. and 760 mm. in a 1-l. sample.

The calculation is as follows:

- 1 equivalent chlorine = $\frac{24.45}{2} = 12.23$ l. at 25° C. and 760 mm.
 1 l. *N* sodium thiosulfate = 12.23 liters chlorine at 25° and 760 mm.
 1 cc. 0.01 *N* sodium thiosulfate = 0.1223 cc. chlorine at 25° C. and 760 mm.
 In a liter sample 1 cc. 0.01 *N* sodium thiosulfate = 122.3 p. p. m.
 1 cc. 0.00818 *N* sodium thiosulfate = 100 p. p. m. in a liter sample at 25° C. and 760 mm.
 For a sample of *A* liters,
 1 cc. 0.00818 *N* sodium thiosulfate = $\frac{100}{A}$ p. p. m.
 5000 p. p. m. = 14.51 mg. per l.

METHOD OF TESTING CANISTERS AGAINST PHOSGENE

SOLUTIONS—(1) Alcoholic sodium hydroxide, chlorine-free. Five hundred cc. of aqueous sodium hydroxide solution (35 g. per 100 cc. water) diluted to 9 l. with 95 per cent alcohol.

(2) 0.00818 *N* silver nitrate. Approximately 1.5 g. per l. of water, diluted to 0.00818 *N* as shown by titration against standard 0.01 *N* sodium chloride solution.

(3) Potassium chromate indicator. Use 50 g. of neutral potassium chromate in a little distilled water. Add enough silver nitrate to produce a slight red precipitate. Filter and make up to one liter.

(4) Pieces of filter paper 1 cm. × 2 cm. are placed in water and 3 or 4 drops of strong Congo-red solution added. Paper is allowed to soak 1 hr. The best depth of color must be determined by experience.

(5) *p*-Dimethylaminobenzaldehyde test paper, while not being used as a qualitative test paper, due to the fact that the color change is not marked in low concentrations of hydrochloric acid, which first appears in the effluent air, has been found to be valuable in locating gas leaks in the machine. (Its preparation has been described under absorbent testing.)

(6) Phenolphthalein solution. One per cent in 95 per cent alcohol.

APPARATUS—The apparatus is nearly identical with that used for chlorine. The phosgene is taken from an iron cylinder similar to that used for chlorine. The excess gas is absorbed in alcoholic sodium hydroxide. For the qualitative test a 4 in. glass tube $\frac{3}{4}$ in. in diameter, containing a test paper, is used instead of the absorption bottle of the chlorine apparatus. The effluent quantitative samples are drawn off by means of a small flow meter instead of an aspirator.

Phosgene readily corrodes brass. The controlling valve is, therefore, protected by means of a soda-lime tower placed in line just after the main flow meter.

A three-canister apparatus such as that used for chlorpicrin can be substituted for the two-canister type described if it is desired to run a greater number of tests.

PROCEDURE—The procedure is the same as that for chlorine. Moistened Congo-red paper is used in the qualitative test. The quantitative samples are absorbed in alcoholic sodium hydroxide solution. The tests are run at 32 l. per min. and 5000 p. p. m. The main flow meter is set at 30 l. per min., while 2 l. per min. are passed through a qualitative tube or a quantitative sampling bottle. Fifty per cent relative humidity is used. Half-liter and 2-l. samples are taken for the entering and effluent concentrations, respectively.

NOTE—Phosgene is readily absorbed by the rubber connections. To avoid error in the qualitative test and effluent concentration determinations, the rubber connections at the top of the canisters are changed for every test and thoroughly washed with alcohol before being replaced.

ANALYSIS—The gas samples are absorbed by aspirating through 50 cc. of alcoholic sodium hydroxide solution in which the phosgene is hydrolyzed to sodium carbonate and sodium chloride. One absorption tube with petticoat bubbler is sufficient. Phenolphthalein is added and the excess sodium hydroxide neutralized with approximately normal nitric acid. The chloride is determined by titration with 0.00818 *N* silver nitrate, using potassium chromate solution as indicator.

The use of moist Congo-red paper as an indicator depends upon the presence of hydrochloric acid in the effluent gas and the consequent change in color of the paper from red to blue.

CALCULATIONS—The calculations are substantially the same as for chlorine.

- 1 cc. 0.00818 *N* silver nitrate = 100 p. p. m. phosgene at 25° C. and 760 mm. in a 1-l. sample.
 5000 p. p. m. = 20.225 mg. per l.

METHOD OF TESTING CANISTERS AGAINST HYDROCYANIC ACID

SOLUTIONS—(1) Sulfuric acid. One volume concentrated sulfuric acid (1.84 sp. gr.) to one volume water.

(2) Sodium cyanide. Approximately 25 g. to 100 cc. of water.

(3) Sodium carbonate. 20 g. per l.

(4) Sodium bicarbonate. 20 g. per l.

(5) Iodine. 0.0164 *N*, in potassium iodide solution.

(6) Starch solution. 5 g. per l.

APPARATUS—The apparatus, shown in Fig. VI, is similar to that used for chlorine, except that the gas is supplied from a generator instead of a cylinder. The canister stand is built to hold two canisters. T-tubes, carrying the entering and effluent gas, and soft rubber connections are used which permit shutting off either canister by means of pinch clamps.

A three-canister apparatus such as that used for chlorpicrin can be substituted for the two-canister type described if it is desired to run a greater number of tests.

The generator is a 5-l. bottle which is placed in an ice bath. Dropping tubes for the sulfuric acid and sodium cyanide, a tube for passing in air to carry over the gas, an outlet tube, and a siphon are inserted into the bottle through a large rubber stopper. A small flow meter is provided to control the rate at which air enters the generator. The air incidentally serves to agitate the liquid and provide thorough mixing. Bottles containing dilute sulfuric acid, sodium cyanide solution, and water are placed on a shelf directly above the generator and connected to it by siphon tubes. A small compressor forces the air through the generator.

PROCEDURE—To start a run, the ice bath is filled, an inch of water run into the generator (to assist in hold-

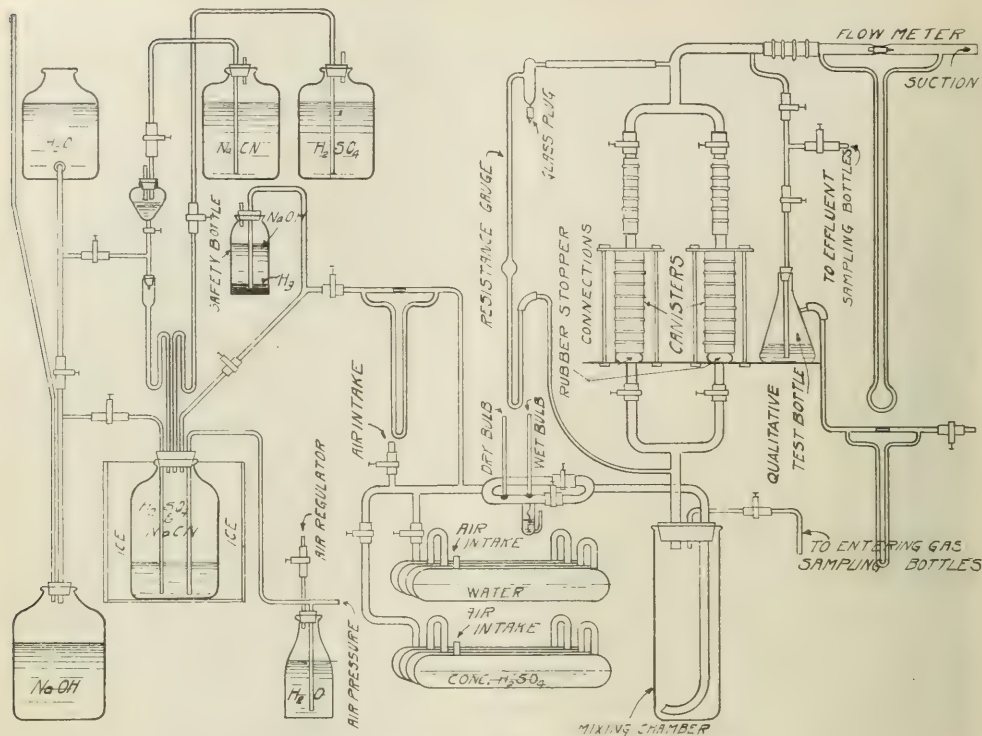


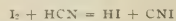
FIG. VI.—APPARATUS FOR TESTING CANISTERS AGAINST HYDROCYANIC ACID

ing in solution the sodium sulfate formed), followed by 750 cc. of dilute sulfuric acid (1 : 1) and about 50 cc. of the cyanide solution. The pumps are then started and air at 32 l. per min. is drawn through the apparatus with an old canister in the line, and at the same time air at 1 to 1.5 l. per min. is forced through the generator and into the mixing chamber. After the addition of the first 30 cc. of cyanide solution (which should take about 5 min.) the flow of solution is gradually cut down during a period of 10 min. to approximately 36 drops per min., where it is held constant. In this way it ordinarily takes $\frac{3}{4}$ hr. to get up concentration. This has been found to give a concentration of 2000 p. p. m. at 32 l. per min. If the concentration is unsatisfactory, it may be changed by varying the rate of air flow through the generator, and the rate of dropping. The concentration, with moderate care in controlling the air flow and dropping rate, can be kept within 5 per cent of that desired.

When the concentration is satisfactory, the canister to be tested is opened to the line, by removing the pinch clamps above and below it, and the old one cut out. Effluent gas at 500 cc. per min. is aspirated through the qualitative test bottle containing 50 cc. of 2 per cent sodium bicarbonate solution, a little starch, and sufficient iodine solution to give the whole a distinct blue tinge. The flow, as indicated by the large flow meter, is set at 31.5 l. per min. to bring the

total through the canister to 32 l. per min. Samples for determining the concentration of entering and effluent gas are aspirated through 50 cc. of 2 per cent sodium carbonate solution in an absorbing cylinder, 5-l. samples of effluent and 1 l. samples of entering gases being taken by means of a flow meter and an aspirator bottle, respectively. The hydrocyanic acid is determined by titration with standard iodine solution, using starch as an indicator. Results are calculated to parts per million of gas at 25° C. and 760 mm.

ANALYSIS—Samples are absorbed in a 2 per cent aqueous sodium carbonate solution and the hydrocyanic acid titrated with 0.0164 *N* iodine solution, using starch as an indicator, the reaction being as follows:



CALCULATIONS—11 *N* iodine solution = $\frac{24.45}{2}$ l. hydrocyanic acid at 25° C. and 760 mm.

1 cc. *N* iodine solution = 12.23 cc. hydrocyanic acid at 25° C. and 760 mm.

1 cc. 0.01636 *N* iodine solution = 200 p. p. m. at 25° C. and 760 mm. in a 1 l. sample.

2000 p. p. m. = 2.22 mg. per l.

METHOD OF TESTING CANISTERS AGAINST CHLORPICRIN

SOLUTIONS—*Absorbing Solution*—Equal volumes of 2 per cent sodium peroxide solution and 95 per cent alcohol mixed just before using.

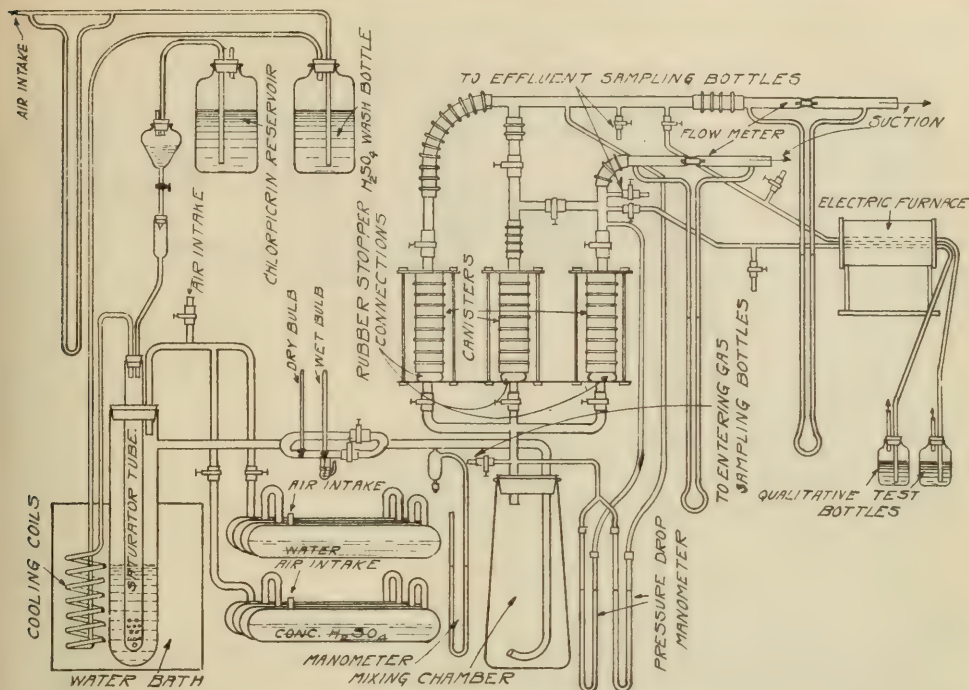


FIG. VII.—APPARATUS FOR TESTING CANISTERS AGAINST CHLORPICRIN

Standard Solution—Silver nitrate solution, 0.0123 *N* 2.3 g. per l. standardized against standard sodium chloride solution and diluted to 0.0123 *N*.

Potassium Chromate Indicator—Use 50 g. of neutral potassium chromate in a little distilled water. Add enough silver nitrate to produce a slight red precipitate. Filter and make up to one liter.

Qualitative Test Solution—Potassium iodide solution, 20 g. potassium iodide per l. Starch solution, 5 g. starch per l.

APPARATUS—The apparatus used is shown in Fig. VII. It is similar in part to those previously described. The chlorpicrin is contained in a glass tube 5 cm. in diameter and 60 cm. long, and is maintained at 25° C. in a water bath. Air at constant rate (regulated by a flow meter) is bubbled through the liquid after having been previously passed through a coil in the water bath. The height of liquid is held constant by dropping liquid steadily from a dropping funnel sealed in the top of the tube. A siphon tube is also sealed in for the purpose of removing the liquid when desired. The bath is agitated by an air pump to insure even temperature.

An additional volume of air, sufficient to make the total 32 l. per min. per canister, is drawn into the line through the humidity control and, together with the chlorpicrin-air mixture, passes by the humidity indicator and into the mixing chamber. The mixing jar is a glass cylinder 10 cm. in diameter and 40 cm. high,

closed with a wooden stopper sealed in with sealing wax. By means of rubber tubing and a screw clamp at the air intake, the pressure inside the mixing jar is kept at 2 cm. of water below atmospheric. This is determined by a manometer, one side of which is connected in the line. (The slight reduction in pressure is merely to insure no possible exit of gas through the large air intake.)

The iron stand and the method for clamping the canister in place is the same as on the chlorine machine, except that it is arranged for three canisters in parallel. After leaving the mixing chamber the air stream is divided so that two canisters may be tested simultaneously, yet independently of each other. The third canister may be substituted at will for a canister on which the test has been completed, thus avoiding interruption between tests (see diagram). The gas passes from each canister to a large flow meter and thence through a needle valve to the suction pump.

A manometer for measuring the pressure drop across each canister is connected in the line by means of side tubes on each side of the canister.

The qualitative test is made by using two quartz tubes filled with broken porcelain and heated in an electric or gas furnace to 400° C.

PROCEDURE—The bath agitator is started and the furnace heated.

With two old canisters in the train, air at 32 l. per min. is drawn from the mixing jar through each. At

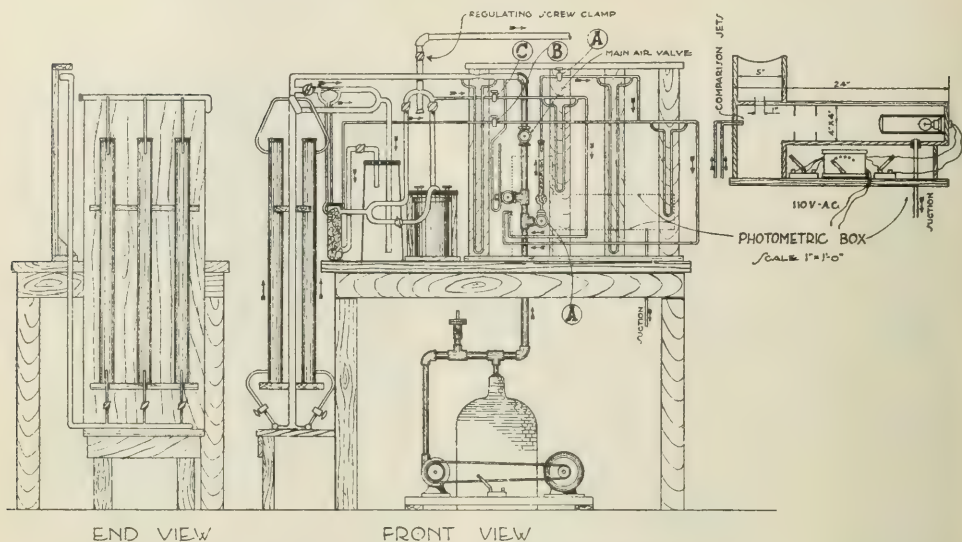


FIG. VIII—APPARATUS FOR TESTING CANISTERS AGAINST SMOKE

the same time, air is started through the chlorpicrin at such a rate as will give the desired concentration of chlorpicrin in the final gas-air mixture (2500 p. p. m. for routine tests). Liquid chlorpicrin is added from the dropping-funnel as fast as it is vaporized in the tube. The temperature is kept between 23° and 28° C. and the humidifier adjusted to give 50 per cent relative humidity. The screw cock on the air intake is closed till the pressure within the apparatus is 2 cm. of water below atmospheric.

In the meantime, the third, but new, canister has been inserted in place. When the desired concentration has been reached, the flow through one of the old canisters is switched through this new one and its test thus started. Another new canister is now inserted in place of this released old one and the flow of gas changed as above. For convenience, the canisters are inserted so as to "break" at different times. The pressure drop of each canister is taken at 85 l. per min. before and after the test. The time and temperature are noted at the beginning of the test. Every 20 min. during the test the entering gas concentration is determined by aspirating 1-l. samples through the two absorbing bottles, each containing a mixture of 25 cc. of 2 per cent aqueous sodium peroxide solution and 25 cc. of 95 per cent alcohol and analyzing as described below. Effluent gas is aspirated through the furnace and the qualitative test bottle, containing about 50 cc. of 2 per cent potassium iodide solution and a few drops of starch solution, at 1 l. per min. The large flow meter is set to deliver 31 l. per min. while the qualitative test is being taken, in order that the total flow through the canister may be kept constant at 32 l. per min. When the first positive qualitative test is obtained a 2-l. effluent sample

is taken, followed by at least two others before the canister has fallen to 90 per cent efficiency.

PRECAUTIONS—The furnace used in the qualitative tests has been found to hold up small amounts of chlorine and consequently gave a false test. To overcome this it is necessary to draw air through the furnace for about 20 min. between tests. Delays are avoided by turning off the qualitative test immediately after the "break" and at once starting the air through the furnace.

ANALYTICAL METHOD—The analytical method depends on the formation of sodium chloride by the decomposition of chlorpicrin by alcoholic sodium peroxide solution.

Samples of entering and effluent gases of known volume are aspirated through two bottles, each containing 50 cc. of a half and half mixture of 2 per cent (by weight) sodium peroxide solution and 95 per cent alcohol.

The solution is washed out into an Erlenmeyer flask, neutralized with nitric acid, and titrated immediately with silver nitrate solution, using potassium chromate indicator.

CALCULATIONS—1 g. equivalent chlorpicrin vapor = $\frac{24.45}{3}$ l. at 25° C. and 760 mm.

∴ 1 l. N silver nitrate = $\frac{24.45}{3}$ l. chlorpicrin vapor at 25° C. and 760 mm.

1 cc. 0.01 N silver nitrate = 0.0185 cc. chlorpicrin vapor at 25° C. and 760 mm.

∴ 1 cc. 0.01 N silver nitrate = 81.5 p. p. m. chlorpicrin vapor at 25° C. and 760 mm. in a 1 l. sample.

∴ 1 cc. 0.0123 N silver nitrate = 100 p. p. m. chlorpicrin vapor at 25° C. and 760 mm. in a 1 l. sample.

2500 p. p. m. = 16.61 mg. per l.

METHOD OF TESTING THE FILTERING EFFICIENCY OF CANISTERS AGAINST TOBACCO SMOKE¹

PRINCIPLE OF THE METHOD—"Tobacco Smoke" is generated by passing air over ignited sticks consisting of a mixture of tobacco, rosin, and potassium nitrate. The smoke thus produced is passed through the canister at a rate of 85 l. per min. A part of the entering smoke is by-passed and diluted with a measured amount of air; the mixture is then passed through a flow meter (maintained at 1500 cc. per min.) and allowed to issue from a jet alongside a similar jet of the effluent smoke. A constant amount of this effluent smoke (1500 cc.) per min. also issued from a jet. A strong beam of light is directed lengthwise upon these two jets of smoke. The Tyndall beams are observed laterally and the relative amounts of air and entering smoke varied until the two streams of smoke appear bright. Inasmuch as the same volume of smoke-air passes through both jets, the amount of air required to dilute the unfiltered smoke and produce the same optical density in the two streams is a measure of the efficiency of the filter. The scale in the dilution meter is arranged to give the percentage efficiency of the canister directly; this may be calculated from the formula

Percentage efficiency =

$$100 \times \frac{\text{Cc. air used for dilution}}{\text{Total cc. (1500)}}$$

APPARATUS—The apparatus is shown to scale in Fig. VIII, arrows indicating the direction of flow of air and smoke. Air under pressure passes through a flow meter and enters a main to which are connected three pairs of vertical iron cylinders, 5 cm. in inside diameter and 90 cm. long. A part of the air may be by-passed and then mixed with the smoke stream in the mixing chamber. Inside each cylinder is hung a tobacco stick which is ignited at the bottom when the machine is put in operation. The smoke produced by the combustion of these sticks passes into a main which delivers it to a jar, which jar acts as a settling chamber. From the settling chamber the smoke passes through a filter bottle which contains a loose plug of cotton for removing any large particles of smoke, tarry matter, etc. Before the settling chamber and the tar filter is placed a by-pass through which the smoke can be directed to the exit while the apparatus is being adjusted and the canisters changed.

From the tar filter a small part of the smoke passes through a flow meter, adjusted to give 1500 cc. per min. after dilution with air, and then into the optical box. The rest of the smoke passes into the canister jar in which the canister is placed, and is forced through the canister at a rate of 85 l. per min. After having passed through the canister, 1500 cc. are metered and led into the optical box through a jet, and the remainder is discarded through the regulating valve. A connection and a valve, A, are provided, in order that air from the compressed air line can be metered by the "percentage flow meter" and used to dilute the unfiltered smoke mixture before the diluted mixture is

metered and passed into the optical box through the second jet.

The optical box consists of a wooden box of the shape and dimensions shown in the drawing. It is painted dull black inside in order to prevent reflection of light. The smoke jets are illuminated by a lamp (6 to 8 v., 24 c. p.) and condensing lens system situated at the end of the box opposite that through which the smoke enters. A slight suction on an outlet near the lamp removes the smoke from the box. The glass tips from which the smoke issues are of 3 mm. inside diameter. A rheostat or transformer is used in series with the lamp in order to regulate the brightness of illumination of the smoke jets, a bright illumination being used in matching the jets in the case of a good canister and a poorer illumination in the case of a poorer canister.



FIG. IX.—EXTERIOR OF MAN-TEST LABORATORY

One of the most important parts of the apparatus is the percentage flow meter. This should be carefully calibrated, and the diluted smoke flow meter checked against it before each run in order to avoid any error due to plugging of this flow meter with smoke. The effluent smoke flow meter should also be checked against this diluting air flow meter.

PROCEDURE—(a) *Adjustment of Apparatus*—About one end of a tobacco stick, wrap a wire so as to form a loop; evenly ignite the opposite end, hang the stick on the upper stopper by the loop so that the upper end is about 10 in. from the stopper, and then tightly insert the stopper in the smoke cylinder. Fill the six tubes in this manner. With the regulating screw clamp partly open and the by-pass around the canister box open, the main air valve is opened until a differential corresponding to 85 l. per min. shows on the main flow meter. Usually a maximum of 30 l. per min. is allowed to pass through the smoke tubes (5 l. per tube); the balance is by-passed and meets the smoke stream in the mixing chamber.

The regulating screw clamp and the main air valve are so adjusted that 85 l. are passing with a pressure

¹ Method worked out by Lt. H. C. Arnold, P. M. Horton, and E. S. Longfellow.

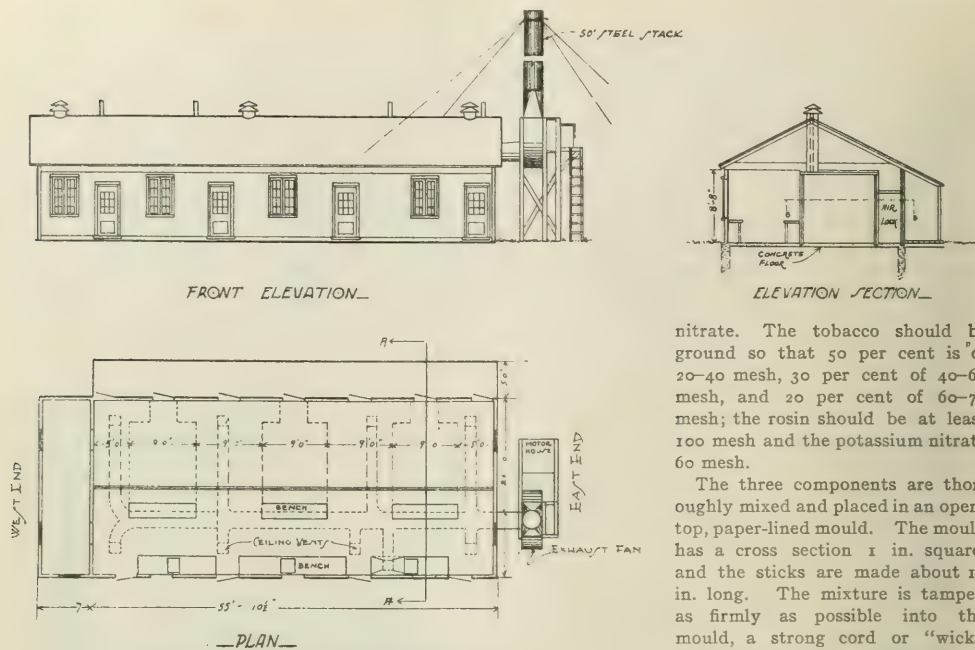


FIG. IX—ELEVATION AND PLAN OF MAN-TEST LABORATORY

head of 80 mm. of mercury, shown by an open end manometer placed just before the main flow meter. This head is necessary to operate the measured smoke sample flow meters. When smoke is passing uniformly through the apparatus, close the by-pass around the canister box, thus directing the smoke through the canister under test.

(b) *Manipulation for Test*—Check the diluted smoke flow meter by opening the air dilution valve A until 1500 cc. shows on the percentage flow meter. The differential on the diluted smoke flow meter then shows 1500 cc. per min. and should be maintained at this height throughout the test (the scale is made adjustable for convenience).

While closing A, open B correspondingly, so that the diluted smoke flow meter remains constant at 1500 cc. per min. Adjust these two valves until the two smoke streams appear equally dense when observed in the optical box. The intensity of the light should be adjusted to correspond with the density of the smoke, the denser the smoke the less the illumination required for the highest precision in matching. To check the observation, two other readings should be taken, one slightly above and the other slightly below the true match.

The total time for passage of smoke through the canister should probably not exceed 5 min. Usually it will vary from 1 to 3 min.

DISCUSSION—The tobacco sticks are made of 63 per cent tobacco, 30 per cent rosin, and 7 per cent potassium

nitrate. The tobacco should be ground so that 50 per cent is of 20-40 mesh, 30 per cent of 40-60 mesh, and 20 per cent of 60-70 mesh; the rosin should be at least 100 mesh and the potassium nitrate 60 mesh.

The three components are thoroughly mixed and placed in an open-top, paper-lined mould. The mould has a cross section 1 in. square, and the sticks are made about 15 in. long. The mixture is tamped as firmly as possible into the mould, a strong cord or "wick" then inserted in the center to give strength to the finished stick, and

the stick heated in an oven until it begins to smoke. (The rosin melts and forms a binder for the rest of the material.) As soon as the stick has hardened the paper may be removed.

Tobacco smoke is not a clogging smoke and no error is encountered due to change in nature of filter because of absorption of smoke in the short time necessary for a test. The concentration of the testing cloud may vary slightly from time to time, but produces no effect upon the relative filtering efficiency of the canister.

METHOD OF CONDUCTING MAN TESTS AND DESCRIPTION OF CHAMBER

GENERAL—The man test laboratory at the American University provides facilities for determining the efficiency of gas masks and other protective devices, such as gas-proof clothing. Here concentrations of various gases are established in suitable chambers and the anti-gas apparatus tested directly on men.

Drawings and photographs of the laboratory and auxiliary apparatus are given in this report.

DESCRIPTION—The man-test laboratory (Fig. IX) is a one-story building, 56 ft. in length and 25 ft. in width. The main part is occupied by three gas chambers, laboratory tables, and various devices for putting up and controlling gas concentrations in the chambers. A small part at one end is used as an office and storeroom.

Good ventilation is of great importance in a laboratory of this nature. This is secured by means of a

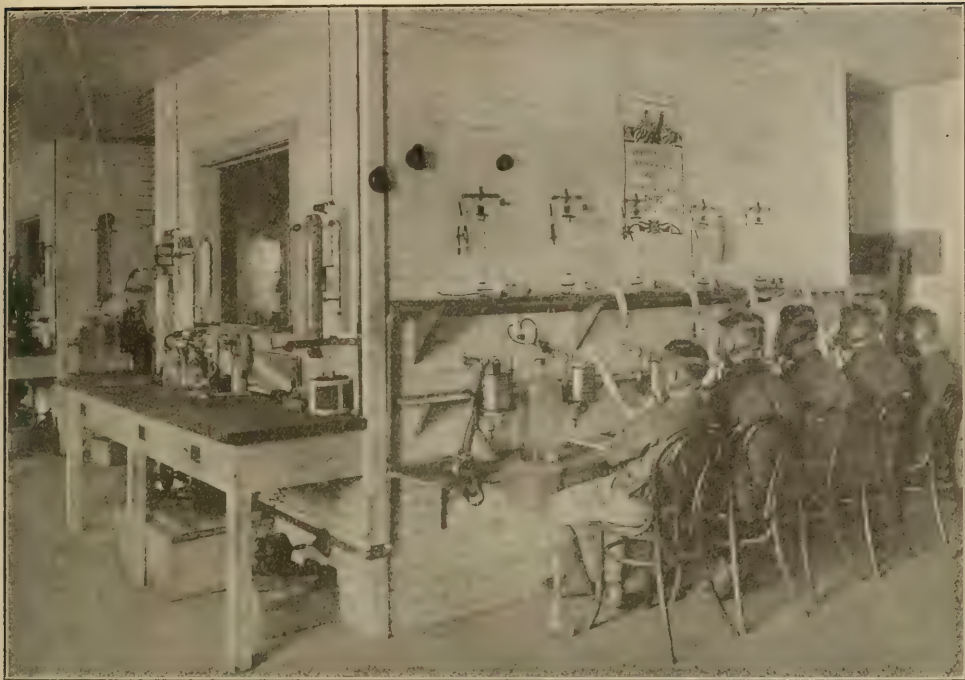


FIG. XI—INTERIOR OF MAN-TEST LABORATORY

6-ft. fan connected to suitable ducts (see Fig. X). The fan is mounted on a heavy framework outside and at one end of the building. The fan is driven at a speed of about 250 r. p. m. by a 10-h. p. motor. The main duct is 33 in. square and branches off into nine smaller ducts, each 16 in. square, extending to all parts of the building. A connection is also made to a small hood used when making chemical analyses.

The gases, fumes, etc., drawn out by the fan, are forced up and out of a stack 30 in. in diameter, extending upward 55 ft. above the ground level.

The stationary laboratory tables are provided with the usual facilities for making chemical analyses, and extend along one side of the building directly opposite the gas chambers. Here the analytical work necessary in controlling the concentration of the gas in the chambers is performed.

The main features of each of the three gas chambers are identical. Auxiliary pieces of apparatus are used with each chamber, the type of apparatus being determined by the characteristics of the gas employed. The features common to all chambers will be described first, and then the special devices will be set forth.

FEATURES COMMON TO ALL CHAMBERS—Each chamber is 10 ft. long, 8 ft. wide, and 8½ ft. high, having, therefore, a capacity of 680 cu. ft. or 19,257 l. (see Fig. XII). The floor is of concrete, and the walls and ceiling are constructed on a framework of 2 × 4 in. scantling, fin-

ished on the outside with wainscoting and on the inside with two layers of Upson board (laid with the joints lapped) covered with a ½ in. layer of special cement plaster laid upon expanded metal lath. The interior finish is completed by two coats of acid-proof white paint. The single entrance to the chamber is from outside the laboratory, and is closed by two doors, with a 36 × 40 in. lock between them. These doors are solid, of 3-ply construction, 2½ in. thick, with refrigerator handles, which may be operated from either inside or outside the chamber. The door jambs are lined with ¾ in. heavy rubber tubing to secure a tight seal.

At the end of the chamber opposite the doors, a pane of ¼ in. wire plate glass, 36 × 48 in., is set into the wall, and additional illumination may be secured by 2 headlights, 12 in. square, set into the ceiling of the chamber and of the air-lock, respectively, and provided with 200-watt Mazda lamps and Holophane reflectors. Beneath the large window, a heavy built-in table, 24 in. wide, extends across the width of the chamber outside, for holding sampling devices or any other apparatus necessary for the tests. Openings into the chamber, five in number, are spaced across this end beneath the window and 9 in. above the table top. Two of these openings are of 1½ in. pipe and the remaining three of 1 in. pipe threaded on the exterior to receive connections. Beneath the tables

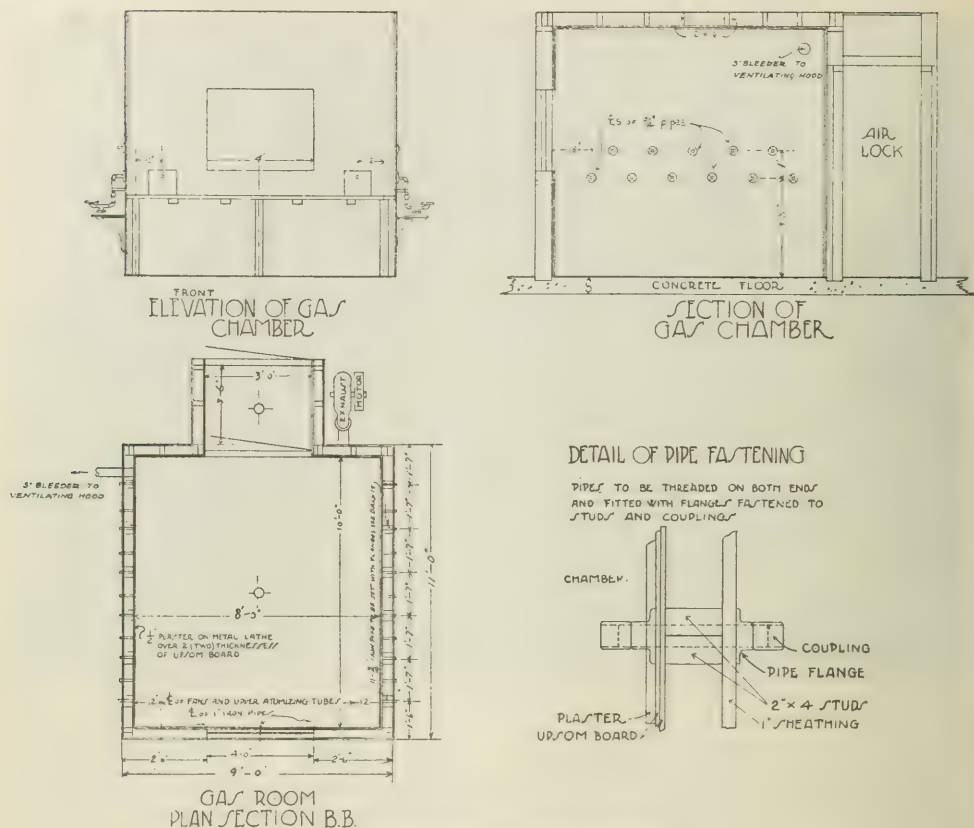


FIG. XII—ELEVATION AND PLAN OF GAS CHAMBERS

are installed fan motors and an air pump for producing either pressure or vacuum in the chamber. The fans for keeping the concentration uniform, two for each chamber, are 16 in. in diameter, 6-bladed, mounted in adjacent corners opposite the door; their shafts, running through stuffing boxes, are coupled directly to small $1\frac{1}{8}$ -h. p. motors having a speed of 1725 r. p. m. and mounted under either end of the table outside the chamber. Between these is placed a Leiman (size B) air pump, driven by a $\frac{1}{2}$ h. p. motor and delivering 10 cu. ft. air at a speed of 600 r. p. m. An expansion tank is provided, and, by means of suitable connections, either the intake or exhaust of the pump may be applied to the chamber. These pumps are employed for a number of purposes to be described later.

The arrangements for attaching the canisters to be tested are adaptable to a large variety of types of canisters. Fig. XIII shows the device used for the standard army canisters. Along both sides of the chamber the wall is pierced, at a height of 44 in. from the floor, by a series of $\frac{3}{4}$ -in. pipes (six in all) spaced 18 in. apart and extending about 3 in. through

the wall. On the exterior of the chamber the pipes are bent downward, then horizontally, and finally upward, terminating in a flat plate, A, of lenticular outline. At the proper distance apart to permit the adjustment of a canister between them, two threaded $\frac{1}{4}$ -in. rods, F, F, extend upwards for $8\frac{1}{2}$ in. through the plate, and are provided with wing nuts. To attach the canister, a $\frac{1}{4}$ in. rubber gasket of the proper shape is laid on the flat plate, the canister placed upon it, and a yoke, B, of $\frac{1}{8}$ -in. sheet steel laid across the top; then, by turning down the wing nuts, the canister is pressed on the gasket until an air-tight fit is secured. As the vertical rods are threaded for $4\frac{1}{2}$ in. of their length, standard type cans of any height from $8\frac{1}{2}$ in. down may be accommodated. Small wooden blocks are placed under the yoke when very short styles are tested. For the standard oval-bottom canister with its circular central opening, a simple circular gasket suffices, but by providing several sets of oval gaskets large enough to engage the periphery of the canister, and with central openings of different sizes, it has been found possible to accommodate many experimental types. Short, cylindrical canisters of the

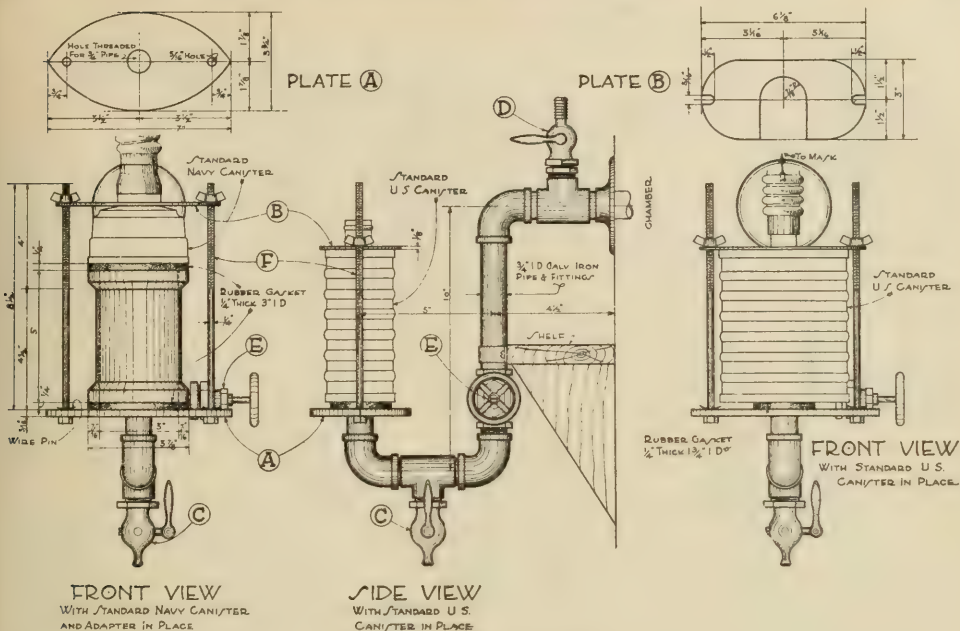


FIG. XIII—DETAILS OF CANISTER HOLDER

German type are attached by means of a cylindrical adapter (Fig. XIII) of heavy iron piping 5 in. high and of the same diameter as the canister. As shown in the figure, the adjustment is the same as for standard types, an additional gasket being inserted between the canister and its adapter. A gate valve, E, set in the piping allows the connection with the gas chamber to be shut off at will and prevents the escape of gas when no canisters are in position. At the lowest point in the bend of the piping, a small petcock, C, is inserted for draining off any liquids which may condense in the tubes. Three of the pipes on each side of the chamber have an additional petcock, D, attached just where they emerge from the wall. These are used for aspirating samples of the gas for analysis, the samples thus obtained being as nearly representative as possible of the concentration inhaled into the canisters. For convenience in collecting samples, two shelves are placed along the sides of the chamber (Fig. XII): a large one, 14 in. wide and 27 in. from the floor for holding the large aspirating bottles, and another 4 in. wide and 12 in. higher up, for holding the gas-washing cylinders in which the samples of gas are absorbed. The larger shelf is used also for holding the papers and magazines provided for the use of men taking the tests.

The obvious advantage of the bracket arrangement described above is that the canisters may be attached or changed at will, without any necessity for disturbing the concentration of gas by entering the chamber to make these adjustments. However, if it is necessary

that canisters should be attached inside the chamber, this is provided for by a second series of $\frac{3}{4}$ in. pipes, five on each side, set in at a height of 56 in. from the floor and spaced 18 in. apart, alternating with those of the lower series. These pipes merely extend through the wall and terminate in smooth nipples, 3 in. long, the attachment to the canisters being completed by lengths of flexible tubing. Connections outside the chamber are made in similar fashion with flexible rubber tubing, the tubes being tightly stoppered when not in use. Practically all styles of canisters may be tested inside the chamber by this means.

Arrangements for removing the gas from the chamber consist of a small "bleeder" which allows a continuous escape of small amounts, and a large blower for rapidly exhausting the entire contents of the chamber. The bleeder is $2\frac{1}{2}$ in. galvanized pipe connected with the chamber at one corner near the ceiling. It is fitted with a gate valve and empties into a duct connecting with the large fan which constantly creates a strong draft up the stack at one end of the laboratory. The blower, a Sirocco No. 2, is connected with the chamber at one corner near the floor (Fig. XII) by a 6 in. pipe provided with a gate valve. The blower is driven by a $\frac{3}{4}$ h. p. motor at a speed of 700 r. p. m. It is connected so that it draws the gases out of the chamber and delivers them to the large ventilating fan through a separate duct to avoid the corrosive action of the gas on the entire ventilating system.

A sensitive U-tube water manometer with an in-

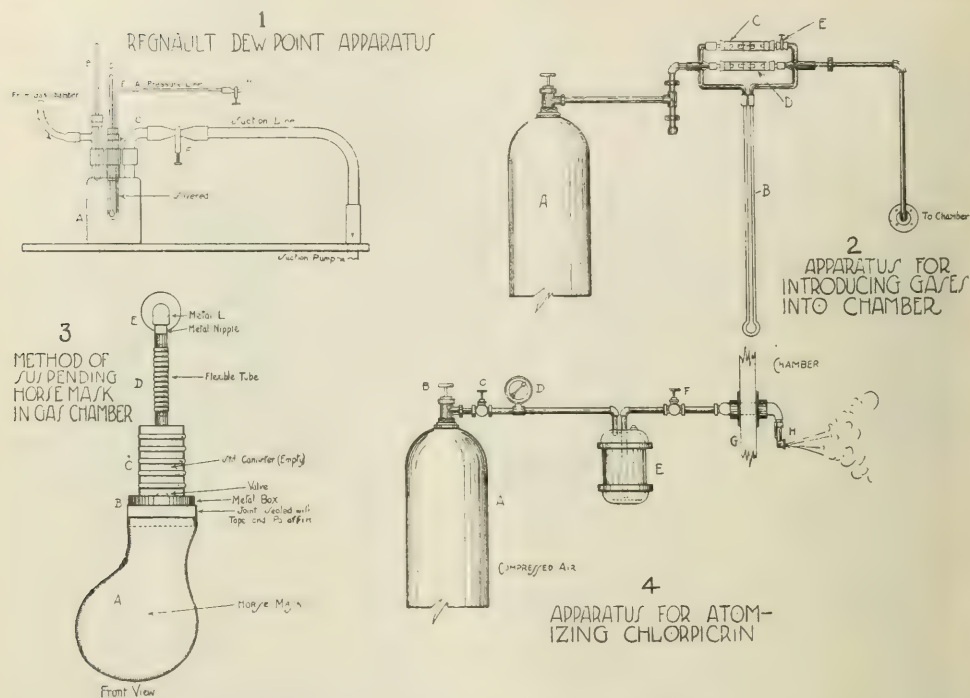


FIG. XIV—APPARATUS FOR INTRODUCING GASES AND DETERMINING DEW POINT

clined arm is connected with the chamber mounted on the wall beneath the window. It records either pressure or suction, and may be read directly to tenths of an inch of water. When running tests, the usual procedure is to open the gate valve of the bleeder until the manometer indicates a pressure within the chamber very slightly less than that of the air outside, thus preventing leakage of the gases out into the laboratory. The gate valve of the large blower is kept tightly closed except when clearing out the chamber after a test.

Other general features of the equipment of each chamber deal with the determination of the physical conditions surrounding the tests, often a matter of considerable importance. The temperature of the gas inside the chamber is easily ascertained by means of a thermometer suspended inside the window in such a position as to be read from the outside. The relative humidity of the mixture of air and gas in the chamber is determined by means of a somewhat modified Regnault dew point apparatus (see Fig. XIV-1) mounted on the built-in table. This apparatus consists of a 3-necked Wolf bottle, A, one opening of which is connected directly to the interior of the chamber and another to the intake pipe of the air pump beneath the table, so that by regulating the valve F, a steady stream of the air-gas mixture may be drawn through the bottle. A thermometer, B, measures the temperature of the mixture as drawn

from the chamber. The central opening of the bottle is closed by a thin-walled test-tube, C, which has been silvered on the inside for a distance of about $1\frac{1}{2}$ in. from the bottom. A second thermometer, D, extends down into this tube, also a small glass tube, E, drawn out to a capillary and connected to the pressure line of the pump. To operate the apparatus, the test-tube C is partly filled with ether, and the valve F opened, drawing in air and gas from the chamber. Air from the pressure line E is then blown through the ether until it is cold enough to produce a deposition of moisture on the surface of the test-tube, easily visible against the silvered background. The thermometer D immersed in the ether gives a dew point temperature, and the thermometer B the temperature of the air-gas mixture entering the bottle, from which data the relative humidity may be calculated, using the tables furnished in Bulletin 235, of the U. S. Weather Bureau.

It is necessary that the test-tube should be silvered on the inside, as the gases would quickly tarnish the mirror if placed on the outside. The tendency of the bubbling ether to mechanically strip off the thin layer of silver is prevented by protecting it with a very thin coat of water glass (sodium silicate). The apparatus is frequently checked against readings made in the chamber, using a standard sling psychrometer.

SPECIAL APPARATUS HUMIDIFIER—Other items of

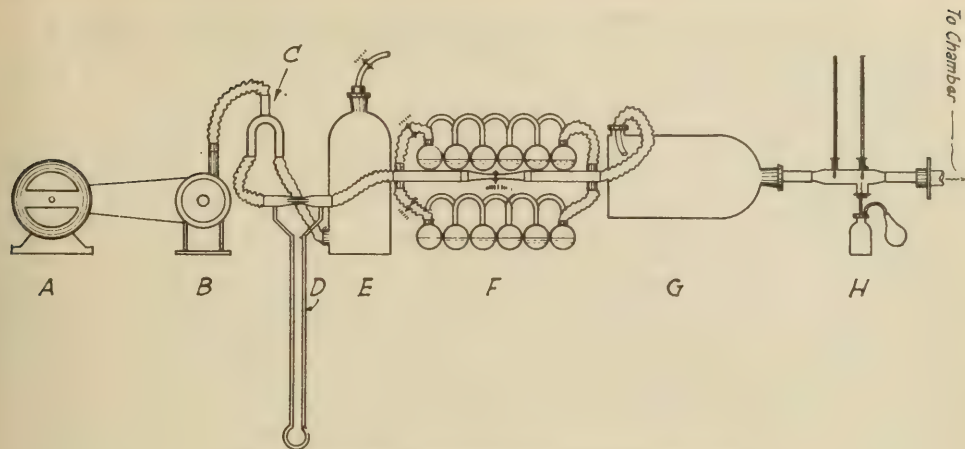


FIG. XV—APPARATUS FOR CONTROLLING HUMIDITY OF AIR IN GAS CHAMBERS

general equipment for the laboratory include a device for humidifying or drying air (Fig. XV) which may be attached to any of the pumps for delivering air of any desired degree of humidity to the chambers. Half the tubes are filled with distilled water, and the other half with concentrated sulfuric acid; by means of a set of clamps, the air from the pump may be sent directly into the chamber or may be shunted through either the drying or moistening tubes, giving a range of from 10 per cent to 90 per cent relative humidity. A wet-and-dry-bulb thermometer installed in the line affords a constant check on the moisture content of the air being forced into the chamber.

PRESSURE DROP AND LEAK DETECTING APPARATUS—Another piece of apparatus consists of a combined pressure drop machine and leak tester (Fig. XVI) for measuring the resistance of canisters and testing them for faulty construction. This is mounted on a small table, with the motor and air pump installed on a shelf underneath. The resistance, or pressure drop, of canisters is measured by the flow meter A and the water manometer B. Air is drawn through the canister and the flow meter A at the rate of 85 l. per min., the flow being adjusted by the needle valve. The pressure drop across the canister is read on the water manometer B, one end of which is connected to the suction line, the other open to the air. The reading is generally made in inches, correction being made for the resistance of the connecting hose and the apparatus itself.

Canisters are tested for leaks by the apparatus shown at D in Fig. XVI. The canister is clamped down tightly by wing nuts against a piece of heavy $\frac{1}{4}$ -in. sheet rubber large enough to cover completely the bottom of the canister and prevent any inflow of air through the valve. Suction is then applied, and a leak is indicated by a steady flow of air bubbles through the liquid in the gas-washing cylinder E. A second gas-washing cylinder, empty, is inserted in the line between E and the canister as a trap for any liquid

drawn back when the suction is shut off. If a leak is shown, it is located by applying air pressure to the canister and then immersing it in water.

In addition to the general equipment so far described, the several chambers are fitted with certain devices for aiding in the particular work for which they are used. These can perhaps best be described by explaining the methods followed for handling the gas most commonly employed in each chamber, although the procedure is typical of a class in every case, except for slight variations.

DETONATION OF SOLIDS AND LIQUIDS—The chamber at the east end of the house is used for those gases

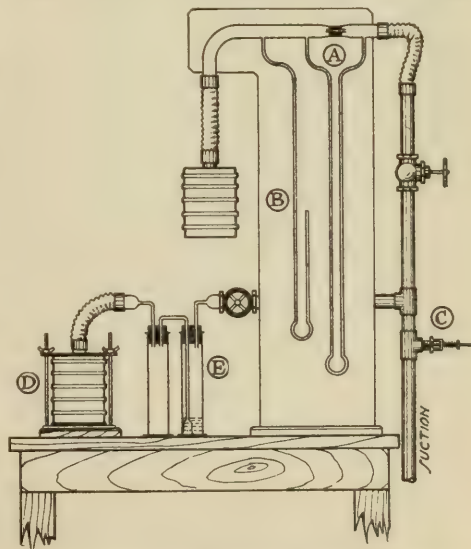


FIG. XVI—APPARATUS FOR DETERMINING PRESSURE DROP AND FOR DETECTING LEAKS IN CANISTERS

whose concentrations are secured by detonating small amounts of the solid or liquid substances. Typical of this class is diphenylchlorarsine. The concentration of this compound is secured by detonating the solid substance, using No. 6 electric detonators enclosed in the gelatin capsules containing the solid. At the beginning of a test, a calculated weight of diphenylchlorarsine sufficient to give the desired concentration is detonated, and every 10 min. thereafter an additional amount of the substance is detonated to reinforce the concentration. Five of these reinforcements are made at 10-min. intervals, and the test allowed to run 10 min. after the last detonator is exploded. Tests of this nature are usually run for 1 hr. The weights necessary to produce the desired concentrations are calculated from the gram-molecular volume of the substance, assuming that a gram-molecular weight of any substance in true gaseous form occupies 24.45 l. under average laboratory conditions.

The gelatin containers holding the compounds to be detonated are No. 10 veterinary capsules of 1 oz. capacity.

The detonators are placed directly inside the capsules, the lids being perforated by melting a hole through the gelatin, using a heated iron rod. A small loop is made in the lead wires just above the blasting cap. This serves to hold the capsule snugly up against the detonator. After the two halves of the capsule have been fitted together, they are held by a short strip of adhesive tape to prevent the jar of other explosions from knocking them apart. Fig. XVII-1 illustrates the appearance of a filled capsule and its detonator ready for use.

In order to protect the chamber walls, canisters, connecting hose, etc., from flying particles of the fulminate caps, which are driven off with great force, guards are provided, a separate one for each detonator, or six in all. These are made of 12-gauge sheet iron (nothing lighter will do) and are constructed as shown in Fig. XVII-2. They are strung on a wire extending through the middle of the chamber from the top of the door casing to the casing of the window opposite, being spaced about 15 in. apart and at the same height from the floor as the canisters to be tested, *viz.*, about 50 in. A system of permanent wiring connects the guards with the exterior of the chamber. Small insulated binding posts mounted on the upper sheet-iron discs make it possible to use short leads (18 in.) on the detonators, and to replace exploded ones rapidly and easily. Outside the chamber the wires connect with small insulated copper plates fastened to the wall and numbered to correspond with numerals painted on the detonator guards, so that the capsules may be detonated in any desired order. Fig. XVII-3 illustrates the method of wiring used.

SUBSTANCES GASEOUS AT ORDINARY TEMPERATURES—
The middle chamber is used for those substances which are gases at ordinary temperatures and may be introduced into the chamber directly from the ordinary steel storage cylinder. Phosgene is the one most commonly used, and the description of the methods

employed for this gas may be taken as typical of the class. The special equipment of this chamber consists of flow meters particularly designed for getting up and maintaining the desired concentration. These flow meters are permanently attached to the wall, one on either side of the large window. They are constructed almost entirely of iron and copper piping and of glass tubing, joined either by solder or hard De Khotinsky cement, rubber connections being used only where indispensable. The arrangement of the larger flow meter is shown in Fig. XIV-1. It is constructed mainly of $\frac{1}{4}$ -in. iron piping, with a union (not shown) for the rapid replacement of exhausted cylinders. A gas cylinder is shown in position at A; it is 4 ft. high and 10 in. in diameter. The long U-tube B for measuring level differences is of glass, as are the tubes holding the capillaries C and D. It will be noticed that the apparatus has two capillaries, the upper and larger of which, C, may be closed off at will by means of the clamp E. The other capillary, D, is much finer and gives a much smaller flow of gas for the same level difference in the U-tube. When getting up the initial concentration, both capillaries are open and the gas feeds in rapidly; after the approximate concentration desired has been reached, the larger capillary, C, can be shut off and a small, steady flow of gas maintained through the smaller one, D. For still finer adjustments, a second flow meter of very small capacity is built against the wall on the opposite side of the window. This one has connections of $\frac{1}{8}$ in. piping, and is coupled by a union to a small 14 × 4 in. phosgene cylinder held in rigid bracket attached to the wall and resting on a small electric hot plate, as it is sometimes necessary to warm the cylinders to secure sufficient pressure. The larger tank is warmed, in cold weather, by means of a gas flame. The U-tubes of both flow meters are filled with "Usoiline," an inert material oil not affected by phosgene. With gases like chlorine, no heating of the cylinders is necessary.

In running tests with phosgene, the initial concentration is obtained by feeding in the gas through the large flow meter with both capillaries open; then a steady stream of both air and gas in the desired proportion is fed into the chamber continuously in an amount somewhat in excess of that removed by the men inhaling through the canisters. The Leiman pump mounted beneath the table delivers air through a flow meter into the chamber at the rate of 125 l. per min., while at the same time one or the other of the phosgene tanks is feeding in gas at the proper rate to give the concentration desired. The piping of both tanks is so arranged as to deliver the gas into the chamber just above the air inlet from the pump, insuring rapid mixing. As the canisters are usually tested in lots of ten at a time, and the average breathing rate of a man is about 8 l. per min., it will be seen that a considerable excess of air and gas is being constantly forced into the chamber. This excess is taken care of by the bleeder which carries the surplus mixture off into the stack. The manometer is used to assist in regulating the gate valve until the pressure

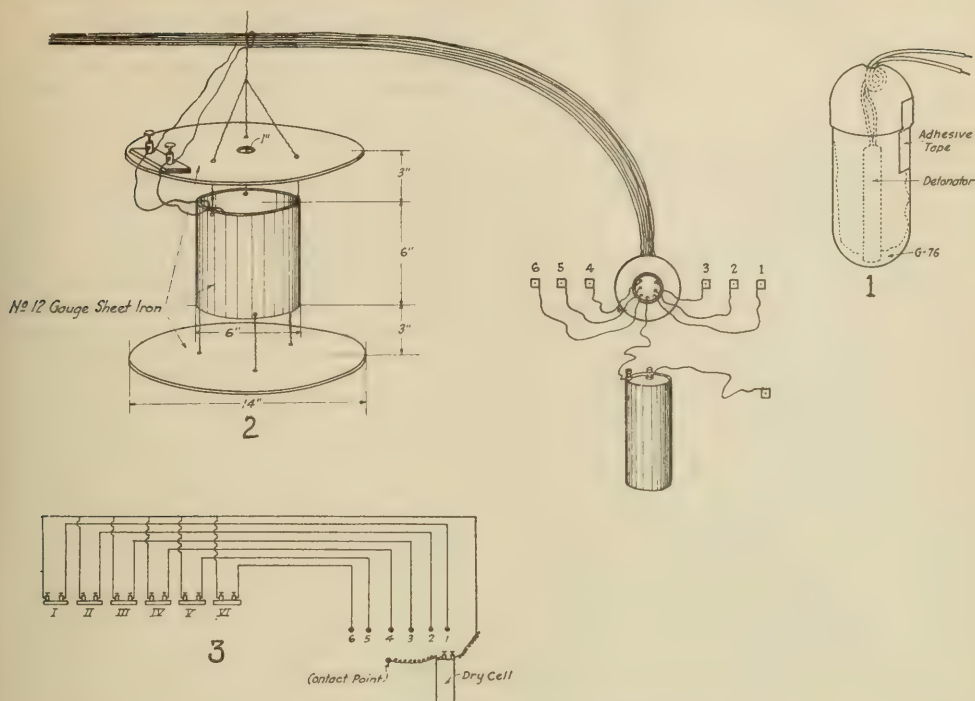


FIG. XVII—APPARATUS FOR DETONATING SOLID AND LIQUID SUBSTANCES

inside the chamber is very slightly less than that of the air outside. This prevents leaks.

SUBSTANCES LIQUID AT ORDINARY TEMPERATURES—
The chamber at the west end of the laboratory is used for putting up concentrations of substances which are in a liquid form under ordinary conditions. This is accomplished by spraying or atomizing them in the chamber. Some atomizers have been specially constructed for the purpose. They have a large capacity and are made of glass. The nozzles are extra long (12 in. or more), extending through the wall and well into the chamber. These atomizers are operated by means of a foot bellows or an automobile foot pump. However, for atomizing chlorpicrin, which is the liquid most commonly used, an apparatus has been devised using compressed air, which works very successfully.

The same apparatus can be used for many other liquids. The arrangement is shown in Fig. XIV-4. A is a tank holding air at a pressure of 1800 lbs. per sq. in. controlled by valve B and a needle valve, C, of more delicate adjustment. The container for chlorpicrin, E, is made of a short section of pipe capped on both ends, with connections as shown. The gauge D indicates the pressure in the apparatus. The ball valve F allows the chlorpicrin to escape into the chamber through the nozzle H which is from an ordinary orchard sprayer and works on the centrifugal principle. To operate, the measured amount of

chlorpicrin is introduced into the container E, through a small hole at the top, which is then tightly closed by means of a screw plug. The ball valve F is closed and valve B opened; then by means of the needle valve C the pressure in E is raised to 150 lbs. per sq. in., as indicated by gauge D. The needle valve is then closed and valve F opened, whereby the chlorpicrin is expelled into the chamber in the form of a fine mist. The concentration is kept up by successive small amounts atomized at regular intervals or by a continuous flow of air and chlorpicrin in the proper proportions, as in the case of phosgene.

UNIFORMITY OF GAS CONCENTRATION—To test the efficiency of the fans in keeping a uniform concentration, a survey has been made of one of the chambers, using a concentration of approximately 11,000 p. p. m. of chlorine. After thorough mixing by the fans, 2 l. of the air-chlorine mixture were aspirated through each of the sampling tubes in order to displace all air in the tubes and connections, with the mixture to be analyzed. The absorption cylinders were then attached, and 1 l. samples of the contents of the chamber aspirated through them simultaneously at the rate of 1 l. per min. The analyses are given below. Samples 1 and 4 were taken near adjacent corners nearest the window, and almost directly over the fans; Samples 2 and 5 from the middle of each side; and Samples 3 and 6 from near the corners nearest the door and farthest from the fans.

SAMPLE No.	CONCENTRATION P. p. m.
1.....	11,325
2.....	11,300
3.....	11,230
4.....	11,315
5.....	11,275
6.....	11,225
MEAN.....	11,278

The maximum variation from the mean was 53 p. p. m., or 0.5 per cent. It is assumed, therefore, that the concentration is practically uniform in all parts of the chamber.

METHODS OF CONDUCTING TESTS—Three general methods of conducting man tests are followed:

(1) Canisters are placed in the brackets outside the chamber or fastened to the wall tubes within the chamber. The subjects of the test remain outside the chamber, and the facepieces of the masks are connected directly to the canisters, in the first case, and to the wall tubes connecting with the canisters, in the second case. The concentration is established and the time noted. Then the men put on the masks and breathe until they can detect the gas coming through the canisters. Reading matter is provided for the men during the test period. When gas is detected, the time is again noted and the time required for the gas to penetrate the canister is reported as the "time to break down" or "service time" of the canister. Ten canisters are tested at one time, and the average of the results for the 10 canisters is taken for that type of canister. Much less accurate results are obtained when the final figure is based on a small number of canisters. This is largely due to the various breathing rates and sensitivities of different men.

(2) The canisters are placed as in (1), but it is only necessary to know if they will give perfect protection for a given length of time. The procedure is the same as in (1), except that the test is arbitrarily stopped at the end of the indicated time, and the number of canisters and the service times of the same noted.

(3) When the canisters are of such a type that they cannot be properly tested as in (1), or when it is desired to test the penetrability of the facepiece, the men wear the complete mask and enter the chamber. They remain until gas penetrates the canister or the facepiece, as the case may be, or until it is determined that the desired degree of protection is afforded. The service time is computed as in (1).

(4) Maximum-breathing-rate tests are made either by men in the chamber or by the men outside, in which they do vigorous work on a bicycle ergometer. In this test the average man will run his breathing rate up to 60 or 70 l. per min.

The concentration of the gas is followed throughout the test by aspirating samples and analyzing them.

TYPE OF MASKS USED—In general, the following procedure holds, although variations occur in special cases:

When men enter a gas chamber, the full facepiece is, of course, required. The type of facepiece will be determined by the nature of the gas. If the gas is most easily detected by odor or eye irritation, a modified Tissot mask is used. If it is most easily detected by throat irritation, a mouth-breathing mask is employed.

When men are outside the chamber, the choice is made in the same manner, except in the case of detection of the gas by throat irritation. In this case the mouthpiece is attached to two or three lengths of breathing tubes and a separate nose-clip is used. The facepiece is not needed and the men are much more comfortable without it.

DISINFECTION OF MASKS—Mouthpieces are disinfected after use by first holding them under a stream of running water and brushing out thoroughly with a test-tube brush; then the latter is dipped into a 2 per cent solution of lysol, and the inner parts of the mouthpiece are brushed out well; finally the mouthpiece and exhaling valve are dipped bodily into the lysol solution and allowed to dry without rinsing. Tissot masks are wiped out with a cloth moistened in alcohol, followed by another cloth moistened in 2 per cent lysol solution. The flexible tubes are given periodic rinsings with 95 per cent alcohol.

APPLICABILITY OF MAN TESTS—Man tests are applicable to all gases which can be detected by the subject of the test before he breathes a dangerous amount.

The man test laboratory described in this report provides facilities for getting information concerning the efficiency of canisters, facepieces, etc., within very short periods of time, without waiting for the construction of special apparatus required for machine tests. To get satisfactory results from machine tests, a delicate qualitative chemical test for the gas is essential. Man tests can be made when such a qualitative test is not known. Further, man tests can be made with higher concentrations of some gases than is practicable with machines. Evolution of excessive amounts of moisture when high concentrations of some gases are used causes much more trouble with machine tests than with man tests.

On the other hand, man tests are adversely affected by the varying sensitivities and lung capacities of the men, and the humidity of the air-gas mixture is not subject to as exact control as is the case with machine tests.

The development of the foregoing methods was started by the Bureau of Mines in April 1917, immediately after this country entered the war. At that time no information whatever was available on how to grade and test gas-mask absorbers, or the masks themselves. The early development work was done in the Bureau of Mines Gas Laboratory at the Pittsburgh Station, and, as a matter of fact, most of the methods were completely worked out before any information from abroad became available.

While many improvements were made after interchanging information with the British and French laboratories, the methods remained essentially the same as originally devised. Subsequent improvements were mainly along the lines of greater standardization, more rapid manipulation, and extending the tests to all sorts of new gases.

ORIGINAL PAPERS

COMMERCIAL OXIDATION OF AMMONIA TO NITRIC ACID¹

By CHARLES L. PARSONS

Received May 8, 1919

It is realized by all chemists and all economists that there is no more important problem before the world, both for the production of food in time of peace and of munitions in time of war, than the fixation of atmospheric nitrogen. All civilized countries are deeply interested and many are actively engaged in scientific and industrial research for its solution.

There are two distinct methods of procedure: One is to produce the combined nitrogen primarily in the form of nitrates, the other is to obtain it directly or indirectly in the form of ammonia. The methods which produce nitric acid without first producing ammonia, while applicable to the production of munitions, do not lend themselves readily to the production of fertilizers in a form acceptable to the agriculturist and are, therefore, subject to great economic disadvantage in time of peace. Those which first produce ammonia, or from which ammonia and ammonia compounds can readily be obtained, are particularly applicable to use as fertilizers and have distinct commercial advantages. As immense sums for construction and maintenance of plants are involved, it therefore becomes almost a necessity to base the production of fixed nitrogen on some process which yields ammonia. Accordingly if nitrogen fixation plants used for fertilizers in time of peace are to be depended upon for munitions in time of war, some method for converting ammonia into nitric acid, essential to all explosives, is imperative. This paper, therefore, deals with the methods and apparatus which have been used or are being used for the oxidation of ammonia to nitric oxide which, absorbed in water, yields nitric acid.

The importance of the oxidation of ammonia to nitric acid was early realized in the United States. North America has no resources of natural nitrates, but the United States does produce and has produced large quantities of ammonia as a by-product in the coking of coal. Although other sources of nitrates were available for war, it was, nevertheless, imperative to be able to utilize by-product ammonia, should America be cut off from Chile. Statements had been made broadcast in this country that coal-tar ammonia could not be successfully oxidized on account of impurities. Accordingly two months previous to the passage of the National Defense Act of June 3, 1916, the Secretary of the Interior had, on April 7, 1916, offered to the Secretary of War the aid of the Interior Department in any capacity that would be useful in the study of methods and materials necessary for large-scale manufacture of nitrogen products. During April and May 1916, the writer had several informal conferences with officials of the War Department and on June 6, 1916, by request of Brig. Gen. William Crozier, made a

tentative report on the fixation of atmospheric nitrogen by methods then known. As a result of recommendations then made, an agreement was signed on August 10, 1916, whereby the Smet-Solvay Company, in cooperation with the Bureau of Mines and with the approval of General Crozier, undertook to erect at Syracuse a plant to demonstrate whether by-product ammonia could be successfully oxidized on a commercial scale to nitric acid. It was through this agreement that the writer became interested in ammonia oxidation.

HISTORICAL RÉSUMÉ

It is not the purpose of this paper to go extensively into the literature of ammonia oxidation. Those interested in detail will find excellent bibliographies on the subject.¹ The discovery of the general principle of oxidation of ammonia belongs to Kuhlman, a French chemist, who as far back as 1839² found that ammonia could be oxidized to nitric acid and that platinum, as well as other metallic and non-metallic substances, would catalyze this reaction. At that time, however, there was no possibility of commercially applying the process and it remained for Wilhelm Ostwald to study and develop the reaction for commercial purposes.³ While Ostwald obtained patents in foreign countries, such as France, England, Switzerland, and America, he was unable to hold them in Germany on account of Kuhlman's former work and the process was, therefore, developed as a secret one in his own country. As early as 1909 a small plant was installed at Gerthe in Westphalia for the conversion of by-product ammonia into nitric acid, using platinum as a catalyzer. This plant continued operations at least until 1913 for in 1912 and 1913 it paid dividends to its stockholders. A second plant using the Ostwald process was erected at Vilvorde, Belgium, by an English company. The first published sketch of an ammonia oxidizing plant with estimates of cost⁴ probably refers to this plant and its operations. The Vilvorde plant was erected in the chemical products factory of M. Duché, a Frenchman who was president of the French Chamber of Commerce of London. This plant was captured by the Germans early in the war but neither it nor the plant at Gerthe, nor indeed the Ostwald process as developed by Ostwald, appear to have been used to any extent during the war in Germany itself. The process used at Vilvorde was installed during the war at Angoulême, France, and Dagenham, England. The writer visited both of these plants in October and November 1916. The general features of this process are now known and were first publicly described by W. S. Landis in a lecture given before the Electrochemical Society in New

¹ Helen R. Hosmer, "Literature of Nitrogen Industries, 1912-1916," *THIS JOURNAL*, 9 (1917), 424; John C. Boyce, "Bibliography of the Production of Synthetic Nitric Acid and Synthetic Ammonia," *Met. & Chem. Eng.*, 17 (1917), 228.

² *Ann.*, 29 (1839), 281.

³ Berg, u. Hüttenm. Rundschau, 3 (1906), 71; also, Schmidt u. Böcker, *Ber.*, 1906, p. 1366.

⁴ *Iron and Coal Trades Review*, May 23, 1913.

¹ Paper read before the Washington Section of the American Chemical Society, May 8, 1919.

York on April 3, 1919.¹ The plant is made up of a large number of small units, in principle much the same as described in Ostwald's original patent and illustrated in Fig. 1.

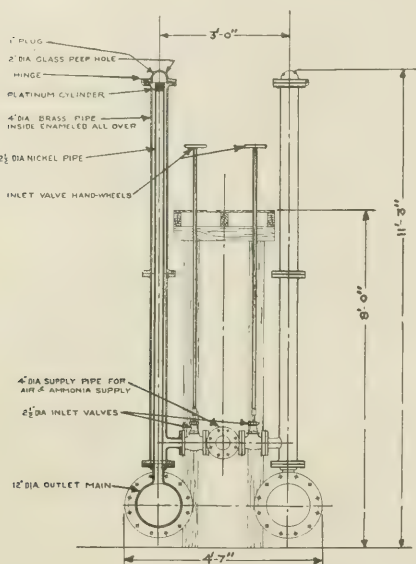


FIG. 1—OSTWALD METHOD. DOUBLE UNIT

The mixed gases pass up the outer tube, being preheated by the hot inner nickel tube, so that they come in contact with the platinum catalyzer at a temperature not far from 600° C. The mixed gases come in contact with the only known materials, namely, nickel and silica lining, which will withstand the temperature necessary and also themselves have little decomposing effect on the ammonia previous to its coming in contact with the platinum catalyst. The inner tube might be constructed of aluminum to even better advantage, if the aluminum would only withstand the temperatures involved, as nickel does have a tendency to decompose ammonia even at 500°. The plant at Angoulême produced many thousands of tons of nitric acid during the last years of the war, but is reported to have been severely handicapped in its efficiency by the phosphine present in the ammonia used. During the later years of the war the reason for the low results was found and by blowing out the phosphine from the autoclaves the efficiency of the plant was very greatly increased.

Dr. Karl Kaiser, a professor in the University of Heidelberg, had patented previous to the war a modified method of procedure for oxidizing ammonia and had installed a small plant at Spandau, near Berlin. This plant, as early as 1912, was operating on an experimental basis and was shown during that year and 1913 to representatives of French and American firms with an idea of its adoption in these countries. The

process consisted essentially of a cross section of platinum gauze placed in an iron pipe, the ammonia-air mixture being preheated by mixing hot air with ammonia just before it reached the catalyst, thus largely avoiding the decomposition of the mixed gases which takes place if they are passed through iron pipes at an elevated temperature. Very high efficiencies, much over 100 per cent, were claimed for this process, but the results obtained were found to be due to faulty methods of analysis. With modifications the process is capable of commercial application but cannot compete with more modern apparatus. It was apparently the first plant which used platinum in the form of platinum gauze. A discussion of the operation of this process and its capacity will be found in a controversy printed in *Chem.-Ztg.*, 1916, p. 14.

MODERN METHODS

It is interesting to note that while Germany knew she could successfully oxidize ammonia before she began the European war in August 1914, nevertheless the methods known at that time for the oxidation of ammonia do not appear to have been extensively used during the war itself. The war had scarcely begun when the Frank-Caro interests, representing the cyanamide industry, began extensive investigation on ammonia oxidation and also developed the commercial conversion of cyanamide nitrogen into ammonia gas in order that it might be used for the production of nitric acid. They gathered together near Berlin some of the best chemical engineers of Germany and of the Scandinavian countries. Fortunately, W. S. Landis, a representative of the American Cyanamid Company, was also present. He obtained much important information and secured autoclaves and other machinery which, in spite of great difficulty, he succeeded in bringing to this country. During the early part of 1915 he installed these autoclaves in an American munitions plant.

The Berlin Anhaltische Maschinenbau A. G., which obtained the rights to the Frank-Caro oxidation process, had already during 1915 installed some 30 projects of a yearly capacity of more than 12,000,000 kg. of ammonia and had in process of erection projects capable of oxidizing 17,000,000 additional kilograms.¹ The apparatus which they used in the early part of 1915 and which at that time was confined chiefly to the production of nitric oxide for sulfuric acid plants is described in detail, together with the method of operation, by Schuphaus.² It is hard to conceive how the German government could have allowed the publication of this article, for it gives all the essential details of the Frank-Caro process as first developed on a commercial scale. It is true that at the time of its publication (early 1916) the B. A. M. A. G. had already abandoned electric heating and were using a multiple gauze, as may be easily deduced from the discussion above referred to.³ But it is hard to conceive how the German government could have allowed the publication in such great detail of a method which,

¹ *Chem.-Ztg.*, 1916, p. 14.

² *Metal. u. Erz.*, [2] 13 (1916), 22

³ *Chem.-Ztg.*, 1916, p. 14.

¹ *Chem. & Met. Eng.*, 30 (1919), 471.

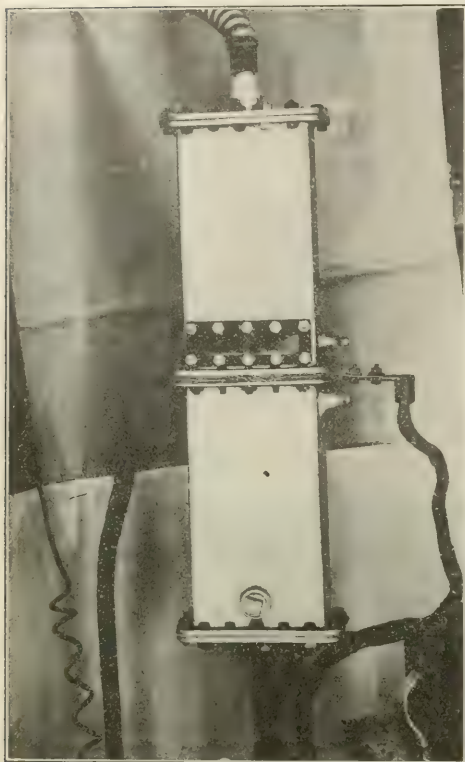


FIG. 5 - EXPERIMENTAL AMMONIA OXIDIZING APPARATUS ELECTRICALLY HEATED

Division was established some months later. The writer wishes to acknowledge the valuable assistance of all of these chemists and, without going into the details of their individual accomplishment, wishes to state that it was due to their efficient efforts that the work was successfully accomplished.

Before leaving for Europe to view the European operations, early in October, the writer, assisted by others, prepared general plans for the erection of a small plant at Split Rock near Syracuse. While this plant was being erected, experiments were directed chiefly to an attempt to develop a catalyzer, metallic or non-metallic, other than platinum. After three or four months' work with a large number of non-metallic catalyzers and some metallic gauzes, details of which will be published later, it was concluded to confine further work to platinum. Other materials, while hastening the reaction, worked with a lower conversion of ammonia to nitric oxide. All non-metallic catalysts, although some showed high efficiency, involved such high cost for material and construction of apparatus that their use was found to be impracticable. The writer is still of the opinion that although non-metallic catalyzers are known which will

give high efficiency and which are extremely cheap in themselves, nevertheless the large amount of material that has to be used, the consequent size of the apparatus that has to be constructed, the labor cost of installing the catalyzer and removing it when it deteriorates, the difficulties of granulation and of avoiding local overheating will even with the cheapest catalyst render it uneconomical when platinum can be procured. The platinum used for catalysis is chiefly a capital charge, as most of it can be recovered and reworked into new gauze whenever such recovery becomes necessary. Its effective life, the smallness, cheapness, and simplicity of the apparatus, its high efficiency, and its ease of replacement will probably maintain platinum as by far the best catalytic agent for ammonia oxidation.

Much detailed information was obtained from the

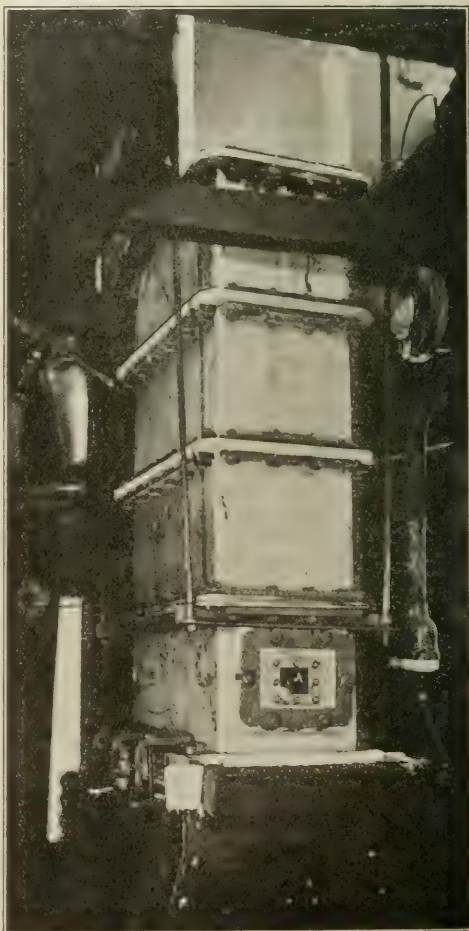


FIG. 6 - AMMONIA OXIDIZING APPARATUS OF LANDIS TYPE

laboratory. A small, electrically-heated converter, having a platinum gauze with an exposed 3×6 in. gauze surface, was used to determine in the laboratory many of the factors having to do with ammonia oxidation. This apparatus is illustrated in Fig. 5. An experimental apparatus similarly constructed and patterned from memory on the apparatus used in the Warners, N. J., plant was built at Syracuse in connection with the necessary cooling and absorption towers. It was first electrically-heated, using various sizes of platinum gauze, the gauze itself being 13×26 in., of which 12×24 in. were effective, the balance being taken up between the sheets of the asbestos insulation. The gauze finally adopted was of 80-mesh, 0.0026 in. wire, the electricity for heating being carried to the apparatus by silver tubes 13 in. long at each end of the gauze. The apparatus worked well and it was early determined that, with the high "A" grade by-product ammonia furnished by the

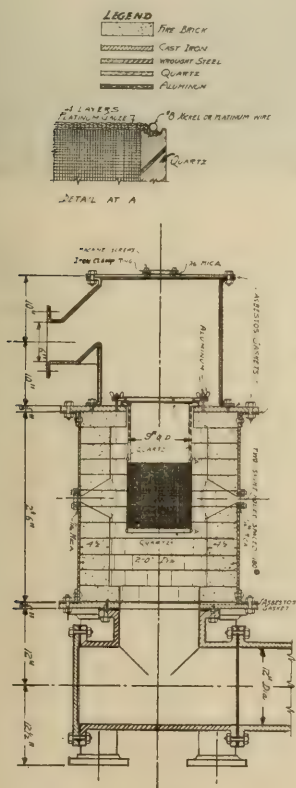


FIG. 7

Semet-Solvay Company, there was no difficulty whatever in oxidizing ammonia with this apparatus at a high degree of efficiency. It seemed best early in the work to do away with the electrical heating altogether

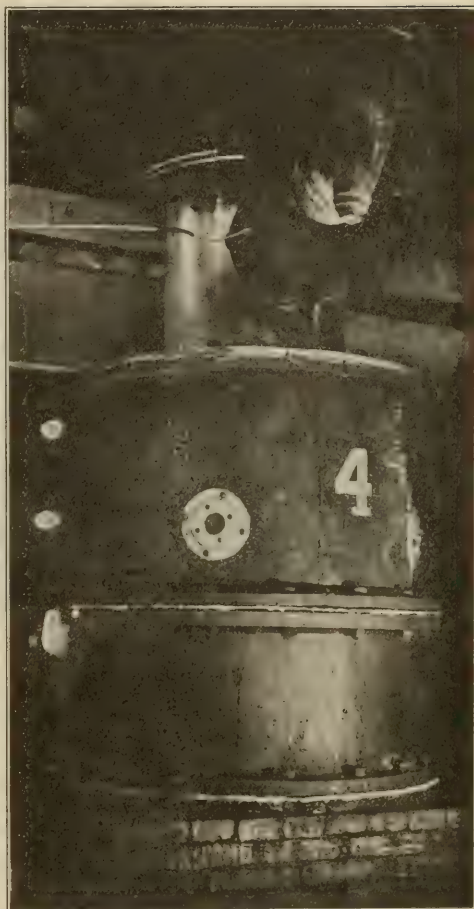


FIG. 8—AMMONIA OXIDIZING APPARATUS OF JONES-PARSONS TYPE

in order to save electric power and expensive electrical apparatus. This was accomplished by using three gauzes superimposed on each other, each being first activated separately. In this form the cost of electrical heating was done away with and details of this apparatus were sent, with permission of the Government, by the Semet-Solvay Company to their English correspondents, Brunner Mond and Company, and formed the basis of an experimental plant erected by that company in England, using, however, a much smaller cross section of platinum gauze. The first commercial-sized apparatus installed at Syracuse is shown in Fig. 6. Although this apparatus functioned with multiple gauzes with a fair degree of success, the temperature could not be adequately maintained at all times without preheating, and it was later abandoned on the development of the cylindrical converter.

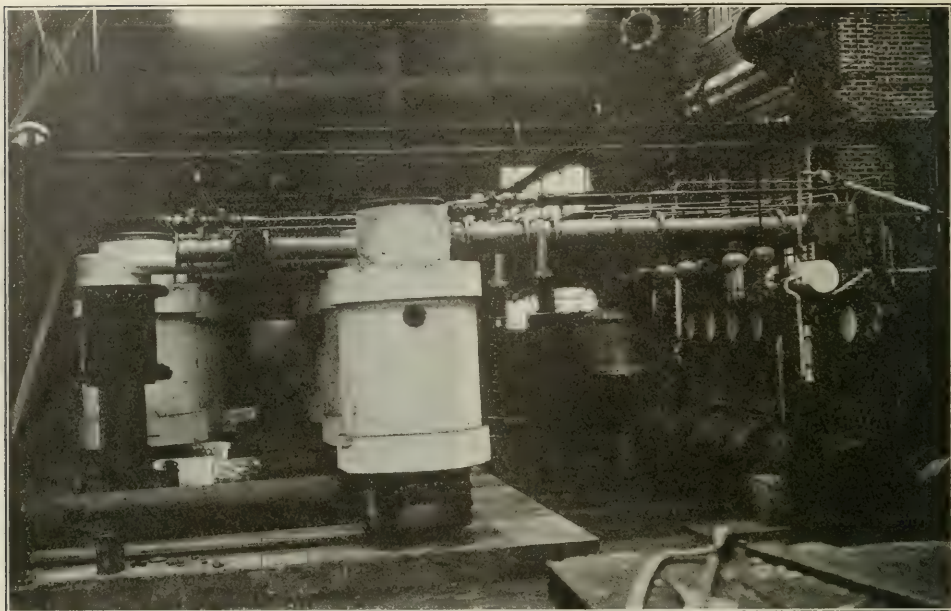


FIG. 9

The work on the flat multiple gauze converter showed that the heat was too rapidly carried away by the gas stream. An attempt was accordingly made to design a converter which would retain more of the heat of reaction. This was successfully accomplished in the cylindrical converter shown in cross section in Fig. 7, while a photographic reproduction of the first rough converter is shown in Fig. 8. This was built up from pipe sections on hand in the works of the Semet-Solvay Company. In this converter the platinum gauze is so arranged in cylindrical form of four superimposed layers of gauze that the inside surface is always reflecting against another red-hot surface, while on the outside the fire brick lining of the converter soon reaches a red heat and reflects this heat back against the outer walls of the cylinder. By this method a much larger amount of heat is retained in the converter and with pure ammonia and proper catalyst the converter is entirely self-sustaining and needs no outside heat of any kind except that generated by the reaction itself. Preheating of the gas is not necessary, but a heat regenerator is readily and easily installed and was recommended to the Nitrate Division for the first installation in Chemical Plant No. 1 at Muscle Shoals to meet any possible exigencies, such as unduly cold weather, which might arise. The installation of this apparatus in Plant No. 1 at Muscle Shoals is shown, by courtesy of the Nitrate Division of the Ordnance Department, in Fig. 9. This installation is essentially as recommended by the Bureau of Mines, except that the Bureau recommended the installation of a preheater and also the

exclusive use of aluminum pipes for all gases before they reached the converter. After the gases have passed through the converter, iron pipes are perfectly satisfactory so long as the gas temperature is above 175° to 200° . Much below this temperature corrosion takes place. This converter has the advantage of very low cost of construction, very high unit capacity, and very low cost of operation. It works with as high efficiency as any apparatus made and is easily constructed out of the simplest materials. The apparatus is built out of cast iron or boiler iron lined with fire brick. The pipes conducting the ammonia-air mixture to the apparatus should be made of aluminum, the entrance chamber, designed by G. A. Perley, shown on the illustration, having some minor advantages. A simple aluminum L or T works equally well if there is a gas holder in the line to take up pulsations. The platinum gauze is attached to a nickel or quartz entrance cylinder and the end of the 4-ply platinum cylinder is closed with a nickel or quartz plate. Quartz is preferable and can now be readily obtained. Quartz and silicates in general have less tendency to decompose an ammonia-air mixture than any metals. Nickel, quartz, and aluminum are the only three substances which have been found to be suitable for this purpose, other substances tending to cause the ammonia to burn to nitrogen and water. Aluminum is better than nickel in this respect except for its much lower melting point. Porcelain would work as well as quartz except for its contraction and expansion under heat and consequent tendency to fracture. A platinum wire is much to be preferred to a nickel

LOG OF CONVERTER No. 4. APRIL 25-MAY 18, 1918
Gauze 0.0026 in. wire, 80 mesh, activated in electrically-heated apparatus

GAS FLOW			RUN BY	DATE AND REMARKS	GAS FLOW			RUN BY	DATE AND REMARKS
NH ₃ Per cent	Cu. ft. per Min.	YIELD Per cent			NH ₃ Per cent	Cu. ft. per Min.	YIELD Per cent		
10.18	180	92.9	Davis	April 25	11.36	190	93.5	Cawley	May 6
10.08	180	93.7	Davis		11.22	180	91.1	Cawley	1/2 cm. suction
11.37	180	93.5	Cawley		11.18	180	91.2	Cawley	
8.22	180	89.0	Davis						May 7
8.79	180	89.4	Davis		11.18	175	88.3	Cawley	1 cm. pressure
10.15	200	87.6	Davis		11.13	175	88.5	Cawley	
9.46	200	91.2	Davis		10.95	247	88.5	Davis	
9.42	200	94.4	Perley		10.95	247	85.8	Davis	
8.90	200	85.2	Davis		11.35	247	86.4	Davis	
8.90	200	83.4	Davis		10.35	247	lost		
				April 26	10.45	250	86.4	Davis	2 1/2 cm. pressure
9.16	205	96.3	Perley		10.50	250	87.2	Davis	
9.07	205	95.1	Perley		11.28	250	88.0	Brush	
9.07	205	96.8	Perley						May 9
8.93	197	87.2	Davis		11.87	150	89.6	Davis	1 cm. pressure
9.28	197	86.4	Perley		11.87	150	89.7	Davis	
9.28	197	84.0	Perley		10.02	150	89.8	Davis	
9.61	200	86.1	Davis						2 cm. pressure (?)
9.61	200	86.6	Davis		10.45	190	85.0	Brush	
9.27	203	88.6	Cawley		10.45	190	93.3	Brush	
9.08	203	90.6	Cawley	April 28	?	190	90.2	Brush	May 10
9.86	203	92.5	Cawley		?	190	91.8	Brush	
9.86	203	90.2	Cawley						
10.15	200	84.1	Davis		11.38	160	94.4	Brush	1 cm. suction
10.10	200	84.2	Davis		10.64	170	89.3	Davis	
9.93	?	97.0	Perley		10.64	170	89.6	Davis	
10.13	?	97.8	Perley		10.38	170	91.6	Davis	1 cm. pressure
10.13	?	98.0	Perley		10.60	170	89.4	Brush	
					10.60	170	90.0	Brush	
9.90	200	90.8	Perley		11.18	170	89.5	Cawley	May 11
10.05	200	91.0	Perley		11.06	170	89.9	Cawley	
9.87	200	90.6	Perley	April 29					
10.02	200	94.7	Cawley		11.01	170	92.8	Davis	May 13
10.15	200	92.6	Cawley		11.01	170	93.6	Davis	
9.53	203	93.0	Perley		11.01	170	92.2	Davis	
9.73	205	91.0	Perley		11.01	170	93.2	Davis	1/2 cm. suction
9.81	205	90.9	Perley		10.95	170	91.0	Davis	
9.90	205	87.2	Cawley		11.10	170	90.9	Davis	
9.90	205	91.5	Cawley		10.37	170	90.2	Davis	May 14
					11.39	170	89.6	Brush	
10.93	202	90.6	Davis		11.39	170	91.0	Brush	
11.08	202	91.3	Davis	April 30	11.20	170	89.5	Brush	May 15
9.84	198	95.1	Perley						
10.34	198	87.0	Perley		10.48	175	94.5	Brush	
10.21	198	86.0	Perley		10.48	175	94.6	Brush	May 16
10.22	198	96.0	Cawley		11.15	185	93.4	Davis	
10.30	198	89.5	Cawley		11.15	185	93.2	Davis	
10.56	197	89.8	Perley		11.11	185	89.9	Brush	1/2 cm. pressure
11.18	197	86.8	Davis		11.11	185	90.1	Brush	
10.68	197	88.3	Perley		11.35	175	88.8	Davis	
11.11	197	89.1	Davis		11.10	175	89.4	Cawley	2 cm. pressure
11.11	197	91.2	Davis	May 1	11.57	185	90.6	Davis	
10.93	197	83.0	Cawley		11.57	185	91.4	Davis	
10.98	197	88.7	Cawley		11.66	185	87.57	Cawley	1 cm. suction
10.41	197	84.6	Davis		11.45	180	90.7	Davis	
10.38	197	85.7	Davis		11.45	180	90.9	Davis	
10.38	197	87.6	Davis		11.05	180	96.2	Cawley	1/2 cm. pressure
					11.32	180	92.5	Brush	
9.11	185	84.6	Davis		11.29	195	91.0	Cawley	
9.18	185	85.5	Davis	May 2	11.33	195	90.5	Cawley	May 17
9.18	185	84.3	Davis						
9.48	185	87.6	Perley		10.10	175	95.1	Davis	
9.49	185	89.0	Perley		10.10	175	94.5	Davis	1/2 cm. suction
10.27	196	85.0	Cawley		10.10	175	94.1	Davis	
10.30	196	86.6	Cawley		9.94	170	94.5	Davis	
10.21	196	88.5	Davis		9.90	170	94.0	Davis	Normal feed pressure
10.38	196	87.7	Davis		9.90	170	93.0	Davis	
					9.86	170	91.5	Cawley	
				May 3	11.21	162	88.7	Brush	Pressure about atmospheric
11.27	180	89.8	Cawley		11.21	162	88.5	Brush	
11.19	180	89.2	Cawley		10.93	172	90.6	Davis	
11.02	180	88.8	Davis		10.93	172	90.8	Davis	May 18
10.99	180	89.8	Davis		11.03	159	92.1	Brush	
10.99	180	89.7	Davis		11.03	159	91.1	Brush	
11.60	178	90.8	Davis		11.30	165	90.7	Cawley	May 19
11.60	178	91.0	Davis						
11.38	178	92.2	Davis						
11.38	178	91.2	Davis	May 4					May 20
11.38	178	91.2	Davis						
11.35	178	90.9	Cawley						
11.48	178	91.2	Cawley						May 21
11.38	190	89.2	Cawley						May 22
11.40	190	90.2	Cawley						
10.99	190	90.4	Davis						
10.99	190	90.6	Davis	May 5					May 23
11.43	187	94.8	Cawley						
11.45	187	93.2	Cawley						
									May 24
10.71	190	94.9	Davis						May 25
10.71	190	94.3	Davis						
10.71	190	93.5	Davis						
11.22	190	90.0	Cawley						

Found some leaks around bottom plate of silica holder. These were patched.

wire for fastening the gauze in place and is simply a capital charge, as its value is not lost. The holder is so arranged that it can be easily removed at any time if necessity arises. There are peep-holes in the top of the aluminum entrance cap and in the outer sides of the apparatus so that the platinum gauze may be viewed both from the inside and from the outside of the platinum cylinder. The gauze is lighted, after being activated, by simply applying a torch for a moment through one of the peep-holes. When the ammonia-air mixture is started the apparatus almost immediately begins operation and after coming to heat, which it does in a few hours, will continue without interruption for months if supplied a pure gas mixture.

The cost of the converter, exclusive of platinum, should not exceed \$200. It contains a platinum gauze 13 in. wide and 113 1/2 in. long wound in 4 layers into a 9 in. cylinder. The cylinder when completed, if made of 80 mesh gauze, 0.0026 in. wire, weighs 16 1/2 oz., and has a capacity of about 2 1/2 tons of 100 per cent nitric acid per day and works with an efficiency above 90 per cent, with a gas flow of 200 cu. ft. per min. of 10 to 11 per cent ammonia-air mixture. If the gas flow is increased, the capacity can be easily brought up to 3 tons per day but the efficiency at the same time drops off 2 or 3 per cent. The best results obtained for any single run of this converter during the experimental work operated on a commercial scale gave the following:

208 lbs. of nitric acid per hr. or
21 7 lbs. per sq. ft. of gauze surface, or
14.1 lbs. per oz. of platinum

with the gas containing 10 1/2 per cent of ammonia being run at the rate of 200 cu. ft. of mixed gases per minute, with an efficiency of 94 per cent. The converter was also run at a capacity of 250 lbs. of nitric acid per hr., but under these conditions the efficiency dropped below 90 per cent. Careful measurements show the temperature of the gauze itself in this converter, when running with pure ammonia of 11 per cent ammonia content, to be approximately 825° C.

The exit gases at the bottom of the converter are above 600° C. Ammonia from cyanamide will not work well in this apparatus unless first purified from the phosphine which is always present, although much more in some cyanamide ammonias than in others. This purification is simple and easy and may be accomplished either by first making aqua ammonia under proper conditions, or by passing the mixed gas through gas-mask charcoal or whetlerite which immediately oxidizes phosphine to phosphoric acid which is retained as ammonium phosphate in the mass. Patents for this method of purification have been applied for by J. D. Davis. Also, a patent has just been granted to W. S. Landis¹ for the elimination of most of the phosphine by first blowing air through the ammonia autoclaves before turning on the steam for ammonia production. With "A" grade coal-tar ammonia, hav-

ing an organic number¹ of 50 or less, the apparatus has always worked with high efficiency and without difficulty of any kind so long as the gauze was kept free from iron oxide or from oil of any kind. Its efficiency with "B" grade ammonia having an organic number of 200 or over is lower, the temperature of the gauze falling off exactly as it does with phosphine, although not to so great an extent. If, however, the gases are preheated before entering the converter, as can easily be accomplished by the waste heat from the reaction, the temperature of the platinum can undoubtedly be held even with these lower grade materials. While it is not to be expected that impure ammonia can be oxidized with as high an efficiency as pure ammonia, nevertheless there can be little doubt that better results will be obtained even with impure ammonia, whether in this or in an electrically-heated apparatus, if the gauze is kept up to a proper operating temperature. To accomplish this desired result, either electric heating or preheating should serve equally well. Regenerative heating has the advantage of costing nothing.

OPERATING EFFICIENCY

A number of converters were installed at Syracuse both for experimental purposes and plant operation. At the time of the installation the production of nitric acid and sodium nitrite needed by the Semet-Solvay Company was so profitable that the converters were run, both old style and new style, day and night in order to obtain output. At that time it was profitable to run the converters even with some of the poorer gauzes, to be mentioned later, which were so contaminated that they gave low efficiency.

The report on page 547 by J. D. Davis on Converter No. 4, which was run for experimental purposes with varying conditions from April 25 to May 18, 1918, shows results obtained by three observers running the apparatus independently and making efficiency determinations by two different methods which checked each other.

SUMMARY

1—All these data are representative except some 4 or 5 determinations known to be off. The average is the best criterion available for publication for the work of this converter and gauze. One hundred and sixty determinations were made by four different chemists using two different methods of determination. Average per cent ammonia, 10.57. Average yield, 90.7 per cent.

The air flow was always noted and was varied from 159 to 205 cu. ft. of mixed gases per minute, one trial day being run at 250 cu. ft. but not included in the average. This rapid flow of gas gave a capacity of 5880 lbs. of nitric acid per day, but the efficiency dropped off to 87 per cent.

2—If we average the results by periods excluding only the results taken at a flow of 250 cu. ft. per min. we obtain the following figures:

¹ The "organic number" here referred to is the number of cubic centimeters of N/100 potassium permanganate which are decolorized by 100 cc. of the ammonia water under consideration.

Period No.	No. of Tests	Average Percentage of NH_3	Efficiency Per cent
1	21	9.44	90.0
2	20	10.11	91.4
3(a)	20	10.27	87.4
4	20	10.96	90.0
5	17	11.20	91.2
6	20	10.87	91.1
7	19	11.16	91.0
8	19	10.71	92.2
9	13	10.64	91.9

(a) Most of the low results were in this period, during which leaks developed around the quartz bottom.

The last results are the best and a 92 per cent efficiency with 10.5 per cent ammonia and with 200 cu. ft. per min. capacity can easily be reached with this converter.

3—One can pick out sets of results obtained under conditions considered favorable which will make a better showing. However, the above represents more nearly what a good works operator would obtain with ordinary care, given the proper design of furnace, good ammonia, and good platinum.

Another of these cylindrical converters was run continuously by the Semet-Solvay Company for commercial purposes without repairs or alterations from February 23 to September 15, 1918, when the gauze was injured by an accident which caused caustic from the sodium nitrite absorption towers to back up into the burner. The analytical control of this converter was not as continuously conducted as the experimental burner since it was being run purely for commercial purposes in the hurry of war production. The average of all tests, forty in all for this period, made by the Semet-Solvay Company was 91.4 per cent.

Further work with this converter has been carried on at Plant No. 1 by Captain G. E. Perley, of the Nitrate Division, Ordnance Department. Important results have been obtained by him which he will publish later.

SOME GENERAL PRINCIPLES OF AMMONIA OXIDATION

Mr. F. G. Liljenroth,¹ in an article on "The Starting and Stability Phenomena of Ammonia Oxidation and Similar Reactions," has theoretically considered some of the phenomena accompanying and influencing ammonia oxidation, basing his curves on the hypothetical figure of 750° C., as the temperature at which maximum efficiency is obtained. While this temperature is, undoubtedly, low, the conclusions are unaffected thereby. The curves are decidedly interesting and it seems well to consider here also some of the factors which apply to all forms of apparatus using platinum as a catalytic agent for the oxidation of ammonia. It is impossible in this paper to more than summarize the results obtained in the laboratory and in the plant.

Given a definite concentration of pure ammonia gas at a definite temperature with a given catalytic agent, in this case platinum, the amount of conversion or capacity of any apparatus or converter is dependent upon the surface of platinum exposed to the reaction. The object, then, is to bring as large a surface of platinum as possible into contact with the ammonia to be oxidized and to bring pure ammonia to this surface up to its capacity to bring about chemical change.

A. QUALITY OF PLATINUM—The platinum should be as pure as possible, consistent with strength. Fine wire cannot be drawn from platinum unless it contains some hardening element. Iridium is the best for this purpose, and iridium in the necessary quantity to allow platinum to be drawn into fine wire has not proved harmful in our experiments. This is also true of palladium. Pure palladium gauze is as active as or even more active than platinum, but has no life, falling to a powder of palladium black within a few hours. Ten to 20 per cent palladium in platinum apparently in no wise injures the oxidizing efficiency of the gauze, but the gauze is harder to activate and has not given as much satisfaction as a platinum gauze with a small amount of iridium, which meets every need. Iron in the platinum, even in small quantities, is a very serious impurity, as much as 0.2 per cent seriously affecting the efficiency of the operation. One large gauze used commercially containing this amount of iron never functioned well. Iron, however small in amount, should be entirely eradicated; even that added through drawing by steel dies should be removed by washing in strong hydrochloric acid. Any iron in the wire gradually works to the surface where iron oxide is formed. Every precaution should be taken to keep iron out of the platinum and iron oxide from its surface, whether the iron comes from the platinum itself or is carried mechanically from iron pipes with the gas. Rhotanium gauze (an alloy of palladium and gold) was tried but was found to have no catalytic effect so far as conversion of ammonia into nitric oxide was concerned. The ammonia gas burned almost wholly to nitrogen and water.

B. SIZE OF WIRE AND MESH OF GAUZE—In the gauzes actually tried by the Bureau of Mines, namely, 70 mesh 0.0026 in. wire, 80 mesh 0.0026 in. wire, and 100 mesh 0.0015 in. wire, the 80 mesh gauze gave by far the best results. It is, however, improbable that this size of gauze is the best. Mr. Alvan Allen Campbell, of the Newark Woven Wire Cloth Company, Newark, New Jersey, which company has woven most of the gauzes used by the Government, has published a paper¹ on platinum gauzes used as a catalyzer for the oxidation of ammonia, giving a table of weights, active surfaces of platinum, air space, etc., of various meshes of gauze made from various diameters of wire. His figures would indicate that a finer mesh and a finer wire give a much larger surface of platinum per gram of platinum and that in all probability more efficient results for the platinum used would be obtained from a platinum-iridium alloy of 99 per cent platinum and 1 per cent iridium, if a 150 mesh gauze with 0.0015 in. wire were used. Although this gauze may be mechanically weak, it is highly desirable that it should be tried out commercially and that a 120 mesh 0.002 in. and a 150 mesh 0.002 in. wire should also be experimented with.

C. ACTIVATION OF PLATINUM GAUZE—Fresh, smooth platinum wire shows comparatively little catalytic activity. If, however, it is exposed around 800° to a

¹ Chem. & Met. Eng., 19 (1918), 208.

¹ THIS JOURNAL, 11 (1919), 468

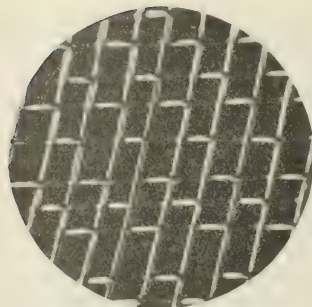


FIG. 10—PLATINUM WIRE SCREEN, 100 MESH, NEW, NOT ACTIVATED

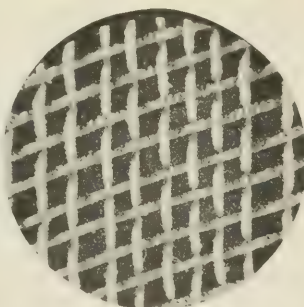


FIG. 11—PLATINUM WIRE SCREEN, 100 MESH, ACTIVATED FOR AMMONIA OXIDATION. JULY 25, 3 P.M., TO AUGUST 17, 9 A.M., 1917

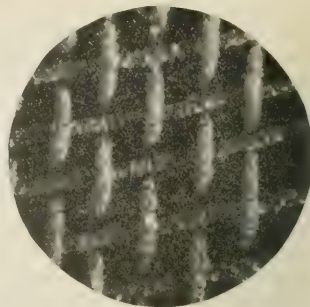


FIG. 12—PLATINUM WIRE SCREEN, 100 MESH, ACTIVATED FOR AMMONIA OXIDATION. JULY 25, 3 P.M., TO AUGUST 17, 9 A.M., 1917

rather rich ammonia-air mixture it takes on in a few hours a gray appearance, the wire becoming covered with spongy platinum. Whether this simply increases the effective surface or changes the nature of the platinum is hard to judge. Certainly, however, the platinum must first be activated before it is successfully used. In an electric apparatus this takes place simply by operation, particularly if the ammonia concentration is increased for a few hours. With the cylindrical converter, however, it is necessary to first activate the platinum gauze two feet at a time in a flat electrically-heated converter before it is worked up to the cylindrical form. One electrically-heated converter should be kept on hand in any large plant for this purpose. Otherwise the inner layers of this platinum cylinder become activated from the rich ammonia but the outer layers take weeks or even months to activate, even if they become notably changed at all. The results of this activation are shown in Figs. 10, 11, and 12.

D. CATALYTIC POISONS—As already pointed out in this paper, phosphine is a very serious catalytic poison. It has been elsewhere shown¹ that as little as 2 or 3 parts in 100,000,000 has a distinct effect. Also, as previously stated, iron oxide and grease, oil or tar of any kind must be kept away from the platinum gauze or dark spots showing inefficient catalytic action will appear. A new gauze should be washed with pure gasoline or ether before being activated. It is undoubtedly due to some volatile tar-like bodies that the temperature of a self-heating gauze falls off when ammonia with a high organic number is burned. Fortunately, all of these impurities are easily removed and there should be no excuse for any of them reaching the gauze in a properly constructed ammonia oxidation plant. Hydrogen sulfide or organic bodies which burn without leaving a residue on the gauze have little deleterious action, at least when present in small quantities. Acetylene itself is not harmful, and cyanogen and hydrocyanic acid are oxidized to nitric oxide apparently as easily as pure ammonia itself.

¹ G. B. Taylor and Julian H. Capps, "Effect of Acetylene on Oxidation of Ammonia to Nitric Acid," *THIS JOURNAL*, 10 (1918), 457; "Effect of Phosphine and Hydrogen Sulfide on the Oxidation of Ammonia to Nitric Acid," *Ibid.*, 11 (1919), 27.

E. TEMPERATURE OF REACTION—The temperature at which platinum best oxidizes ammonia is certainly above 825° C. All results obtained by the Bureau indicate that the temperature should never be allowed to fall below 750° and that the efficiency of operation increases with the temperature above this point and certainly does not fall off below 900° or 925°. The increase in efficiency above 825°, however, is relatively slow as the temperature rises. A few definite measurements were made by Taylor during his laboratory experiments, all indicating increased efficiency as the temperature rose, but the number is too small to warrant the publication of a temperature curve. The cylindrical converter certainly worked best around 825°, the highest temperature at which it could be maintained with pure ammonia at efficient concentration without regenerative heating. All the experiments with the small laboratory apparatus previously described gave better results as the heat of the gauze was increased. An operating temperature of at least 825° is recommended. This should apply to all apparatus using platinum as a catalyzer.

F. CONCENTRATION OF MIXED GASES—Efficiency at a proper operating temperature undoubtedly varies within limits inversely with the amount of ammonia present, although not necessarily proportionate thereto. With a self-heating gauze and pure ammonia, 10 to 12½ per cent of ammonia in the gases is desirable to keep the gauze to proper temperature. While a slightly lower efficiency obtains with the higher concentrations of ammonia, nevertheless there is a compensation in actual operation in the fact that the nitric oxide gases produced vary directly with the concentration of the ammonia in the gas burned, and these higher concentrations of nitric oxide absorb much more readily in the absorption towers and yield a higher concentration of nitric acid. With percentages lower than 10 per cent, regenerative heating or electric heating is advisable, the regenerative heating having the advantage that it utilizes the waste heat of the reaction, while electric heating is costly both from the standpoint of power and the electric apparatus required. Any preheater used must be constructed of aluminum or of silicate material, if the gas mixture

and not simply the air alone is preheated, for otherwise a considerable proportion of the ammonia will be converted into nitrogen and water before it reaches the platinum gauze. Numerous experiments carried out by the Bureau and also results obtained by others¹ indicate that great care must be exercised in regard to the substances which come into contact with the mixture of ammonia and air if decomposition is not to take place at elevated temperatures. The following unpublished experiments by G. B. Taylor illustrate these points. In these experiments the material was filled into a porcelain tube which was heated while the ammonia-air mixture was slowly passed through.

MATERIAL	Temp. Deg. C.	NH ₃ Destroyed Per cent
Pieces of pure aluminum sheet.....	550	0.0
Vitrified silica (pieces of broken tube).....	680	0.8
Nickel wire, 2 mm. diameter in form of small staples.....	500	1.4
Nickel wire, 2 mm. diameter in form of small staples.....	580	11.3(a)
Nickel wire, 2 mm. diameter in form of small staples.....	690	22.0(b)
Porcelain (pieces of broken dish glazed on one side).....	700	0.0
Alundum cement, briquettes.....	710	34.0
Alundum cement, briquettes.....	590	2.3

(a) 1.8 per cent oxidized to NO.

(b) 1.0 per cent oxidized to NO.

Electric heating or regenerative heating will undoubtedly enable lower concentrations of ammonia gas to be burned with slightly increased efficiency, an efficiency offset, however, as already pointed out, by the lower concentration of the nitric oxide obtained. It is the writer's opinion that a concentration of approximately 1 volume of ammonia to 9 volumes of air will be found to be an excellent basis of operation under ordinary conditions, but that when a heavy output is required a concentration of from 11 to 12 per cent by volume of ammonia may be burned to distinct advantage.

G. EFFICIENCY OF CONVERSION—In speaking of efficiency of conversion, it is necessary to point out that efficiency of operation of the converter has been and must be determined on the basis of gas analysis. In the determination of the total efficiency of a plant actual weights of ammonia used and nitric acid obtained will give an over-all commercial efficiency which is independent of such analysis, but such efficiency of operation includes not only the losses involved in the catalytic reaction but also involves mechanical losses. The methods used by the Bureau of Mines in its experimental work for the determination of the efficiency of reaction are two: one described by G. B. Taylor and J. D. Davis,² the other being the method used by the American Cyanamid Company which is soon to appear in *THIS JOURNAL* in an article by Capt. D. P. Gaillard entitled "Analytic Method of Determining Efficiency of Ammonia Oxidation," an advance copy of which has been furnished to the writer by the courtesy of Capt. Gaillard. These two methods have been used side by side for months in the investigations of the Bureau of Mines and the Ordnance Department and have closely checked each other.

¹ W. Ramsay and S. Young, "The Decomposition of Ammonia by Heat," *J. Chem. Soc.*, 45 (1884), 88; E. P. Perman and G. A. S. Atkinson, "The Decomposition of Ammonia by Heat," *Proc. Roy. Soc.*, 74 (1904), 110; A. H. White and W. Melville, "The Decomposition of Ammonia," *J. Am. Chem. Soc.*, 27 (1905), 373.

² "Analytical Control of the Ammonia Oxidation Process," *THIS JOURNAL*, 9 (1917), 1106.

On the other hand, the method used in England for the determination of the efficiency of ammonia oxidation, as used in American hands, yields results notably higher. As the early published data on the efficiency of ammonia processes by Kaiser and others often ran above 100 per cent, presumably owing to the actual burning of nitrogen and oxygen, but really due to the inaccuracy of the method employed, great care should be exercised in efficiency determinations. There is no reason to believe that the efficiency of any apparatus using the same platinum as a catalyzer will vary notably from the efficiency of any other apparatus if the same condition of temperature, gas concentration, purity of gas, and absence from premature decomposition are observed. With proper precaution, a commercial plant using the Frank-Caro apparatus, the apparatus of the American Cyanamid Company, or the cylindrical converter should yield efficiencies above 91 per cent, and it is believed, with further refinements, that oxidation efficiencies of 95 to 96 per cent are quite possible.

ELECTRIC HEATING VS. SELF HEATING OR REGENERATIVE HEATING

The chief advantage of the cylindrical converter over an electrically heated converter is one of cost. With a pure gas and a definite temperature, held by retaining heat in the converter itself or obtained through preheating, the same surface of platinum gauze should and will give the same output of nitric oxide no matter which form is used. Electrical units take up very much more space for a given output. Each unit, although having approximately one-fifth of the capacity, costs more than the cylindrical unit of five times the capacity, and the difference in cost of construction and operation are very considerable factors. The electrical unit for a given output requires a heavy additional expenditure for converter units, for dynamos, electrical meters, transformers, switchboards, and wiring, a large amount of extra piping, extra land, extra buildings for installation, and extra platinum. Also a considerable enlargement has to be made to any power plant required. The amount of electricity used is no small item, being 5,500 continuous horse power for a plant the size of Plant No. 2 at Muscle Shoals, employing, as before stated, 696 converters. To this must be added additional cost for repairs, overhead, interest, and amortization, and for labor. Small units always require more labor for a given output than large ones in almost any form of chemical operation.

COST OF NITRIC ACID PRODUCTION

While the present paper has simply to do with the oxidation of ammonia to nitric oxide and scarcely touches upon the cooling, absorption, and concentration to nitric acid, nevertheless these divisions of the subject are none the less important and require the greater part of plant outlay both for construction and operation.

In these times of change, unsettled conditions, and high prices, any chemist would be rash to make predictions of cost of construction and operation with

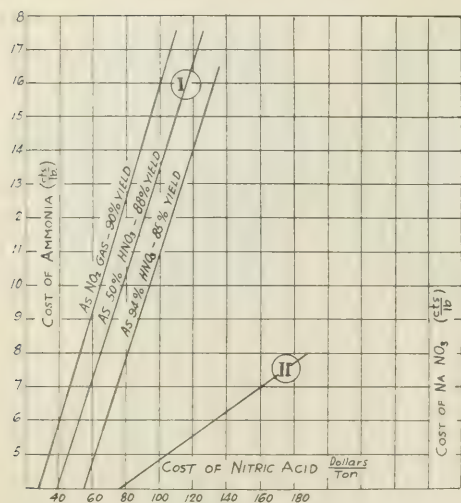


FIG. 13—COST OF NITRIC ACID

I—From Ammonia by Oxidation II—From Sodium Nitrate

claims to exactness. The following figures should, therefore, be considered simply as an "order of magnitude." They are round figure averages between the (1917-18) costs of one actual plant and the estimates of a reliable and experienced engineering and constructing firm for the erection and operation during 1918 of another. To these figures in the case of acid costs, \$3.00 per ton has been arbitrarily added as estimates of late have always proved low. It is, accordingly, the opinion of the writer that the following figures may be considered high for 1919-1920. They include cost of vaporizing, oxidizing, cooling, absorption, weighing, and concentration systems with buildings and foundations, and an addition of 20 per cent to operating costs for repairs, interest, and depreciation.

PLANT CONSTRUCTION COSTS

Plant for 25,000 tons HNO_3 (100 per cent) per yearAs 50 per cent HNO_3 \$45.00 per ton yearAs 94 per cent HNO_3 60.00 per ton year

PLANT OPERATION COSTS

Per ton HNO_3 (100 per cent)As NO gas \$ 5.00 plus cost of NH_3 As 50 per cent HNO_3 15.00 plus cost of NH_3 As 94 per cent HNO_3 30.00 plus cost of NH_3

In order to make a comparison with the cost of 94 per cent acid from sodium nitrate, \$48.00 may be taken as fabrication cost per ton of nitric acid (100 per cent basis) and add thereto the cost of 2800 lbs. of commercial Chile saltpeter.

Fig. 13 will then make plain the relation between the costs of the two methods of producing nitric acid on the basis above adopted.

A study of Fig. 13 should give at a glance an idea as to when the production of nitric acid by ammonia oxidation can compete commercially with the old methods from Chile nitrate. It is evident that sulfuric acid

plants would save money by its immediate adoption, that 36° B ϵ . nitric acid can at present prices of ammonia be made as cheaply as from sodium nitrate even if it drops to pre-war prices, and that ammonia has to drop in price only a few cents per pound in order to have concentrated nitric acid also made competitively by the oxidation of ammonia.

BUREAU OF MINES
WASHINGTON, D. C.

STUDIES ON THE OFFICIAL METHOD FOR PYRIDINE IN AMMONIUM NITRATE

By R. M. LADD

Received September 17, 1918

The original government directions for the determination of pyridine in ammonium nitrate read as follows:

Dissolve a known weight, approximately 100 g., in 100 cc. of distilled water, using a 1 liter Kjeldahl distilling flask. A few drops of methyl orange and 5 cc. of normal sodium hydroxide solution are added. The pyridine and ammonia are then distilled into 100 cc. of sodium hypobromite solution (100 g. sodium hydroxide dissolved in 500 cc. of water, 25 cc. bromine added, and the solution made up to 1000 cc.) contained in an Erlenmeyer flask of approximately 800 cc. capacity. The ammonia is decomposed by the hypobromite solution while the pyridine passes unaffected into a second receiving flask containing 10 cc. of $\text{N}/10$ sulfuric acid. From the acid used the pyridine is calculated. One cc. $\text{N}/10$ sulfuric acid is equivalent to 0.0079 g. pyridine. Twenty minutes' boiling is sufficient.

At first glance it appears that different analysts would interpret this test in different ways and hence would obtain different results.

In our laboratory we first set up the apparatus without any condenser. We found that at one of the other plants belonging to the company a condenser was being used as shown in Fig. 1. The inspector when he came advised the use of a condenser. Since that time we have set up the apparatus as shown in the figure.

But this is only one of the difficulties. The series of results in Table I will show what widely differing results can be obtained by different interpretations of the method.

TABLE I

SAMPLE	Grams Used	Method ¹	Vol. of Distillate Cc.	Pyridine Per cent
A.....	100	1a	?	0.0000
	300	1b	40	0.0020
	100	1c	75	0.0210
B.....	300	1a	?	0.0005
	100	1b	40	0.0150
	100	1c	50	0.0350
J.....	100	1a	?	0.0003
	500	1b	100	0.0020
	300	1c	100	0.0169
	200	1c	75	0.0166

¹ Method 1a calls for 20 min. of slow boiling in hypobromite flask.

Method 1b calls for the destruction of the ammonia before boiling starts in the hypobromite flask, then rapid boiling until the required amount of distillate has been collected.

Method 1c calls for 20 min. rapid boiling in the hypobromite flask, without preliminary slow heat to destroy the ammonia. Ammonia was invariably carried over by this method, hence the results were always too high.

Table II shows a series of results which would seem to indicate that not all the pyridine is carried over by this method, even when the time of boiling is counted from the start of rapid boiling in the hypobromite flask.

TABLE II

SAMP- PLE	Grams Used	Vol. of Dis- tillate Cc.	Additional		Additional	
			Pyridine Per cent	Dis- tillate	Pyridine Per cent	Dis- tillate
G...	150	1b	40	0.0120	100	0.0070
H...	300	1b	40	0.0325	40	0.0081
I...	300	1b	40	0.0293	40	0.0064
K...	300	1b	50	0.0226	200	0.0005
L...	300	1b	50	0.0155	100	0.0008

Composite
of K
and L
residues!

550 1b 50 0.003

¹ Residues from K and L were filtered and run as new sample.

Evidently the method has given poor satisfaction in practice, for it was modified in the following appendix of June 25, 1918:

SPECIFICATIONS GE-321-I

APPENDIX IV

JUNE 25, 1918

THE DETERMINATION OF PYRIDINE IN AMMONIUM NITRATE

The method as stated No. 8, page 4, of the Ammonium Nitrate Specifications, is modified as follows:

Dissolve approximately 250 g. ammonium nitrate in 250 cc. of distilled water contained in a one liter Kjeldahl distilling flask. Add 4 to 5 drops of methyl orange and connect the distilling flask, through a Kjeldahl vapor trap, to a tall narrow wash bottle. The dimensions of this wash bottle should be from 8 to 10 in. high by 1½ to 2 in. in diameter. In the wash bottle are placed 300 cc. of sodium hypobromite solution. (This solution is made by dissolving 100 g. of sodium hydroxide in about 800 cc. of distilled water and then adding, very slowly, preferably by drawing through in vapor form, 30 cc. of bromine and making the solution up to one liter.) The sodium hypobromite solution must be at least 3 in. deep in the wash bottle. The wash bottle is connected through a Kjeldahl vapor trap with a condenser fitted with a tube of blocked tin.

Add 85 cc. of N/2 sodium hydroxide solution to the solution of ammonium nitrate in the distilling flask, warm the solution in the wash bottle by setting it in a vessel of hot water, and begin the distillation. The distillate is caught through an adapter, in a beaker containing 25 cc. of N/10 sulfuric acid. During the distillation, the heat from the vapors should be sufficient to maintain the temperature in the hypobromite solution at approximately 75° to 80° C. If this is not the case, additional heat must be applied. After 100 cc. have been distilled, the distillation is stopped and the distillate in the beaker is titrated with N/10 sodium hydroxide, using phenolphthalein, and the pyridine calculated. One cubic centimeter of N/10 sulfuric acid is equivalent to 0.0079 g. of pyridine.

(Signed) C. C. WILLIAMS,
Brig. Gen., Ordnance, N. A.
Acting Chief of Ordnance

WAR DEPARTMENT
OFFICE OF THE ACTING CHIEF OF ORDNANCE
WASHINGTON, D. C.
June 25, 1918

There are two things about these specifications which seemed to me to render them impractical.

1—If the hypobromite be maintained at a temperature of 75° to 80° C., it would seem impossible to obtain 100 cc. of distillate. Repeated attempts have shown that 2 hrs. heating with the liquid in the Kjeldahl boiling rapidly and the temperature in the hypobromite flask maintained between 75° and 80° gave no distillate. The conditions named are incompatible. Is the temperature or the amount of distillate the more important consideration? Table III

will indicate how widely different are the results obtained by tests.

TABLE III

SAMPLE	Grams Used	Method	Distil- late Cc.	Pyri- dine Per cent
M1.....	100	11b:	100	0.029
M2.....	250	11a:	?	0.002
M3.....	250	11a	?	0.002
M4.....	No record of method			0.010

¹ Method 11a calls for the holding of the temperature of the hypobromite between 70° and 80° C. for 1½ to 2 hrs. regardless of the amount of distillate.

² Method 11b calls for 100 cc. of distillate regardless of the temperature of the hypobromite. In order to do this it is necessary to increase the temperature to or above 100° C.

³ Run by Government inspectors.

2—The other objection is to the use of phenolphthalein as the indicator. Table IV shows that this indicator is entirely unaffected by the alkalinity of pyridine. It also shows a condition which has been mentioned to me by three analysts, namely, that at times an added amount of acid gets into the receiver.

TABLE IV

SAMPLE	Grams Used	Method	Distil- late Cc.	Methyl Orange ¹	Phenol- phthalein ²	Double E ³
O.....	200	11b	50	0.0251	—0.0051	0.0292
L.....	300	11b	50	0.0132	—0.0024	0.0155
P.....	250	11b	100	0.0063	+0.0013	0.0050
S.....	250	11b	100	0.0083	+0.0045	0.0038

¹ Methyl orange indicates the combined pyridine and ammonia.

² Phenolphthalein indicates the ammonia and absorbed acid.

³ The difference in end-points represents the true reading for the pyridine.

This additional acid will not be indicated by the methyl orange unless in amounts large enough to more than neutralize the pyridine obtained.

The table also indicates that ammonia is sometimes driven over, in which case the results will be high if methyl orange alone is used.

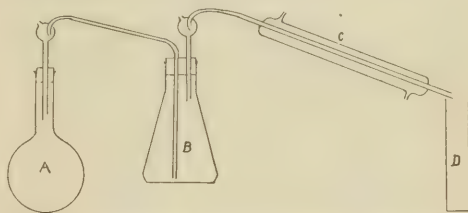


FIG. 1—APPARATUS FOR PYRIDINE AS ORIGINALLY USED IN THIS LABORATORY

In our laboratory we found that check results could be obtained provided any definite procedure was followed. If the procedure was varied the results varied.

In order to get concordant results, then, it is only necessary to specify the method more in detail. The question was, which modification of the method gave results which were a true representation of the amount of pyridine present.

To answer this question, pyridine-free ammonium nitrate was prepared by taking the residues left from several pyridine determinations. These were first filtered, then made alkaline with ammonium hydroxide and evaporated until crystals appeared on cooling. These crystals were separated from the mother liquor, washed with water and then with alcohol (to remove excess methyl orange), and were then redissolved, made alkaline with ammonium hydroxide, filtered, and recrystallized. The new crystals were separated

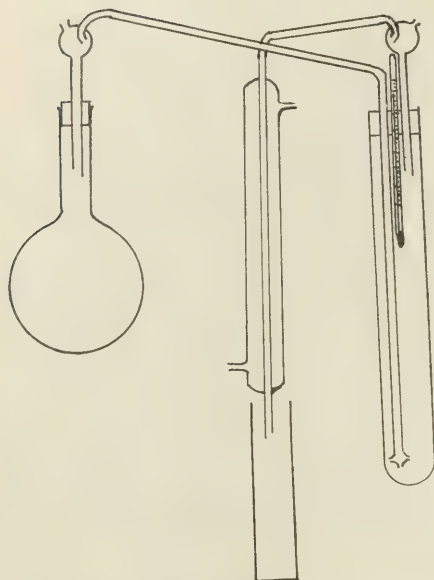


FIG. 2—APPARATUS FOR PYRIDINE AS NOW USED IN THE AETNA LABORATORY

The whole is set around a single ring stand. The hypobromite flask is 2 in. by 14 in. The hypobromite, 300 cc., occupies $7\frac{1}{2}$ in. of the height at the start of the test

from the mother liquor, washed and dried. The recovery was not more than 50 per cent. The crystals thus obtained were long needles, absolutely colorless and odorless. They gave a clear, colorless solution. They were considered chemically pure.

TABLE V—SERIES OF DETERMINATIONS ON KNOWN BLANKS

Grams Used	Pyridine Per cent
170	0.0005
170	0.0000
170 $\frac{1}{2}$	0.0000
170 $\frac{1}{2}$	0.0005
250 $\frac{1}{2}$	0.0003
250	0.0003
250	0.0006
250	0.0003

¹ Determination made in special apparatus which had no rubber connections or stopper.

TABLE VI—DETERMINATIONS ON KNOWN PYRIDINE

Grams Used	Known Pyridine	Found	Error	Percentage Error
170	0.0385	0.0387	0.0002	0.5
170	0.1155	0.1114	0.0041	3.6
170	0.0041	0.0050	0.0009	18.0
?	0.3816	0.3778	0.0038	1.0
250	0.0113	0.0095	0.0018	15.5
250	0.0113	0.0095	0.0018	15.5

TABLE VII—CHECKS ON UNKNOWN SAMPLES

SAMPLE	Grams Used	Pyridine Per cent	Average	Error	Percentage Error
B1	250	0.0187		+0.0021	12.6
B2	150	0.0147		-0.0019	11.4
B3	100	0.0182		+0.0016	9.6
B4	500	0.0153		-0.0011	6.8
B5	100	0.0173		+0.0007	4.2
B6	100	0.0150	0.0166	-0.0016	9.6
C1	250	0.0000		-0.0003	
C2	250	0.0005	0.0003	+0.0003	
D1	300	0.0030		-0.0004	
D2	150	0.0017	0.0034	+0.0003	
E1	250	0.0030		+0.0005	
E2	250	0.0020	0.0025	-0.0005	
N1	250	0.0108		+0.0005	
N2	250	0.0098	0.0103	-0.0005	

The results in Table V were obtained by the use of this salt under the method specified later. Table VI

shows the results on a series of known, and Table VII the results on a series of unknown samples.

These results would indicate that this method is accurate to the second place in decimals. When figures appear in the second decimal place, error should not exceed 15 per cent or 0.02. When figures appear in first decimal place error should not exceed 5 per cent or 0.005. When figures appear in third decimal place error should not exceed 0.001. Figures beyond the third decimal place are not significant.

The method used is as follows:

Dissolve 250 g. of sample in 300 cc. of distilled water, using a 1000 cc. Kjeldahl or Florence flask. Add a few drops of methyl orange and neutralize with 10 per cent sodium hydroxide solution. Then add 15 cc. excess of 10 per cent sodium hydroxide solution. Set up apparatus as shown in Fig. 2, using 300 cc. hypobromite solution in the second flask and receiving the distillate in 25 cc. N/10 sulfuric acid. Distill until 100 cc. of distillate have been collected. The heating should be very slow until all the ammonia, driven off, has been destroyed. This point will be indicated first by an acid reaction of the methyl orange in the first flask and second by the gradual reduction of the amount of nitrogen given off, in very small bubbles, in the hypobromite. At this point the hypobromite flask should not be warm enough to burn the hand (not above 70° to 75° C.). It is now safe to increase the heat so that boiling occurs in the hypobromite in 10 to 15 min. and 100 cc. of distillate comes over in 20 to 25 min. after active boiling starts.

Titrate the liquid in the receiver, using N/10 sodium hydroxide solution with methyl orange as the indicator.

Record the end-point; add $\frac{1}{2}$ cc. of phenolphthalein (1:1000) solution and continue the titration until a red color which will persist for 30 sec. appears. Subtract the methyl orange end-point from that obtained with phenolphthalein, and multiply the difference by 0.0079. The result is the pyridine bases in grams. Methyl orange indicates pyridine plus ammonia. Phenolphthalein indicates ammonia. Difference is due to pyridine.

Because of the fact that the methyl orange and phenolphthalein end-points are never quite the same and because an absorption of carbon dioxide by the sodium hydroxide solution may bring it about that they vary still more widely, it is necessary to standardize the solutions used to both end-points and to make a correction for their normal difference. This correction should be checked by a new standardization at least once a week. We found that with our solutions this difference was usually about 0.4 cc.

In case it is desired to use a sample of a different size, maintain the proportions indicated above, except that the total solution in the first flask should always be about 500 cc.

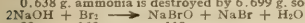
The hypobromite solution is made up as follows: 100 g. sodium hydroxide are dissolved in 800 cc. of water, 25 cc. of liquid bromine are added, and the mixture shaken until the bromine is entirely dissolved and made up to 1000 cc. The solution should be made up a day in advance. It will maintain its strength for at least a week if kept in a stoppered, dark bottle. It will be brown in color. Should the brown color disappear during the distillation it would mean that an excess of ammonia is present. This should also be indicated and eliminated from the calculations by the double end-point called for, but in case this happens it is well to repeat the test, using more of the hypobromite solution.

The reactions involved and the calculations on which the proportions are based are indicated in the following equations:



15 cc. 10 per cent sodium hydroxide solution contains 1.5 g. sodium hydroxide
1.5 g. sodium hydroxide will free 0.6375 g. ammonia
 $2\text{NH}_3 + 3\text{NaBrO} \longrightarrow 3\text{H}_2\text{O} + \text{N}_2 + 3\text{NaBr}$

0.638 g. ammonia is destroyed by 6.699 g. sodium hypobromite



25 cc. bromine = 79.5 g. bromine

300 cc. solution contains 17.7 g. hypobromite (approx.)

There should be a large excess of hypobromite. This is required for safety.

Soap should never be used in cleaning any piece of apparatus used in this test. We found that beakers which had been washed with soap and were later used as receivers threw the results very much too high even after being rinsed 8 or 10 times.

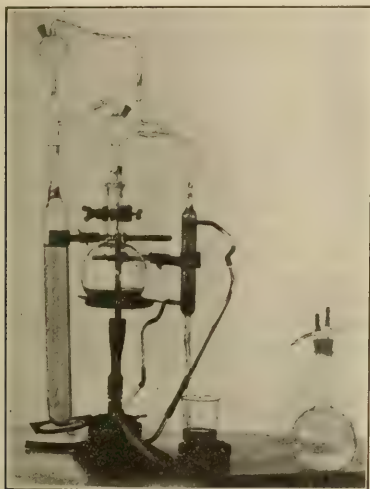


FIG. 3.—SPECIAL APPARATUS USING GROUND GLASS CONNECTIONS AND STOPPERS TO DETERMINE THE INFLUENCE OF RUBBER

The apparatus now used in this laboratory is indicated in Fig. 2. During the course of our investigation the question arose as to the influence of the rubber stoppers and connections. In order to determine this an apparatus was constructed in which all joints and stoppers were ground glass. The determinations made on this apparatus are indicated in Table V. Our conclusion is that the rubber is not objectionable, provided a good grade is used.

AETNA LABORATORY
AETNA EXPLOSIVES COMPANY
AETNA, INDIANA

DETERMINATION OF SMALL AMOUNTS OF BENZENE IN ETHYL ALCOHOL

By F. W. BABINGTON AND ALFRED TINGLE

Received October 28, 1918

For certain war purposes, and under restrictions, the Inland Revenue Department of Canada allows alcohol to be denatured by the addition of benzene. Since 0.5 per cent of benzene is allowed to suffice, a con-

siderable degree of accuracy is required in the determinations made in this laboratory to ensure compliance with the regulations.

At first the method used was a slight variation of that published by Holde and Winterfeld,¹ as modified by Wolff.² As admitted by these authors, the results are below the truth. Holde and Winterfeld apply a correction of +0.3 per cent. It is obviously impossible to obtain satisfaction from a method which calls for a correction equal to 60 per cent of the probable total.

Having satisfied ourselves that the method is subject to errors arising both from the principles on which it rests and from its manipulative details, we have designed another means of measurement which is both more accurate and more rapid. This is now adopted as the standard method for its purpose by the Inland Revenue Department of Canada.

DESCRIPTION OF THE HOLDE-WINTERFELD-WOLFF METHOD

To 100 cc. of the alcohol-benzene solution, water is added till the sp. gr. is brought to 0.96. This mixture is distilled, the first 10 cc. (Holde-Winterfeld) or 20 cc. (Wolff) of distillate being collected and transferred to a graduated vessel. The distillate is diluted with 20 cc. water (Holde-Winterfeld) or 80 cc. saturated brine (Wolff). The volume of benzene which separates is read, giving the percentage direct. It usually takes 2 to 3 hrs. for the benzene to collect sufficiently for the reading to be made. The benzene layer is never clear and the accurate determination of its limits is usually very difficult.

RESULTS BY THE HOLDE-WINTERFELD-WOLFF METHOD

The determinations tabulated below were made upon solutions of benzene in alcohol (95 per cent by volume) prepared with great care to known strengths. In all cases the first portion of distillate taken was 10 cc. In some cases a second portion of the next 10 cc. or 20 cc. was collected and examined separately. The figures show, however, that this precaution is unavailing, as the amount of benzene so collected is too small for detection by this method.

Expt. No.	Volume of Distillate Collected		Volume of Benzene Found		Total Benzene Found		
	First Run-nings	Second Run-nings	First Run-nings	Second Run-nings	Uncorrected Per cent	Per cent Corrected ¹	Benzene Actually Present Per cent
1	10	0.0	0.0	0.0	0.0	0.3	0.2
2	10	10	0.0	0.0	0.0	0.3	0.2
3	10	10	0.3	0.0	0.3	0.6	0.4
4	10	10	0.4	0.0	0.4	0.7	0.8
5	10	10	0.5	0.0	0.5	0.8	0.8
6	10	10	1.2	0.0	1.2	1.5	1.6
7	10	20	1.3	0.0	1.3	1.6	1.6

¹ Correction made by adding +0.3 according to Holde and Winterfeld.

It is evident that without the use of a correction, the figures obtained are so inaccurate as to be useless, and that the "correction" is only correct for cases where the benzene is present to the extent of nearly 1 per cent or more. For our purposes such a method is useless.

¹ *Chem.-Ztg.*, **32** (1908), 313.

² *Ibid.*, **34** (1910), 1193.

DESCRIPTION OF CANADIAN INLAND REVENUE METHOD

To 100 cc. of the solution to be tested, 200 cc. of water are added. No matter how strong the alcohol this is enough water to bring the sp. gr. above 0.96, and a moderate excess of water is no disadvantage. The mixture is distilled and the first 20 cc. of the distillate is collected in a suitable graduated vessel.

We have found a straight 50 cc. Eggertz tube, divided into tenths of a cubic centimeter, very suitable. It must be provided with a close-fitting straight-sided rubber stopper for insertion when the distillation is completed. A 50 cc. burette may be substituted for the Eggertz tube if allowance is made for the volume of the undergraduated portion immediately above the stopcock. Some such straight-sided vessel has great advantages over one in the form of a flask, and graduated cylinders with small enough subdivisions cannot easily be obtained.

Should it be suspected, from the appearance of the mixture after dilution, that the benzene present exceeds 0.75 per cent, it is a wise precaution to collect a further 10 cc. of distillate (making 30 cc. in all) in a separate vessel. This second running should be treated like the first 20 cc. and any benzene found in it should be added when the percentage is being calculated.

The rate of distillation should be about 1 cc. per min., and should not be allowed to exceed 1.5 cc. per min. To the distillate thus obtained is added 15 cc. of potassium dichromate solution ($\frac{1}{4}$ % saturated) followed by 2 cc. of hydrochloric acid (sp. gr. 1.2). After mixing well, the closely stoppered tube is allowed to stand till an olive-green color develops. Fifteen minutes generally suffices. By careful measurement from a pipette, 10 cc. of petroleum ether are next added to the contents of the tube. The mixture is thoroughly agitated, then allowed to separate into two layers, and the volume of the upper layer read. This volume less 10 cc. gives the percentage of benzene present in the sample.

In the table below will be found the results obtained by this method on the same mixtures employed for our determinations by the Holde-Winterfeld-Wolff method.

TABLE II

Expt. No.	Volume of Distillate Collected		Volume of Benzene Found		Total Benzene Found Per cent	Benzene Actually Present Per cent
	First Runnings	Second Runnings	First Runnings	Second Runnings		
7	20	..	0.2	..	0.2	0.2
8	20	..	0.2	..	0.2	0.2
9	20	..	0.4	..	0.4	0.4
10	20	..	0.4	..	0.4	0.4
11	20	..	0.7	..	0.7	0.8
12	20	..	0.7	..	0.7	0.8
13	20	..	1.4	..	1.4	1.6
14	20	10	1.5	0.1	1.6	1.6

The above table shows only three divergences between the benzene found and that known to be present. In every case this is due to our having neglected the precaution we recommend of collecting a second portion of distillate. Such errors are small and only occur where the percentage of benzene is relatively high.

Certain experiments which we have made, the details of which need not be given, show that the presence of a large amount of acetone in the distillate would increase the apparent amount of benzene.

Pyridine would give a similar result, but its interference can be quite overcome by increasing to 3 cc. the amount of hydrochloric acid added in the oxidation stage of the determination.

It may be noted that determinations can be made more rapidly by the new method than by the old, the accuracy being at the same time increased, while the use of an arbitrary correction is avoided.

ANALYTICAL LABORATORY
DEPARTMENT OF CUSTOMS AND INLAND REVENUE
OTTAWA, CANADA

THE PROXIMATE ANALYSIS OF WOOD

By W. H. DORE

Received October 21, 1918

This paper is a preliminary report on a study of the chemistry of certain California woods from the standpoint of their chemical utilization. As the first step in this investigation a complete proximate analysis of these woods has been undertaken and a consideration of the analytical methods employed and results obtained is herewith presented.

There have been numerous contributions to the literature of wood chemistry in recent years. Most of these have been of a rather scattering nature, but several investigators have undertaken the systematic investigation of the chemistry of particular woods. While much information as to constituents of wood and methods of procedure has resulted from these studies, the data now available has the defect of not being summative. Examples of complete analyses of woods are practically absent from the literature, if we except a few attempts in which the undetermined matter is broadly classified as "non-cellulose material by difference."

An analysis of a wood in which all of its material is accounted for appears to have advantages over one that gives a number of constants of the wood without expressing their summative value, from both theoretical and practical standpoints. Our knowledge of the chemistry of wood cannot approach completeness as long as there is a large gap of undetermined constituents. Neither can a wood be completely evaluated commercially until all constituents of possible economic importance have been determined.

In view of the exceedingly complex nature of wood and the meagerness of our knowledge of wood chemistry, a complete analysis can mean nothing more than a separation of the wood substance into groups of compounds. It appears to be quite practicable, however, to effect a grouping of wood constituents on the basis of chemical similarity that will have definite theoretical and commercial significance and serve as a starting point for further study.

The structural substance common to all woods is ligno-cellulose, a material in which two constituents (cellulose and lignin) are found and which are believed by most investigators to be chemically combined. Somewhat allied to cellulose are the hemi-celluloses, distinguished from true cellulose by a feebler resistance to the action of chemical reagents. These substances are found to a greater or less degree in all

woods. Of a more incidental occurrence are the extractives, a heterogeneous class of bodies found in woods and believed to be in the nature of excretory products of the life processes. As their name implies, these extractives may be removed from the woods by treating with solvents without affecting the wood tissue. The extractives include volatile oils, resins, tannins, dyes, and other substances of less common occurrence.

The analyses given in this paper include determinations of loss on drying, extractives soluble in benzene, extractives soluble in alcohol, substances soluble in water, substances soluble in 1 per cent sodium hydroxide solution, cellulose, and lignin. It is believed that this classification of wood constituents includes practically all substances occurring in woods and that it is sufficiently logical and useful to warrant its adoption.

The methods of analysis which are now to be described have been adapted from a variety of sources. The author has drawn extensively upon the published writings of Cross and Bevan, König and Rump, Schorger, and others, for methods of procedure. A recent article by Johnsen and Hovey describes several novel methods that are worthy of attention. Unfortunately the article did not come to the author's attention until after his experimental work had been performed and he was therefore unable to make use of the suggestions offered.

EXPERIMENTAL

The work here described is a preliminary study chiefly for the purpose of determining the applicability of the analytical methods to different woods. The figures given are not to be regarded as necessarily indicating the average composition of trees of the species named, as no special attempt was made to make the samples strictly representative.

Sample 1—Redwood (*Sequoia sempervirens*), a slab from a tree about 2 ft. in diameter. Composed mostly of sapwood but including a small amount of the outer portion of the heartwood. Not weathered.

Sample 2—Yellow pine (*Pinus ponderosa*), and Sample 3, sugar pine (*Pinus lambertiana*), were also slabs. Representative of sapwood only. Not weathered.

Sample 5—Live oak (*Quercus aquifolia*), obtained from a number of large chips. Well weathered.

Sample 6—Blue gum (*Eucalyptus globulus*), a log about 6 in. in diameter. Well weathered.

For the analytical sample, fine sawdust was prepared by making a number of cross-sectional cuts with a hand-saw having 11 teeth to the inch. The sawdust so obtained contained a few large fragments of wood which were removed by passing through a 2 mm. sieve. The samples were kept in Mason fruit jars with the lids screwed down tight to avoid changes in moisture content.

ANALYTICAL METHODS

LOSS ON DRYING—2 g. of the wood are air-dried at 100° C. in a constant-temperature electric oven to constant weight. The first weighing is generally made after 16 hrs. drying (over night) and the second

after 24 hrs. In most cases there is practically no difference between these weighings.

BENZENE EXTRACT—2 g. of the wood, dried for 16 hrs. at 100° C., are placed in an alundum thimble and extracted for 6 hrs. in a Soxhlet apparatus. The solvent is evaporated and the residual extract dried for 1 hr. at 100° C.

ALCOHOL EXTRACT—The extracted wood from the above treatment is extracted for 6 hrs. with 95 per cent alcohol which has been treated with potassium hydroxide to remove aldehydes and re-distilled.

WATER SOLUBLE—The above sample of wood, after extraction with benzene and alcohol, is dried at 70° C. over a steam radiator and transferred to a 300 cc. Erlenmeyer flask. 100 cc. of water are added and a reflux condenser fitted to the flask. It is then boiled on a hot plate for 3 hrs., filtered, washed with hot water, dried for 16 hrs. at 100° C., and weighed. For these last operations a Gooch crucible having a cotton cloth disk fitted in the bottom is used. The crucible is dried and weighed in a glass-stoppered weighing bottle, both before and after the filtration. The difference between the weights gives the residue after water extraction. The water-soluble material is calculated by adding loss on drying, benzene and alcohol extracts, and residue after water extraction, and subtracting this sum from the total weight taken or from 100 per cent.

SOLUBLE IN 1 PER CENT SODIUM HYDROXIDE SOLUTION—The dried residue after water extraction is transferred to a 250 cc. beaker by spatula and camel's hair brush. 100 cc. of 1 per cent sodium hydroxide solution are added and the beaker is placed in a boiling water bath containing water at the same level as in the beaker. It is kept in this bath 1 hr., then filtered off on the same Gooch crucible and washed well with hot water. Finally it is washed once with dilute acetic acid (20 per cent), then thoroughly with hot water and again dried in the weighing bottle for 16 hrs. at 100° C. The loss in weight of crucible and contents since the previous weighing represents material soluble in 1 per cent sodium hydroxide solution.

CELLULOSE—2 g. of material dried, extracted with benzene, alcohol, water, and 1 per cent sodium hydroxide as above described, are washed once with water and the excess water drawn off by suction. The moistened residue is then transferred to a 300 cc. Erlenmeyer flask in the following manner: The crucible is inverted over a watch glass and the residue forced out upon it by blowing through the bottom of the crucible. The moist material retains the form of the crucible with the cloth disk upon the top. This is removed with a spatula, the few adhering wood particles are washed off into a beaker, and the cloth is returned to its place in the crucible. The cake of extracted wood is then placed in the flask by inverting the latter over it as it stands on the watch glass and inverting the whole. If a flask with a sufficiently large neck is used this is readily accomplished. Any particles of wood remaining on the watch glass are now rinsed into the crucible as are also those contained in the beaker. They may be transferred to the flask

by a spatula if present in quantity, but a few small particles may ordinarily be neglected as the same filter will be used for the cellulose, and the material will not be lost but will merely escape the first chlorination. These details of manipulation while seemingly complex are quickly and easily carried out after a little practice.

The flask containing the moist sample of extracted wood is then fitted with a perforated rubber stopper carrying a glass tube reaching nearly to the bottom of the flask and terminating on the outside in a short rubber tube. The flask is shaken to break up the cake and distribute the particles over the bottom and thus offer a greater surface to the action of the gas. The tube is connected to the suction pump and the flask exhausted as completely as possible. It is then closed by tightening a pinch clamp upon the rubber tube. The tube is disconnected from the suction apparatus and connected to a chlorine reservoir. Chlorine gas is slowly admitted, the passage of the gas being judged by the rate of passage of bubbles through a wash bottle containing water, interposed between reservoir and flask. During this treatment the flask is cooled by immersion in a beaker of water. As the sample becomes saturated with chlorine the flow of bubbles becomes very slow. This point is taken as the indication of complete chlorination and the flow is interrupted. The flask is then disconnected and a dilute solution of sulfurous acid is immediately added.

The residue is rinsed onto the same Gooch filter and washed with hot water. It is then rinsed into a beaker and 100 cc. of 2 per cent sodium sulfite are added. The whole is boiled for half an hour, after which it is again filtered off on the Gooch and washed thoroughly with hot water.

To secure the complete removal of lignin it is necessary to repeat the entire treatment several times. From 3 to 5 chlorinations alternating with the sodium sulfite treatment are required. The completeness of the process is judged by the appearance of the residue which should consist of fibrous material and should be practically free from unchanged wood fragments. The intensity of color imparted to the sulfite solution is also an index of the quantity of lignin remaining in the fibers.

After the process has been repeated a sufficient number of times to give a pure cellulose, the crucible containing the residue is placed in the glass-stoppered weighing bottle, dried at 100° C. for 16 hrs., and weighed.

In case the sample contains large fragments of wood they will persistently resist chlorination. Sawdust as ordinarily prepared invariably contains a few such particles and in consequence an absolutely pure cellulose is not obtained. In these analyses the residues, after weighing, have always been tested for purity by allowing them to digest in 72 per cent sulfuric acid for 3 hrs. The cellulose is dissolved by this treatment, leaving as a residue any lignin that has not been removed. If appreciable residues are obtained, the mixture is diluted, filtered off on a tared Gooch, washed, dried at 100°, and weighed. The cellulose

determinations are then corrected by deducting the weight of lignin found.

LIGNIN—2 g. of material are dried, extracted with benzene, alcohol, water and 1 per cent sodium hydroxide in the same manner as for the cellulose determination. The dried residue is then transferred to a large Erlenmeyer flask and 20 cc. of 72 per cent sulfuric acid are added. The flask is rotated and shaken until all of the wood particles are moistened with the acid, then left to stand 3 hrs. with occasional attention to see that all particles come in contact with acid. At the end of that time the cellulose is dissolved in the acid, leaving the lignin as a black residue. The mixture is diluted with 50 cc. of cold water and shaken to ensure moistening of all particles, then 300 cc. of boiling water are added. The residue is filtered off on a tared Gooch similar to that used in the other determinations, washed thoroughly with hot water, dried in a weighing bottle for 16 hrs. at 100° C., and weighed as lignin.

By the methods described above, the following results were obtained for the five woods examined. The figures given are in each case the average of a number of determinations. The agreement of duplicate determinations will be discussed later in the article.

TABLE I—ANALYSES OF WOODS—AIR-DRY BASIS
Results in Percentages

Sample No.	1	2	3	5	6
	Red-wood	Yellow Pine	Sugar Pine	Live Oak	Blue Gum
Loss on drying at 100° C.	8.53	8.98	9.84	7.72	10.12
Benzene extract.	0.29	2.02	2.56	0.30	0.06
Alcohol extract.	4.14	3.36	3.78	4.00	2.24
Water soluble.	0.80	1.54	1.98	3.52	1.81
Soluble in 1 per cent sodium hydroxide	7.84	10.47	9.13	7.15	12.25
Cellulose.	47.58	48.38	48.67	47.52	51.48
Lignin.	27.62	23.60	23.25	13.59	13.28
TOTAL.	96.80	96.35	97.12	83.80	91.24

TABLE II—ANALYSES OF WOODS—OVEN-DRY BASIS
Results in Percentages

Sample No.	1	2	3	5	6
	Red-wood	Yellow Pine	Sugar Pine	Live Oak	Blue Gum
Benzene extract.	0.32	2.22	2.84	0.33	0.07
Alcohol extract.	4.33	1.49	1.90	4.33	2.49
Water soluble.	0.87	1.70	2.20	3.81	2.01
Soluble in 1 per cent sodium hydroxide	8.57	11.50	10.13	7.75	13.63
Cellulose.	52.02	53.15	53.98	51.50	57.28
Lignin.	30.20	28.94	28.77	14.73	14.78
TOTAL.	96.51	96.00	96.82	82.45	90.26

DISCUSSION OF METHODS AND RESULTS

SAMPLING—Preparing sawdust is the ideal method of accurate sampling, for the reason that it is the simplest way of obtaining fine material that represents a complete cross section of any given piece of wood. A cross-sectional disk is equally representative, but to reduce it completely to a state of subdivision suitable for analysis by rasping, filing, planing, or other means is a tedious and difficult task. If only a part of the disk is used, much care is required to make the portion taken representative of the disk as a whole.

Other forms that have been recommended by various authors for use in the cellulose determination are shavings by Cross and Beman,¹ and Schorger,² and raspings by Dean and Tover,³ Sieber and Walter,⁴ and Johnsen and Hovey.⁵ Sawdust has generally been looked upon with disfavor, the objections being that the material tends to compact and resist penetration of reagents, particularly chlorine gas, and is

* Numbers refer to corresponding numbers in "References," p. 563

difficult to transfer quantitatively from vessel to vessel without the use of much water from a wash bottle stream.³ In the practice here described these difficulties have been largely avoided and have not appeared to be more serious with sawdust than in the case of similar experiments upon shavings.

The first sample used in this work was prepared from a disk $\frac{1}{2}$ in. thick, cut from a redwood slab (Sample 1). The analytical sample was made by planing shavings from this disk, cutting along the radial lines. The shavings were then broken up by crushing. This material proved unsatisfactory both from the standpoint of ease of manipulation and receptiveness to the action of reagents.

Below is given a comparison of the behavior toward chlorine of redwood, in three different mechanical conditions. The coarse sawdust was prepared by a circular large-toothed saw. The particles over 2 mm. in diameter were sifted out. The other samples were prepared as described.

TABLE III—EFFECT OF MECHANICAL CONDITION ON EASE OF CHLORINATION
SAMPLE 1—REDWOOD

	Number of Chlorinations	Percentage of Lignin in Residue
Shavings.....	4	0.83
	4	0.77
	4	1.61
	4	5.78
Coarse Sawdust.....	4	0.16
	4	1.64
	4	0.30
	4	1.20
Fine Sawdust.....	3	0.53
	3	0.14
	3	0.54
	3	0.48

It will be seen that more lignin is removed from the fine sawdust in three chlorinations than from the coarse sawdust in four chlorinations, also that it is more uniformly removed. The difference between coarse sawdust and the shavings is not so marked but the advantage appears to be slightly with the coarse sawdust. When it is remembered that no effort was spared to secure fine shavings, it is seen that sawdust is decidedly the more satisfactory form of material.

The percentages of cellulose after correction for the lignin in the residues agreed equally well in the different forms of materials.

Schorger⁶ has found it practically impossible to secure a residue of cellulose free from lignins in working with shavings. Johnsen and Hovey,⁵ on the other hand, working with raspings that have passed an 80 mesh sieve but not a 100 mesh one found no difficulty in getting a cellulose that is lignin-free. The author's experience has been that the possibility of completely removing the lignin by chlorination depends solely upon the mechanical state of the sample. No doubt the success of Johnsen and Hovey and the failure of Schorger in that endeavor was due to the fact that the former worked with fine material and the latter with coarse. Fine raspings would, no doubt on account of their uniformity, give a very pure cellulose and, if that were the only consideration, would be the best form of material. The author has preferred to use fine sawdust, with its inevitable occasional coarse particles, for the reason that the material unquestionably is a properly representative sample of the

section cut in making it. When the cellulose residue is corrected for the lignin contained in it the result is as accurate as though a pure cellulose had been obtained and objections to sawdust on the ground that it does not yield a lignin-free cellulose need no consideration.

The selection of material of uniform fineness by the use of fine screens is open to the objection of possibly rendering the sample non-representative. The heavily lignified tissue marking the annual ring, or the grain of the wood, resists mechanical disintegration more than the less lignified material between these rings, and one would therefore expect in the coarser fractions a larger proportion of lignin. The removal of large fragments by a coarse screen does not affect the validity of the sample in the same way, as these fragments have practically the same composition as the entire wood.

LOSS ON DRYING—The matter of drying wood and cellulose has been investigated by various authors and has been studied quite thoroughly in recent years by Renker.⁷ Cellulose retains water persistently at temperatures above 100° C. Although the hygroscopic moisture may be estimated with approximate accuracy by drying to constant weight at 105° to 107°, there is no sharp line of demarcation between hygroscopic moisture and water of hydration lost at higher temperatures. It is apparent therefore that the method here practiced is not to be regarded as an accurate moisture determination but an arbitrary treatment for certain purposes that require an explanation at this point.

It is necessary to dry the material at several stages in the course of analysis and it is essential that the drying should be made each time under the same conditions in order that the results be strictly comparable. It is necessary to remove most of the moisture before beginning the extraction with benzene in order to minimize the danger of hydrolysis during extraction. The loss of weight of the wood substance under the same drying conditions as its fractions are later to be dried is one of the necessary analytical determinations to be included in a summative analysis. As low a temperature as is compatible with approximate drying should be used to avoid decomposition of carbohydrates. Taking all of these requirements into consideration, 100° C. appears to be a logical selection. For convenience a constant-temperature electric oven was used and the drying period was invariably over night, or 16 hrs.

In the beginning experiments were made using a vacuum oven and drying at 60° to 70° C. under 23.5 in. of vacuum for 11 hrs. The data for weight lost, benzene, extract and cellulose determinations were obtained in the case of redwood so dried, and were found to be substantially the same as in the case of material dried at 100° C. for 16 hrs. Accordingly it was concluded that there was no advantage in attempting to lower the drying temperature by vacuum methods and the more convenient temperature of 100° C. was adopted and used throughout the work.

It was also found that there was practically no

difference in the results of the cellulose determination whether the material was dried after water extraction and extraction with 1 per cent sodium hydroxide solution, or whether it was chlorinated without intermediate drying. From this it appears that drying at 100° C. probably does not produce chemical changes in cellulose, at least in the case of redwood.

The loss on drying at 100° C. does not include all of the hygroscopic moisture, but is likely to include some essential oil. It is a purely arbitrary determination made for summative purposes.

BENZENE EXTRACT—A comparison of the amounts of material extracted by various immiscible solvents indicated that benzene extracted slightly more material than ether, petroleum ether, or carbon tetrachloride, and slightly less than chloroform, acetone, or carbon bisulfide. The differences were not marked and the selection of benzene was made in order to make the results comparable to those of other investigators who had used this solvent. The chief substances of economic value extracted by benzene are resins and essential oils.

ALCOHOL EXTRACT—This fraction contains tannins and coloring matter if these substances are present in the wood.

After the extraction of the wood with benzene and alcohol the wood structure remains practically unaltered. It then consists essentially of lignocellulose or cellulose and lignin in chemical combination with each other. The terms cellulose and lignin as here used do not refer to two definite compounds, but each represents a class of substances that are more properly referred to as celluloses and lignins. Normal cellulose or alpha-cellulose obtained by the purification of the cotton plant appears to be a single substance with quite definite constants and properties. In addition to this alpha-cellulose, oxycelluloses and celluloses having methoxy and furfural-yielding groups have been identified in woods. Besides these true celluloses a great many other carbohydrates are known to exist in woods. The list includes the hemicelluloses (mannans, galactans, and pentosans) and simple carbohydrates. Probably a great many other unidentified compounds are also present as synthetic or degradation products related to cellulose and other carbohydrates.

For the evaluation of wood for its cellulose-producing power it is necessary to determine the amount of highly resistant or true cellulose. The ideal method will accordingly include a preparatory treatment which will hydrolyze and remove practically all of the less resistant carbohydrates. In practice it is difficult to decide just how drastic a treatment should be employed for this purpose as the line of demarcation between these groups is not well defined.

König and Rump⁸ have made an extensive study of the substances found in plants. They have divided the celluloses and lignins remaining after the removal of constituents soluble in benzene, alcohol, and water into three groups based upon their resistance to reagents. These are designated as the proto, hemic, and ortho groups of cellulose and lignin. Proto-celluloses and protolignins comprise that portion of the

tissue that is hydrolyzed and dissolved by treatment with enzymes or digestion with water under pressure. The hemicelluloses and hemilignins are removed by the treatment of the residue with 1 to 3 per cent sulfuric or hydrochloric acids leaving finally unaffected orthocellulose and ortholignin.

With our present limited knowledge of the nature of these substances the chief interest in this classification is the possibility that it offers of separating the true or resistant cellulose from the less stable carbohydrates. The orthocellulose of the above authors evidently approximates somewhat to true cellulose, while the distinction between proto and hemic forms has probably no particular significance at this point.

The use of a method of acid hydrolysis for separating the hemic groups is open to the objection that some of the true cellulose might be attacked. Cellulose is quantitatively converted into dextrose by acid hydrolysis under favorable conditions and it would seem that a partial conversion under the conditions given by the authors might occur.

Recently Johnsen and Hovey⁹ have suggested the use of a mixture of acetic acid and glycerin for hydrolyzing and removing the hemicelluloses. These authors claim that true cellulose is unattacked by these reagents. It would seem that this method might furnish a satisfactory distinction between the true and the hemic forms of cellulose.

Cross and Bevan¹⁰ have used digestion for 30 min. with a boiling 1 per cent sodium hydroxide solution for removing the hemicelluloses. Renker⁷ considers that the treatment with sodium hydroxide solution attacks to some extent material that should be regarded as true cellulose and that the digestion should be omitted. Schorger¹¹ makes the same claim and suggests a broader definition of cellulose to include such hemicelluloses as may survive chlorination and sulfite treatment.¹²

In these experiments the author has followed the procedures of Cross and Bevan, using the alkaline treatment for the separation of the hemicelluloses. The method is arbitrary but has the advantage of paralleling such industrial practices as involve alkaline digestion.

A comparison is here given of two analyses of coarse redwood sawdust (Sample 1A). In one of these the alkaline digestion was carried out as described. In the other, cellulose and lignin were determined upon portions in which the alkaline digestion was omitted.

TABLE IV—EFFECTS OF ALKALINE DIGESTION—REDWOOD
Results in Percentages

	Alkaline Treatment	
	Used	Omitted
Loss on drying	13.17	13.17
Benzene extract	0.32	0.32
Alcohol extract	3.85	3.85
Water soluble	0.64	0.64
Soluble in 1 per cent sodium hydroxide	7.38	7.38
Cellulose	45.10	49.11
Lignin (brown ammonia lignin)	28.45	31.38
TOTAL	98.91	98.47

It will be seen that in the case in which the alkali was used the amount of cellulose was 4.01 per cent less and the lignin 2.93 per cent less. The sum of these, or 6.94 per cent, represents the hemic forms of these substances dissolved by the sodium hydroxide

and accounts for most of the 7.38 per cent sodium hydroxide-soluble material.

The water-soluble portion probably contains very easily hydrolyzable carbohydrates and lignin. Klason¹³ has shown that in the case of pine wood, wood gum and bodies closely related to lignin are extracted by boiling water.

Of the numerous methods that have been devised for the determination of cellulose the chlorination method of Cross and Bevan is the only one in which the separation is based upon specific reactions of the lignin group. The other methods depend upon selective oxidation or hydrolysis and have the defect of being unable to remove completely the non-cellulose portion without to some extent affecting the cellulose.

Cross and Bevan¹⁴ long ago demonstrated that when moist lignocellulose is brought into contact with chlorine gas the lignin forms a substitution product that is soluble in sodium sulfite solution. The authors realized that excessive chlorination resulted in secondary reactions in which the cellulose was partially oxidized, but they showed that by limiting the time of action of the gas and cooling the material to 0° C. during chlorination the oxidation reaction could be controlled and accurate results obtained.¹⁵

The method of Cross and Bevan has been critically studied by Renker⁷ who, in addition to limiting the time of chlorination and cooling, adds sulfurous acid solution immediately after chlorination to prevent oxidation. More recently Schorger has made use of the same agencies.

The chlorination as accomplished by Cross and Bevan and by Schorger has been carried out by spreading the material out in beakers and causing a slow flow of chlorine into the beakers so as to bathe the fibers continuously in fresh gas. The work of all these authors tends to show that after sufficient chlorine has been absorbed to form the substitution compound any further exposure to the gas results in partial oxidation of the cellulose. The only effective control therefore is to limit the time of chlorination. The first chlorinations were of 30 to 60 min. duration, the later, 15 to 30 min.

Sieber and Walter,⁴ and more recently Johnsen and Hovey,⁹ carried the reaction on in Gooch crucibles so arranged that the chlorine gas is drawn through by suction. Using fine rasped material, these authors find 4 chlorinations of 20, 15, 15, and 10 min. with the usual intermediate sulfite treatments sufficient to remove all lignin without any oxidation effects. This method has manipulative advantages in that the material remains in the same vessel throughout the process.

In all of the methods here described the material is kept in an atmosphere containing an excess of chlorine over that required for the substitutive reaction and it is attempted to stop the reaction at about the time this reaction is completed and before oxidation begins. The method used by the author in this investigation differs from these in that oxidation is controlled by limiting the amount of chlorine used and never exposing

the fibers to an excess of the gas. This is accomplished by first opening up the pores of the fiber and the space between fibers by evacuating the container, then allowing the chlorine to be drawn into the vacuum. As the substitution in the fiber progresses more gas will be drawn in until the reaction is complete, when the flow will almost stop. This affords a reliable indication of the completeness of the main reaction, and the danger of over-chlorination due to large excess of chlorine in the surrounding atmosphere is obviated.

In order to test the extent to which oxidation is controlled by this treatment, a sample of coarse redwood sawdust (Sample 1A) was chlorinated in the ordinary way in a flask cooled by immersion in a beaker of water at room temperature. Parallel determinations were made on the same sample in which the flasks were packed in a mixture of ice and salt. Cross and Bevan¹⁵ found that by cooling the material to 0° C. during chlorination the yield of cellulose was increased several per cent, due to the control of oxidation. If oxidation were not prevented by the method here employed it would be expected that the results when the freezing mixture was used would be appreciably higher. An examination of the figures below will show that there is practically no difference in the results secured by the two treatments, indicating that oxidation is probably completely controlled without the use of special cooling.

TABLE V—EFFECT OF COOLING—COARSE REDWOOD SAWDUST
Results in Percentages

	Total Residue	Lignin in Residue	Cellulose
Coarse sawdust, water-cooled, 4 chlorinations	45.08	0.16	44.92
	46.63	1.64	44.99
	45.42	0.30	45.12
	46.74	1.20	45.54
Coarse sawdust, in crushed ice and salt, 4 chlorinations	44.95	0.08	44.87
	45.70	0.54	45.16

The data given in the above tabulation show the usual agreement of duplicate cellulose determinations. A variation of several tenths of one per cent is to be expected ordinarily. It should be stated that determinations in which there is a high lignin correction are generally unreliable and such determinations have been excluded from the averages. As examples the following figures for yellow pine and blue gum are quoted.

TABLE VI—AGREEMENT OF CELLULOSE DETERMINATIONS
Results in Percentages

	Total Residue	Lignin in Residue	Cellulose
Sample 2, Yellow Pine	48.40	0.11	48.29
	49.29	0.52	48.77
	52.22	2.29	49.93x
	48.19	None	48.19
	48.27	None	48.27
	51.50	1.37	50.13x
	48.36	None	48.36
Sample 6, Blue Gum	55.89	2.09	53.80x
	51.84	0.26	51.28
	51.84	0.51	51.53
	53.15	1.53	51.62x

The figures marked x are those having large lignin corrections and in all cases but one the results are considerably higher than those with small lignin corrections. The differences between duplicate lignin determinations were of about the same magnitude as in the case of cellulose.

The method used for the determination of lignin is that used by König.¹⁶ This author found that by

treating extracted wood with 72 per cent sulfuric acid after the method employed by Ost and Wilken-¹⁷ there remained a residue of non-cellulose material or lignin. Later König and Rump⁸ found that in this treatment proto- and hemilignins were dissolved by the sulfuric acid as were also a part of the ortholignins. The black residue remaining was termed by these authors "colored ortholignin."

It is evident that this "colored ortholignin" is not a measure of the full lignin content of the wood. Apparently it bears some definite relation to true lignin and von Fellenberg¹⁸ has advanced the theory that König's ortholignin differs from true lignin by 2 molecules of water. For true lignin the formula $C_{22}H_{19}(CH_3)_2O_9$ is proposed and for König's colored ortholignin $C_{22}H_{15}(CH_3)_2O_9$. If these relations hold, the weight of residue obtained by the method here used may be calculated to true lignin by multiplying by a factor that corrects for the two lacking molecules of water. As derived from the ratio of molecular weights of the above compounds this factor is 1.086.

As a test of the applicability of this correction to the results obtained the figures for lignin in the case of the three coniferous woods examined have been multiplied by 1.086 and the sum of the constituents using the new figures has been determined.

TABLE VII—CORRECTION OF LIGNIN DETERMINATIONS
Results in Percentages

	1 Red wood	2 Yellow Pine	3 Sugar Pine
König's colored ortholignin.....	27.62	23.60	23.23
Above figures $\times 1.086$ (von Fellenberg's true lignin) 30.00	30.00	25.63	25.23
Sum on basis of König's lignin.....	96.80	96.35	97.12
Sum on basis of von Fellenberg's lignin.....	99.18	98.38	99.12

It is seen that the totals using this correction are considerably closer to 100 per cent than those using the figures obtained by analysis in the case of the coniferous woods. These findings are consistent with von Fellenberg's theory and indicate the possibility of an accurate lignin determination based upon the method of König with a factor correction. A more complete study of the relation between these two forms of lignin will be required, however, before these figures can be accepted. The author intends to make a further study of these relations.

The totals shown in Tables I and II indicate that in the case of the coniferous woods practically all of the constituents are accounted for, while with the hardwoods such is not the case. This is at least partly due to the nature of the lignin. The lignin obtained from the coniferous woods appears to be a homogeneous substance having the same physical form as the original material. In the case of the two hardwoods examined, there appeared to be a certain amount of material of an appearance somewhat similar to that of the coniferous woods, but in addition a large amount of colloidal substance was obtainable. It is evident that the lignin of the hard woods is a much more complex substance than that of the conifers and that the method of König for its determination does not apply in the case of the former woods. Johnsen and Hovey¹⁹ have come to a similar conclusion, as they state that the method of treating with 72 per cent sulfuric acid applies to spruce and other

conifers but fails entirely with the broad-leaved trees.

In carrying out the lignin determinations considerable hot water was required to wash out the sulfuric acid. The dried residue had a black appearance and it was thought that this might be due to charring during the drying. Several determinations were carried out in which the material was washed slightly with 4 per cent ammonium hydroxide solution followed by hot water to ensure the removal of all sulfuric acid. By this procedure a dull brownish residue was obtained that was somewhat heavier than the black lignin. Two samples of this brown material were Kjeldahled and yielded 0.32 per cent and 0.31 per cent of nitrogen, while a sample of the black material yielded only 0.05 per cent. This indicated that the brown material had taken up ammonia either by absorption or the formation of a compound. Lignin is generally believed to possess acid properties and the formation of an ammonium salt with lignin is not unlikely. The black substance, even after drying, gradually changed over into the brown substance on prolonged digestion in 4 per cent ammonia solution showing that the black color is not due to charring, but is the natural color of the substance.

The possibility of the presence of cutin in woods requires a brief consideration at this point. Cutin is a constituent of barks and epidermal plant tissues generally. It appears to be occasionally present in the wood substance of trees. König and Rump²⁰ have reported the presence in fir and beech of 0.14 per cent and 0.13 per cent cutin, respectively. Cutin is a white substance of waxy appearance and characterized by high resistance to chemical reagents. In the methods here used it remains with the cellulose after chlorination and with the lignin after treatment with 72 per cent sulfuric acid. If present in the woods it would have been left with the lignin correction residue found after treating the cellulose with 72 per cent sulfuric acid. In the case of only one wood, the oak, was any material found that might have been this substance. In that wood a small amount of substance corresponding to the described properties of cutin was obtained but in insufficient quantity to definitely identify it as such. Apparently cutin is not a constituent of importance in the tissue of woods.

In recent years considerable attention has been devoted to the determination of certain constants of woods. These constants include the furfural-yielding groups, methoxy, formyl, acetyl, and acetic residue groups. Schorger²¹ and Johnsen and Hovey²² have lately contributed determinations of these groupings in certain American woods.

These determinations are generally considered as constants of the woods but are in reality constants of constituents of the woods. It appears to the author that a study of the distribution of these constants in the groups, separated according to the scheme outlined in this paper, will have a considerable interpretative value. It is his intention to make such a study.

In general, it may be said that the methods used in this investigation when applied to the conifers account

for practically all of the material of the woods. In the case of the hardwoods, the method for lignin is not applicable, due to the entirely different and highly complex nature of the non-cellulose constituents.

SUMMARY

1—Methods for the summative analysis of woods are described and analyses of five California woods by these methods given.

2—Sawdust is found to be the most satisfactory mechanical condition of wood for analytical purposes.

3—Cellulose in wood is determined by a modification of the Cross and Bevan method involving chlorination *in vacuo*. The cellulose residues are tested for the presence of lignin and corrections applied when necessary.

4—Lignin is determined by König's method with 72 per cent sulfuric acid. The probable relation of lignin so obtained to true lignin is discussed.

5—In the analysis of coniferous woods by these methods 96 to 97 per cent of the wood constituents are accounted for. In the case of the hardwoods examined, the lignin determinations fail and only 83 to 91 per cent of the wood constituents are obtained.

6—Cutin is not a constituent of importance in wood tissue.

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THE DETERMINATION OF IODIDE IN MINERAL WATERS AND BRINES¹

By W. F. BAUGERMAN AND W. W. SKINNER

INTRODUCTION

A large number of methods have been proposed for the determination of iodine in the presence of bromide and chloride and this in itself would seem to indicate that the problem has not been satisfactorily solved. A colorimetric method, depending on the liberation of iodine by nitrous acid and determining

the amount by the intensity of the color imparted to a few cubic centimeters of carbon bisulfide, developed by Struve,¹ modified by Haywood,² has been adopted as a tentative method for the determination of iodide in mineral waters by the Association of Official Agricultural Chemists.³ This method has been studied by the Association of Official Agricultural Chemists and the results reported by one of us.⁴ This report shows that the method gives fairly satisfactory results when applied to mineral waters and brines containing only one or two milligrams of iodine per liter, but that it is not satisfactory when larger quantities are to be determined.

The palladious iodide and thallous iodide methods are reported to give satisfactory results, but the reagents required, palladious nitrate and thallous sulfate, are expensive and not always available. The indirect methods are not suitable where one halogen greatly predominates. Most of the other proposed methods are based on the behavior of solutions of the haloids towards oxidizing agents. Very few, if any, oxidizing agents have been overlooked in the search for a solution of the problem, but some have been only superficially investigated and their limitations not established. An endeavor has been made in this investigation to determine the limitations and suitability of a few of the methods which seemed most promising and to modify them as necessary so that results obtained by their use might be accurate and reliable.

CHEMICALS USED

SODIUM CHLORIDE—The chemically pure reagent was dissolved in water and reprecipitated with hydrochloric acid gas, removed from the liquor by filtration, and finally heated in a porcelain dish until all of the hydrochloric acid had been driven off. It was further purified by several recrystallizations from distilled water.

SODIUM BROMIDE—This was a stock reagent and was purified by recrystallization several times from distilled water.

STANDARD POTASSIUM IODIDE SOLUTION—Potassium iodide was synthesized according to the method employed by Gooch and Browning.⁵ Pure iodine was prepared by twice resubliming C. P. iodine from a small quantity of potassium iodide. Three-fourths of the iodine was added to an excess of electrolytic iron and covered with distilled water. When the iodine had disappeared, the solution was decanted from the excess of iron, the remainder of the iodine added, the solution filtered into a large volume of boiling water to which a quantity of potassium bicarbonate, exactly equivalent to the iodine, had been added and the precipitated iron oxide removed by filtration. It was then made up to a convenient volume and standardized by precipitating and weighing the iodine as silver iodide from aliquot parts by volume.

¹ *Z. anal. Chem.*, **8** (1869), 230.

² Bureau of Chemistry, *Bulletin* **91**.

³ "Methods of Analysis," **1916**, p. 47.

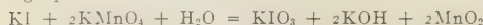
⁴ "Report on Water," W. W. Skinner, Referee A. O. A. C., Bureau of Chemistry, *Bulletin* **162**.

⁵ *Am. J. Sci.*, **39** (1890), 196.

¹ Read before the Division of Water, Sewage, and Sanitation, 56th Meeting of the American Chemical Society, Cleveland, September 10 to 13, 1918.

PERMANGANATE OXIDATION OF IODIDE TO IODATE

Iodide is oxidized to iodate according to the following equation:

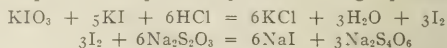


Pean de Saint Gilles,¹ who originated the method, added an excess of potassium permanganate to the neutral or slightly alkaline solution of the haloids, heated a few minutes, added an excess of ferrous sulfate containing sulfuric acid, and titrated the excess of ferrous iron remaining in the solution, or in other words, he determined the amount of potassium permanganate required to oxidize the iodine to iodate. Barneby² calls attention to the important fact that when ferrous iron is titrated with potassium permanganate in the presence of hydrochloric or hydrobromic acids, free halogen is liberated. He recommends, therefore, adding manganese sulfate and phosphoric acid to prevent the liberation of chlorine or bromine. The results reported by him are very satisfactory, iodine being accurately determined in the presence of as much as 20 g. potassium bromide or 10 g. sodium chloride. Klemp³ determined the amount of potassium permanganate necessary to effect the oxidation by observing the point when the permanganate color appears in the solution after adding zinc chloride to facilitate the precipitation of the manganese oxide. This end-point, however, is not very sharp. Reinje⁴ determined the excess of potassium permanganate by titrating with thiosulfate. Sonstadt⁵ precipitated the iodic acid as barium iodate and estimated the iodine in the precipitate, while others recommend destroying the excess of permanganate with alcohol,⁶ or hydrogen peroxide,⁷ removing the manganese oxide by filtration, and titrating the iodic acid in the filtrate iodimetrically.

Gröger's method appears to be the simplest and least complicated and the results in Table I were obtained by the use of this principle which depends upon the relative affinity of the halogens for oxygen, which is different from their affinities for hydrogen. Thus, iodine is most readily oxidized to iodate, and bromide much less readily to bromate, while chloride occupies an intermediate position.⁸ This method is, therefore, especially suitable for determining small amounts of iodine in the presence of large amounts of bromine.

In the experiments, aqueous solutions of potassium iodide or potassium iodide mixed with the other halogen salts, were adjusted to a volume of about 100 cc. in an Erlenmeyer flask, 1 cc. sodium hydroxide solution (4 g. per 100 cc.) added, heated to boiling, excess of potassium permanganate added, and again heated until the precipitated manganese oxide coagulated. It was then allowed to cool, sufficient alcohol added to cause the permanganate color to disappear, and after allowing the precipitate to settle on the steam

bath, it was filtered through a Gooch crucible with suction and washed with hot water. The filtrate, to which 1 or 2 g. of potassium iodide had been added, was acidified with hydrochloric acid and the iodine titrated with sodium thiosulfate. The reactions which take place are expressed by the following equations:



Since only one-sixth of the iodine represents that which was originally present in the sample, the number of cubic centimeters of thiosulfate solution required must be divided by six.

The method is very rapid and the results very accurate. Unfortunately, however, since no separation of the iodine is effected, the solution is not left in a suitable condition for the determination of bromine.

TABLE I—PERMANGANATE METHOD

NaCl Grams Taken	NaBr Grams Taken	I as KI Grams Taken	Total Vol. of Na ₂ S ₂ O ₃ Req'd Cc.	Vol. Na ₂ S ₂ O ₃ Req'd for Iodine Originally Present in Solution Cc.	I Found Gram	Error Gram
..	..	0.0201	9.5 N/10	1.58	0.0200	—0.0001
..	..	0.0602	57.84 N/20	9.64	0.0609	+0.0007
..	5	0.0402	18.99 N/10	3.16	0.0400	—0.0002
..	5	0.0201	19.1 N/20	3.18	0.0201	+0.0000
..	5	0.0201	9.58 N/10	1.59	0.0202	+0.0001
..	10	0.0201	9.58 N/10	1.59	0.0202	+0.0001
..	10	0.0602	28.68 N/10	4.78	0.0606	+0.0004
..	5	0.0012	1.06 N/20	0.18	0.0011	—0.0001
..	10	0.0012	1.02 N/20	0.17	0.0011	—0.0001
..	10	0.0000	0.00 N/20	0.00	0.0000	0.0000

N/20 Na₂S₂O₃, 1 cc. = 0.006320 g. iodine.

N/10 Na₂S₂O₃, 1 cc. = 0.012676 g. iodine.

OXIDATION OF IODIDE TO IODINE BY MEANS OF POTASSIUM BICHROMATE

Dechan¹ proposed a method for the separation of iodides from bromides and chlorides based on the liberation of iodine from neutral solutions of iodides by potassium bichromate according to the equation:



To the sample dissolved in 100 cc. water, he added 40 g. potassium bichromate and distilled with steam. He reports only three experiments and used only small quantities of salts to establish the method, and the results are given below.

Cl Taken Gram	Br Taken Gram	I Taken Gram	I Found Gram
0.0123	0.0126	0.01443	0.01441
0.0560	0.0252	0.02880	0.02833
0.1940	0.0504	0.05760	0.05628

It will be noted that the results for iodine are low, the variation from theory being greater when the quantity is increased. Dechan attributed this to the use of cork instead of glass stoppers in his apparatus, and subsequently described a glass-stoppered apparatus without mentioning whether or not the results were improved by it.

Freidheim and Meyer² repeated the experiments of Dechan, using larger quantities of iodide and found it impossible to set free all of the iodine.

In view of the fact that the statement is made in at least one well-known textbook³ that potassium bichromate will liberate the iodine completely from

¹ *Compt. rend.*, **46** (1858), 624.

² *J. Am. Chem. Soc.*, **37** (1915), 1496.

³ *Z. anal. Chem.*, **30** (1881), 248.

⁴ *Ibid.*, **9** (1870), 39.

⁵ *Chem. News*, **36** (1872), 173.

⁶ Gröger, *Z. angew. Chem.*, **7** (1894), 52; Knudsen, *Chem. Eng.*, **17** (1913), 119.

⁷ *Auger, Bull. soc. chim.*, **11** (1912), 615.

⁸ Roscoe and Schorlemmer, *1*, p. 230; Ostwald, "Principles of Inorganic Chemistry," pp. 272-8.

¹ *J. Chem. Soc.*, **49** (1886), 682; **81** (1887), 690.

² *Z. anorg. Chem.*, **1** (1892), 407.

³ Prescott and Johnson, "Qualitative Analysis," 7th ed., pp. 347 and 367.

iodide, the experiments reported in the table were made.

The distillation flask was made from a 250 cc. ground glass-stoppered wash bottle and the iodine distilled into a 250 cc. salt bottle containing 100 cc. of a potassium iodide solution (10 g. potassium iodide per 100 cc.), which was kept well cooled. A second bottle was connected with this in series, but no iodine went over into the second bottle except a trace in the first three experiments where aëration was employed instead of steam distillation. For steam distillation, the steam was generated from distilled water in a liter Florence flask. In this apparatus, the iodine had no opportunity to come in contact with cork or rubber stoppers. Distillation was continued until about 100 cc. of water had been collected, whereupon it was interrupted and the receiver replaced by another containing a fresh solution of potassium iodide. This was continued until no more iodine was evolved.

An inspection of Table II shows that the results are all low and are not consistent. They confirm Freidheim's and Meyer's statement that iodine cannot be completely set free from iodide by potassium bichromate.

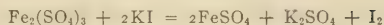
TABLE II—DISTILLATION OF IODINE WITH POTASSIUM BICHROMATE

K ₂ Cr ₂ O ₇	Grams	Solu- tion	Volume of Soln. cc.	NaCl Taken Grams	I Taken as KI Gram	Duration of Dis- tillation, Hrs.	Na ₂ S ₂ O ₃ Solution Cc.	Iodine Found Gram	Error, Gram	Remarks
15	75	..	0.0802	1 1/2	1	1 1/2	5.82 1.54 0.21	0.0701	-0.0101	Boiled and aërated
Total							5.57			
15	75	..	0.0802	1 1/2	2	1 1/2	4.94 0.98 0.26 0.02	0.0781	-0.0021	Boiled and aërated
Total							6.20			
10	75	..	0.0802	1 1/2	1	1	4.60 0.61 0.45 0.21	0.0740	-0.0062	Boiled and aërated
Total							5.87			
20	75	..	0.0802	3	1 1/2	1	5.90 0.18 0.05	0.0772	-0.0030	Distilled in steam
Total							6.13			
40	100	..	0.0602	1	1	1	4.21 0.30	0.0568	-0.0034	Distilled in steam
Total							4.51			
40	100	5	0.0602	1	1	1	4.30 0.30	0.0580	-0.0022	Distilled in steam
Total							4.60			
40	100	5	0.0802	1/4	1	1	4.00 1.35 0.36	0.0719	-0.0083	.....
Total							5.71			
40	100	10	0.0602	1/4	1	1	4.61 0.02	0.0584	-0.0018	.....
Total							4.63			
40	100	10	0.0802	1/4	1	1	6.02 0.22	0.0789	-0.0013	.....
Total							6.27			

Na₂S₂O₃ solution, 1 cc. = 0.0126 g. iodine.

OXIDATION OF IODIDE TO IODINE BY MEANS OF FERRIC SULFATE

The use of ferric sulfate or ferric chloride for the liberation of iodine from iodides according to the equation



has been advocated by many.¹ This method is recommended for the determination of iodine in the presence of bromide and chloride also in practically all modern textbooks on quantitative analysis.² With the exception of Gooch and Mar and Gooch and Ensign, the authors mentioned have not given the method a very thorough investigation. Gavazzi states that when bromides are present, the use of ferric chloride is not permissible, since it will liberate bromine, but that this difficulty is overcome by the use of ferric sulfate, iodine alone being evolved.

Gooch and Mar, working on the problem of a direct determination of chlorine in a mixture of chlorides and iodides, desired a method by which the iodine could be set free and removed from the solution by boiling. They found that from a volume of 300 cc. containing 10 cc. sulfuric acid (1 : 1), 5 g. ferric sulfate, and 0.0059 g. potassium iodide, every trace of iodine had disappeared after 5 minutes' boiling. However, with 1 g. of potassium iodide, all of the iodine was not driven off after boiling for one hour, which they attributed to the establishment of an equilibrium between the ferric sulfate and the ferrous, and they remedied this by adding a small amount of nitric acid to change the ferrous iron to the ferric state.

Gooch and Ensign found the mixture of ferric sulfate, sulfuric acid and nitric acid, recommended above for the separation of iodides and chlorides, unsuitable for the separation of iodides and bromides, because bromine was also liberated.

It was therefore decided to investigate the behavior of ferric sulfate alone. In the following experiments the apparatus employed was the same as in the experiments with potassium bichromate. The ferric sulfate was a C. P. reagent. This forms a clear solution in hot water, but hydrolyzes slightly on boiling. The hydrolysis is considerably increased when salts, sodium chloride for instance, are present.

TABLE III—LIBERATION OF IODINE WITH FERRIC SULFATE

Expt. No.	Fe ₂ (SO ₄) ₃ Taken Grams	NaCl Taken Grams	Iodine Taken as KI Gram	Standard Soln. Cc.	Iodine Found Gram	Error Gram
1	1.5	..	0.0803	12.58 ¹	0.0798	-0.0005
2	1.5	..	0.1004	15.64	0.0992	-0.0012
3	2.0	..	0.1004	15.72	0.0997	-0.0007
4	2.0	..	0.0602	9.40	0.0596	-0.0006
5	1.5	5	0.0602	9.40	0.0596	-0.0006
6	1.5	5	0.1004	15.80	0.1002	-0.0002
7	1.5	10	0.0803	12.60	0.0799	-0.0004
8	1.5	10	0.1004	15.76	0.0999	-0.0005
9	1.5	10	0.0020	0.96 ²	0.0012	-0.0008
10	1.5	5	0.0020	1.10	0.0014	-0.0006
11	1.5	..	0.0020	1.28	0.0016	-0.0004
12	1.5	5	0.0008	0.20	0.0003	-0.0005
13	2.0	..	0.0020	1.22	0.0015	-0.0005
14	2.0	10	0.0020	0.94	0.0012	-0.0008

¹ Experiments 1 to 8, 1 cc. = 0.00634 g. iodine.

² Experiments 9 to 14, 1 cc. = 0.001268 g. iodine.

Volume of solution in distillation flask, 75 cc.

Experiments 1 to 14 in Table III show that in a solution of 75 cc. iodine as potassium iodide in quantities as great as one-tenth of a gram alone, or mixed with as much as 5 or 10 g. of sodium chloride, can be

¹ Carnegie, *Chem. News*, 1891, pp. 60-87; Fallieres, *Z. anal. Chem.*, 25 (1886), 554; von Topp, *Ibid.*, 26 (1887), 299; Weiss, *Rept. anal. chim.*, 6 (1885), 238; Gavazzi, *Gazzetta*, 13, 327, 454; Gooch and Mar, *Am. J. Sci.*, 39 (1890), 293; Gooch and Ensign, *Ibid.*, 40 (1890), 145.

² Olsen, 4th ed., p. 98; Sutton, "Volumetric Analysis," 10th ed., p. 224; Scott, "Standard Methods of Chemical Analysis," 2nd ed., p. 205; Treadwell, "Quantitative Analysis," 3rd ed., p. 656.

determined quite accurately. The iodine is completely removed after 20 or 30 min. distillation.

Experiments 15 to 23, Table IV, show that in a volume of 75 cc., 2 g. of ferric sulfate will liberate bromine from 0.5 g. or more of sodium bromide, but not from 0.4 g. The liberation of bromine proceeds slowly and is not continuous, but ceases as soon as an equilibrium between ferric sulfate and ferrous sulfate is established.

TABLE IV—ACTION OF FERRIC SULFATE ON BROMIDE

EXPT No.	Fe ₂ (SO ₄) ₃ Grams	NaBr Grams	Iodine as KI Gram	Standard Na ₂ S ₂ O ₃ Solution Cc.	Iodine Found Gram
15	2	10.0	0.0000	2.90	0.0184
16	2	5.0	0.0000	1.41	0.0089
17	2	2.0	0.0000	0.40	0.0025
18	2	1.0	0.0000	0.10	0.0006
19	5	1.0	0.0000	0.37	0.0023
20	2	0.5	0.0000	0.01	0.00006
21	5	0.000	0.0000	0.01	0.00006
22	2	0.4	0.0000	0.00	0.0000
23	2	0.4	0.0000	0.00	0.0000

Na₂S₂O₃ solution, 1 cc. = 0.00634 g. iodine.

Volume of solution in distillation flask, 75 cc.

Upon distilling solutions of mixtures of iodide and bromine with ferric sulfate, one would expect that the ferrous sulfate formed by the oxidation of the iodide would prevent or at least hinder the oxidation of the bromide and it is apparent upon comparing the results obtained in Expts. 24 to 30 (Table V) with the results tabulated in Table IV that the supposition is true. Thus, 2 g. ferric sulfate liberated from 10 g. sodium bromide in the absence of iodide, bromine equivalent to 0.0184 g. iodine, and in the presence of 0.0803 g. iodine as potassium iodide, bromine equivalent to only 0.0097 g. iodine (Expts. 15 and 24); also from 5 g. sodium bromide in the absence of iodide, bromine equivalent to 0.0089 g. of iodine, and in the presence of 0.0803 g. of iodine as potassium iodide, bromine equivalent to only 0.0042 g. iodine (Expts. 16 and 25). This can also be demonstrated by distilling a solution containing in 75 cc. 10 g. sodium bromide with a mixture of 2 g. ferric sulfate and 0.2 g. ferrous sulfate.

TABLE V—EFFECT OF BROMIDE ON THE LIBERATION OF IODINE WITH FERRIC SULFATE

EXPT. No.	Fe ₂ (SO ₄) ₃ Grams	NaCl Present Grams	NaBr Present Grams	Iodine as KI Present Grams	Standard Na ₂ S ₂ O ₃ Solution Cc.	Iodine Found Gram	Error Gram
24	2.0	..	10.0	0.0803	14.21	0.0900	+0.0097
25	2.0	..	10.0	0.0803	13.33	0.0845	+0.0042
26	2.0	..	5.0	0.0803	12.76	0.0809	+0.0006
27	2.0	..	1.0	0.0803	12.68	0.0804	+0.0001
28	1.5	..	10.0	0.0803	12.51	0.0793	-0.0010
29	1.5	..	5.0	0.0803	12.52	0.0794	-0.0009
30	2.0	..	1.0	0.0402	6.39	0.0405	+0.0003
31	2.0	..	1.0	0.0201	3.30	0.0309	+0.0008
32	2.0	..	0.5	0.0201	3.18	0.0202	+0.0001
33	1.5	..	0.4	0.0120	9.61 ¹	0.0122	+0.0002
34	1.5	..	0.4	0.0080	6.55	0.0083	+0.0003
35	1.5	..	0.4	0.0020	1.58	0.0020	+0.0000
36	2.0	..	0.4	0.0020	1.68	0.0021	+0.0001
37	1.5	..	0.1	0.0020	1.20	0.0015	-0.0005
38	2.0	10	0.4	0.0020	1.78	0.0022	+0.0002
39	2.0	10	0.4	0.0008	0.55	0.0007	+0.0001
40	2.0	10	0.4	0.0000	0.00	0.0000	-0.0001

¹ Experiments 24 to 32, 1 cc. = 0.00634 g. iodine.

² Experiments 25 to 40, 1 cc. = 0.001268 g. iodine.

Volume of solution in distillation flask, 75 cc.

No bromine will be liberated. On the other hand, when iodide is present in much smaller quantities than in the above experiments, a much smaller quantity of ferrous sulfate is formed and its influence is overcome and superseded by another influence, and the stability of the bromide toward the oxidizing influence of ferric sulfate is decreased. More bromine is liberated when a small amount of iodide is present than when iodide

is entirely absent. In the experiments tabulated in Table III, solutions of pure potassium iodide were distilled with ferric sulfate and in all cases the results obtained for iodine were slightly less than theory. Now it has been demonstrated in Expts. 22 and 23, Table IV, that 0.4 g. of sodium bromide is not decomposed by as much as 2.0 g. of ferric sulfate. However, when a mixture of 0.4 g. of sodium bromide and 0.0120 g. of iodine as potassium iodide was distilled with 1.5 g. ferric sulfate, there was a positive error in the iodine result of 0.0002 g., and a mixture of 0.4 g. of sodium bromide and 0.0080 g. iodine as potassium iodide gave a positive error of 0.0003 g. These errors are small and negligible from an analytical point of view, to be sure, but they show that the stability of the sodium bromide has been decreased. In Expts. 11 and 13, only 0.0016 g. of iodine was obtained from 0.0020 g. of iodine as potassium iodide, while from mixtures of 0.4 g. of sodium bromide and 0.0020 g. of iodine as potassium iodide, 0.0020 g. and 0.0021 g. were obtained (Expts. 35 and 36, Table V). Apparently the accuracy of these last two results leaves nothing to be desired, but their apparent accuracy is probably due to a slight decomposition of the sodium bromide.

In order to investigate this further, the experiments tabulated in Table VI were made. The specified quantity of sodium bromide was introduced into a distillation flask, 75 cc. of water poured in, and then the ferric sulfate added. Pure iodine (Col. 3) was weighed in a weighing tube, the tube introduced into the neck of the distillation flask where the tube was opened and the iodine allowed to fall to the bottom of the flask. The flask was then quickly stoppered and distilled with steam as before. The results show that the presence of iodine reduces the stability of the bromide. We have seen before (Expts. 22 and 23, Table IV) that no bromine will be liberated from 0.4 g. of sodium bromide distilled with 2.0 g. of ferric sulfate, yet in the presence of iodine, 1.5 g. of ferric sulfate decomposed slightly 0.3 g. of sodium bromide (Expts. 45 and 46), also considerably more bromine is liberated from 5 g. of bromide when iodine is present than when it is absent. It seems possible that this is due to the formation of a small amount of bromide.

TABLE VI—INFLUENCE OF IODINE ON THE OXIDATION OF BROMIDE WITH FERRIC SULFATE

EXPT. No.	Fe ₂ (SO ₄) ₃ Taken Grams	NaBr Taken Grams	Iodine Taken Gram	Na ₂ S ₂ O ₃ Solution Cc.	Iodine Found Gram	Error Gram
41	0.0	0.0	0.0486	7.60	0.0480	-0.0006
42	1.5	0.0	0.0439	6.72	0.0425	-0.0014
43	0.0	3.0	0.0548	8.48	0.0536	-0.0012
44	1.5	0.1	0.0390	6.10	0.0386	-0.0004
45	1.5	0.3	0.0418	6.78	0.0428	+0.0010
46	1.5	0.5	0.0512	8.20	0.0518	+0.0006
47	1.5	0.5	0.0431	6.96	0.0440	+0.0009
48	1.5	5.0	0.0586	11.45	0.0724	+0.0138
49	1.5	5.0	0.0385	8.04	0.0508	+0.0123

Na₂S₂O₃ solution, 1 cc. = 0.00632 g. iodine.

Volume of solution in distillation flask, 75 cc.

Bergland,¹ working on a method for estimating bromine in the presence of chloride by liberating the bromine with potassium bisulfate and potassium permanganate and removing it by aspiration, also found

¹ Z. anal. Chem., 1885, p. 184

that chloride was less stable toward the oxidizing agent in the presence of a bromide.

The reaction between ferric sulfate and a solution containing iodide and bromide is, therefore, somewhat complicated. It is a reversible reaction. Using quantities of ferric sulfate and potassium iodide given in Table III, we see that the reaction proceeds completely to the right, but by adding ferrous sulfate it can be prevented from proceeding entirely to the right and not all of the potassium iodide will be oxidized. Substituting sodium bromide for potassium iodide, we see in Expts. 15 to 21, Table IV, that only a small amount of bromide is decomposed and that an equilibrium is established as soon as a small amount of ferrous sulfate is formed. With mixtures of iodides and bromides, if there is present sufficient iodide to form an appreciable amount of ferrous sulfate, this ferrous sulfate will prevent, or at least hinder, the decomposition of the bromide. Now we have also seen that upon distilling a mixture of bromide, iodine, and ferric sulfate, there is certain evidence which points to the formation of a brom-iodide. Ferrous sulfate will hinder the formation of this brom-iodide, so if iodide is present in amounts equivalent to from 0.040 to 0.100 g. of iodine, the iodine may be separated, by distillation with ferric sulfate, from as much as 1 or 2 g. of sodium bromide without any appreciable error due to the liberation of bromine or the formation of brom-iodide. Sufficient ferrous sulfate is formed by the oxidation of the potassium iodide to prevent the liberation of bromine or the formation of brom-iodide.

If the amount of iodine as iodide present is less than 0.040 g., then bromine will be liberated from the above amount of bromide along with the iodine and probably also some brom-iodide will be formed because not sufficient ferrous sulfate is formed to prevent it. And now, finally, if we have a very small amount of iodine, equivalent to only 0.002 or 0.003 g. of iodine in solution with 0.3 or 0.4 g. of sodium bromide, it is not likely that any free bromine is liberated but a small amount of brom-iodide is formed and distills over with the iodine.

It is apparent, therefore, that in distilling mixtures of bromide and iodide with ferric sulfate the stability of the bromide depends upon the absolute concentration of bromide and also upon the ratio of the concentration of iodide to the concentration of bromide, and that this method is not as reliable as the permanganate method. If, however, one is only interested in removing iodine so that it will not interfere with the subsequent bromine determination no difficulty will be encountered. The sample of brine or mineral water used for the bromine determination will not as a rule contain more than 0.1 g. of bromine and usually less on account of the small content of bromide compared with the content of other salts and the disadvantage of working with more than 10 g. or so of salts. Experience has shown that iodine can be accurately separated from such a quantity of bromide. This will be more fully brought out in a subsequent paper.

Iodide in the presence of a large amount of bromide may be determined by making a double distillation

with ferric sulfate. The first distillate consisting of iodine and a small amount of bromine is collected in 100 cc. of a sodium hydroxide solution (50 g. per liter) containing 5 to 10 cc. of 3 per cent hydrogen peroxide. The distillate is then boiled down to 40 to 50 cc. and made slightly acid with sulfuric acid. If any iodine is liberated during acidification, it is reduced with a few drops of a solution of sodium sulfite or sodium thiosulfate. It is then washed into the distillation flask, made up to a volume of 75 cc., 1.5–2.0 g. ferric sulfate added, and distilled with steam into a potassium iodide solution (10 g. potassium iodide per 100 cc.) which is then titrated with sodium thiosulfate. The results tabulated in Table VII were obtained by this method.

TABLE VII.—DOUBLE DISTILLATION WITH FERRIC SULFATE
(1.5 G. Ferric Sulfate Used for Each Distillation)

NaCl Taken Grams	NaBr Taken Grams	KI Taken Gram	I as Found	Error Gram
..	..	0.0803	0.0790	—0.0013
..	..	0.0402	0.0389	—0.0013
..	..	0.0201	0.0196	—0.0005
..	5.0	0.0803	0.0784	—0.0019
5	5.0	0.0803	0.0784	—0.0019
..	5.0	0.0402	0.0391	—0.0011
..	5.0	0.0602	0.0578	—0.0024
..	10.0	0.0201	0.0195	—0.0005

These results are fairly satisfactory but not as good as those obtained by the permanganate method, while the procedure is more time-consuming and difficult to carry out.

CONCLUSIONS

The permanganate method is recommended for the determination of iodine in mineral waters and brines and accurate results can be obtained by observing the following directions:

Take such a quantity of the brine or water as will contain not more than 0.1 g. iodine as iodide or more than 10 g. total salts, adjust the volume to 100 to 150 cc. and boil it with a sufficient amount of sodium hydroxide and sodium carbonate to precipitate the calcium and magnesium. Filter off the precipitate and wash with hot water, introduce the filtrate into an Erlenmeyer flask, adjust the volume to about 100 cc., neutralize with dilute sulfuric acid, and add 1 cc. of a solution of sodium hydroxide (4 g. per 100 cc.). Heat to boiling, add an excess of potassium permanganate, continue the heating until the precipitate begins to coagulate, and then allow to cool. Add sufficient alcohol to cause the permanganate color to disappear and allow the precipitate to settle on the steam bath. Filter and wash with hot water. After cooling, add one or two grams of potassium iodide, acidify with hydrochloric acid, and titrate with standard thiosulfate. The number of cubic centimeters required, divided by six, represents the number of cubic centimeters required by the iodine originally present in the sample.

The iodine may be removed from the sample in which bromine is to be subsequently determined according to the following method:

The neutral or slightly acid sample which should contain not more than 0.1 g. of bromine or 10 g. total salts is introduced into the distillation flask and adjusted to a volume of approximately 75 cc., 1.5–2.0 g. of ferric sulfate added, the liberated iodine distilled with steam into 100 cc. of a potassium iodide solution (10 g. potassium iodide per 100 cc.). The potassium iodide solution may be titrated with sodium thiosulfate solution and the result used to check the figure obtained by the permanganate method. The bromine may be determined in the liquid remaining in the distillation flask according to a method which will be described in a later paper.

SUMMARY

The permanganate method for the determination of iodine in the presence of bromides and chlorides gives very satisfactory results.

Distillation with potassium bichromate will not completely liberate iodine from iodides.

Iodide in the presence of as much as 10 g. sodium chloride can be determined with satisfactory results by distilling with ferric sulfate.

Iodide can be determined quite accurately in the presence of bromide by a single distillation with ferric sulfate if the quantity of bromide present in the sample does not greatly exceed 0.4 g. This method is especially recommended for removing iodine from the sample which is to be used for the bromine determination.

Iodine may be determined in the presence of large amounts of bromide by making a double distillation with ferric sulfate. However, this method is more tedious and time-consuming than the permanganate method and the results obtained not quite so accurate.

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STUDIES ON CANNING¹

AN APPARATUS FOR MEASURING THE RATE OF HEAT PENETRATION

By W. T. BOVIE AND J. BRONFENBRENNER

Received December 17, 1918

The changes in the rate of destruction of bacteria at various temperatures is no exception to the general rule that the speed of reactions greatly increases with temperature. For example, according to Miss H. Chick, the temperature coefficient,² μ , for the killing of *Bacillus typhosus* in hot water is 92,000,³ and for the destruction of the *Bacillus paratyphosus* by means of phenol $\mu = 48,000$. For comparison, the value μ for the hydrolysis of cane sugar by acid is given by Arrhenius as 25,600.

Since the rate of sterilization is inversely proportional to the time necessary for killing, we have, in any problem of sterilization by heat, at least two variables—time and temperature. In the case of sterilization of canned foods by heat a third variable, namely, the distance of any particular organism from the surface of the can, must be considered. It is impossible from the data now at hand to formulate a law connecting these three variables—time, space, and temperature—for, due to the heterogeneous nature of most canned goods and the possible changes in the physical properties as sterilization proceeds, there is an ever varying amount of heat transferred by con-

¹ This work is a part of the investigation of food poisoning, conducted under the direction of Dr. M. J. Rosenau, Professor of Preventive Medicine and Hygiene, Harvard Medical School. The investigations were done under the auspices of the Advisory Committee of the National Research Council on the Toxicity of Preserved Foods, and under a grant to Harvard University from the National Canners' Association.

² The relation between the rates of destruction K_0 and K_1 for two different temperatures T_0 and T_1 , respectively, is given by the formula

$$K_1 = K_0 e^{\frac{\mu(T_1 - T_0)}{T_0 T_1}}$$

in which e is the base of the natural system of logarithms, and μ is a constant which is greater the more rapid the rate of destruction.

³ Calculated from the data given by Miss H. Chick, "The Process of Disinfection by Chemical Agencies and Hot Water," *J. Hyg.* 10 (1910), 237.

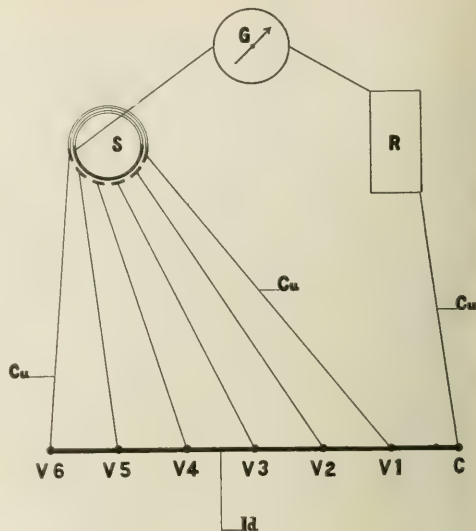


Fig. 1

vection from the outside of the can towards the center. A mathematical treatment of the problem such as might be given for the transfer of heat in a solid conductor, as a disc of iron, is quite out of the question.¹

In the present paper a method is described for determining experimentally the rate of heat transfer in canned foods, during the process of sterilization. The apparatus to be described below has passed through

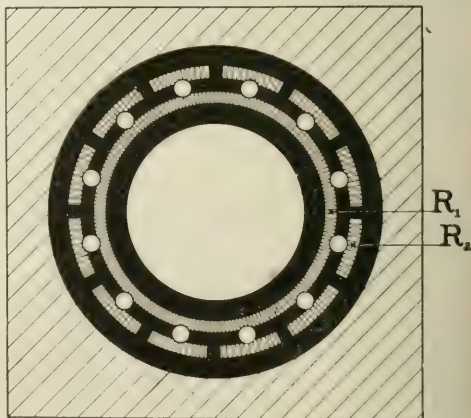


Fig. 2

¹ R. E. Buchanan gives a formula which contains the diffusivity of the canned food as a constant term. Experiments which will be reported later show that, especially with starchy foods, the diffusivity changes during the process of cooking. The change is undoubtedly caused by the absorption of water by the various components of the food. Since the amount of this absorption is influenced by the ripeness of the food, the acidity, etc., the possibility of a practical application of Buchanan's formula seems very doubtful. (R. E. Buchanan, *et al.*, "Notes on Conditions which Influence Thermal Death Points," *Abstr. of Bad.*, 2 (1918), 5.)

various stages of improvement until a form yielding quite satisfactory results has been obtained. Our problem consists in finding the rate of transfer of heat from the outside towards the center of cans of food during the process of cooking and sterilization, as affected by the variations of the autoclave temperature, size of can, viscosity of the food, etc., such as are encountered by the commercial canner. It was necessary, therefore, to make the temperature measurements while the can was sealed and under pressure in the autoclave. Therefore, an electrical method of measuring the temperature was selected.

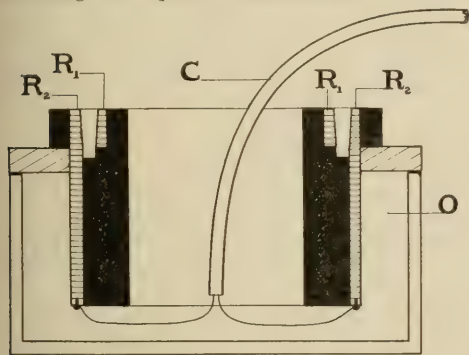


FIG. 3

At first we considered adopting the apparatus which was used by Dr. Buchanan in the experiments referred to above and which Dr. G. E. Thompson was kind enough to describe to us in detail in private correspondence. This apparatus consists of a thermocouple, the constant junction of which is kept outside of the autoclave at a temperature of 0°C ., and the variable junction is led to the center of the can within the autoclave through a suitable steam-tight joint. It is evident that with this arrangement, the temperature variations of the autoclave must be recorded separately; and the final results corrected for these variations. Further, we thought that it would be inconvenient to maintain the temperature of the constant junction at 0°C . in the vicinity of the autoclave.

It occurred to us that it might be advantageous to follow the rate and course of the convection currents upon which, at least in certain kinds of products, the rate of heat penetration largely depends. Therefore, in addition to the variable thermojunction at the center, we placed other junctions at several points within the can.

Our present apparatus consists of a constant thermojunction which is maintained at the temperature of the autoclave and is located just outside of the can. The actual temperature of this junction is obtained from the readings of a thermograph, the bulb of which is placed close to the constant junction. The capillary tube connecting the thermograph bulb with the recording clock is led out of the autoclave through a suitable steam-tight joint.

Connected with the constant junction is a series of variable junctions located in various parts of the can. The thermocouples are connected through a cable of wires to a galvanometer outside of the autoclave. From the deflections of the galvanometer, differences in temperature between that of the autoclave at the constant junction and any particular variable junction within the can could be determined. Temperature measurements could be made at any time during the process of heating and subsequent cooling.

Since measurements closer than 1°C . were not called for, such refinements as high insulation and shields for protection against stray currents were dispensed with. The deflections of the galvanometer caused by the thermoelectric currents were noted and converted into degrees of temperature difference between the junctions. The factor for this conversion was established by a large series of experiments in which the temperatures at different junctions were measured by mercury thermometers. (With the particular galvanometer used, 1.8 units of deflection corresponded to 1°C . difference in temperature, or, as it happened, 1 unit of deflection corresponded to 1°F .)

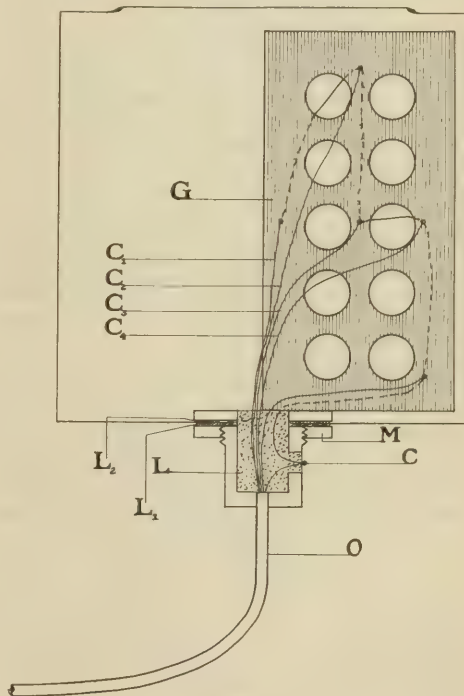


FIG. 4

A wiring diagram of the thermocouple is shown in Fig. 1. The couple was formed from No. 30 copper and ideal wires, marked Cu and Id in the diagram. G is the galvanometer, C the constant junction, V₁,

V_2 , V_6 the variable junctions. R is a variable resistance for cutting down the current when the difference in temperature between two junctions was so great as to cause deflections beyond the galvanometer scale. S is a circular twelve-point changing switch for connecting the galvanometer with the variable junctions V_1 , V_2 , V_6 .

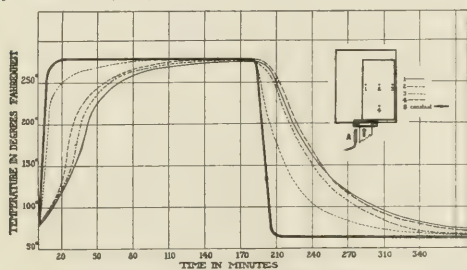


FIG. 5

A detail of this changing switch is shown in Figs. 2 and 3. Fig. 2 is from above; Fig. 3 is a vertical section. The solid black portions are formed of bakelite. R_1 and R_2 are of copper. The leads from the variable junctions are connected at the bottom of the outer ring of contacts. A copper wire connects the galvanometer with the inner ring. A copper pin inserted in any one of the holes connects the outer contact with the inner ring, thus completing the circuit through the particular junction connected with this contact. In order to avoid thermoelectric currents, the pins, contacts, and both rings, R_1 and R_2 , were all formed from the same piece of copper tubing. As a further precaution, the bakelite support and the copper rings were suspended in a constant temperature oil-bath, O . (With the degree of accuracy demanded by these experiments this precaution was later found to be unnecessary.) C is a lead conduit through which the cable of wires from the thermocouples passes to the switch.

Fig. 4 shows the construction of the grid which supports the variable junctions. The grid is placed in the can through the opening before the cover is

sealed at the top, the lead cable O being passed down through a round hole which has been cut in the bottom of the can. By means of the litharge packing L , the leather washers L_1 and L_2 , and the nut M , a steam-tight joint is made at the bottom of the can. The constant junction is at C . The grid G is made of lignum-vitae. The ideal wire passes from the constant junction C , through the litharge packing and along the back of the grid G , as shown by the dotted line. The copper wires C_1 , C_2 , C_3 , etc., pass through holes in the grid and form the variable junctions where they are soldered to the ideal wire. The leads from the constant junction and from the variable junctions pass through the lead cable O and out through the side of the autoclave. The copper leads are insulated with asbestos covering. The entire cable of copper wires is further wound with a single layer of asbestos cord.

As an example of the results obtained with this apparatus, we reproduce a graph, Fig. 5, showing a set of readings from a can of navy beans. On this graph the heavy line is a reproduction of the tracing of the thermograph record of the autoclave temperature. The abscissae and ordinate scales represent respectively the time in minutes and the temperature in degrees Fahrenheit. The other curves on the graph represent readings from the various thermojunctions. The drawing in the upper right-hand corner is a schematic illustration showing the location of the respective thermojunctions.

The temperature of the constant junction (No. 5 in the illustration) is measured by the bulb of the thermograph, A , and is represented graphically by the heavy curve. In the experiment which this graph represents, the can was placed in the autoclave and steam was turned on. As will be seen, a constant autoclave temperature of 280°F . was reached in 15 min. The can remained at this temperature for 180 min., and then the pressure of the autoclave was released, the autoclave opened, and both the can and the bulb of the thermograph quickly immersed in water.

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LABORATORY AND PLANT

COMPARATIVE TESTS OF PALAU AND RHOTANIUM WARE AS SUBSTITUTES FOR PLATINUM LABORATORY UTENSILS¹

By L. J. GERBEVIN AND E. WICHES

Received February 14, 1919

The high cost and scarcity of platinum have greatly stimulated, especially within the past few months, the production of "platinum substitutes" for various purposes. Of those intended for use as chemical laboratory ware, no alloy of base metals tested by the Bureau of Standards has been found suitable. Two types of alloys of gold and palladium have been placed on the market and have come into more or less general

use. These are known as "palau" and "rhotanium." Rhotanium ware is manufactured in several grades, with varying proportions of gold and palladium. A discussion of these alloys, together with tests made by Professor H. H. Willard, has been published by Dr. F. A. Fahrenwald.¹

A series of tests has been carried out at this Bureau to determine the suitability of these alloys as substitutes for platinum in laboratory ware. Four rhotanium crucibles, two of grade A and two of grade C, were submitted for test purposes by Dr. Fahrenwald. This Bureau had previously carried out tests on a palau crucible submitted by the Pacific Platinum Works,

¹ Published by permission of the Director of the Bureau of Standards.

¹ THIS JOURNAL, 9 (1917), 590

of Los Angeles, Cal. The results of these tests have been published in various technical journals¹ and in advertising circulars issued by dealers in laboratory apparatus. For comparison with the results obtained with the rhotanium ware, the same tests were made on an unused palau crucible, purchased in the open market, and on a slightly used crucible of platinum with about 0.6 per cent iridium, made by the U. S. Assay Office at New York.

Palau and rhotanium C have very nearly the appearance of pure palladium, being somewhat darker than hammered platinum. Rhotanium A had a distinct bronze tint. The rhotanium C and palau crucibles were somewhat stiffer than those of rhotanium A and platinum with 0.6 per cent iridium. The composition of the rhotanium and palau alloys is represented by the manufacturers to be as follows:

	Gold Per cent	Palladium Per cent
Palau.....	80	20
Rhotanium A.....	90	10
Rhotanium C.....	70	30

The maximum capacity of the rhotanium crucibles was 11 cc., that of the palau and platinum crucibles 16 cc. each. The total surface area of each of the rhotanium crucibles was approximately 40 sq. cm. That of the palau and platinum crucibles was about 48 sq. cm. each. The weights of the crucibles were as follows:

Platinum Grams	Palau Grams	Rhotanium A ₁ Grams	Rhotanium A ₂ Grams	Rhotanium C ₁ Grams	Rhotanium C ₂ Grams
12.2745	12.4116	7.9615	7.3306	6.3555	6.0084

The tests were of two types, the aim being to determine the resistance of the materials to chemical reagents and their behavior upon heating.

BEHAVIOR TOWARD CHEMICAL REAGENTS

Throughout this series of tests precautions were taken to secure weighings accurate to 0.05 mg. Except after the sodium carbonate fusion, the final weight of one test was taken as the initial weight of the succeeding test. In this one exception, the crucibles were cleaned by scouring before testing further. In the treatment with nitric, sulfuric, and hydrochloric acids, ferric chloride solution, and in the sodium carbonate fusion, the platinum and palau crucibles were treated in separate vessels, while the two rhotanium A and the two rhotanium C crucibles were treated in a third and fourth vessel, respectively. In the treatment with sodium hydroxide solution and the hydrofluoric acid, all the crucibles were treated together in one vessel. In the fusions with sodium hydroxide and potassium pyrosulfate each crucible was treated separately. Further details of procedure are given in the following paragraphs. The results are collected in Tables I and II.

HYDROCHLORIC ACID—The crucibles were immersed in the boiling acid for 4 hrs. At the beginning of the test the specific gravity of the acid was 1.18, and acid of this concentration was added to replace that lost

by evaporation. At the end of the test the acid had a specific gravity of about 1.1. The four resulting solutions were all colored slightly yellow.

NITRIC ACID (SP. GR. 1.42)—The crucibles were immersed in the boiling acid for 3½ hrs. Acid of specific gravity 1.42 was added from time to time to keep up the volume. All the solutions except that from the platinum crucible were decidedly yellow and gave tests for palladium and gold. There was no change in the appearance of the crucibles.

NITRIC ACID (SP. GR. 1.2)—The crucibles were immersed for 4 hrs. in the boiling acid. The solutions were not noticeably colored. The specific gravity of the acid was found to have increased from 1.2 to 1.3.

SULFURIC ACID (SP. GR. 1.84)—The crucibles were immersed in the cold acid. About 1 hr. was consumed in heating the acid to boiling. It was then kept boiling for 3 hrs. In the calculations the test period was considered as 3½ hrs. The acid from the platinum crucible was distinctly yellow, and that from the rhotanium C crucibles slightly yellow.

HYDROFLUORIC ACID (48 PER CENT)—All of the crucibles were immersed in the acid contained in a platinum dish which was covered by another dish containing water to serve as a condenser. The acid was boiled about 3 hrs. and was tinged slightly yellow at the end of this time.

FERRIC CHLORIDE SOLUTION—The crucibles were immersed for 1 hr. in a boiling solution containing 10 per cent hydrated ferric chloride (FeCl₃·6H₂O), and 5 per cent (by volume) of hydrochloric acid (sp. gr. 1.18). Water was occasionally added to keep up the volume. No change in the appearance of the crucibles was noted.

SODIUM HYDROXIDE SOLUTION (20 PER CENT)—All the crucibles were immersed for 4 hrs. in the boiling solution contained in a large platinum dish. Water was added from time to time to keep up the volume.

SODIUM HYDROXIDE FUSION—Each of the 6 crucibles was immersed in the fused alkali (technical) contained in nickel crucibles. The nickel crucibles were kept at a dull red heat (about 600° C.) for 1 hr., in an electric muffle furnace. Both the inner and outer surfaces of the platinum crucible were badly discolored and almost black in spots, but the other crucibles merely presented a dull appearance. The normal appearance of the platinum crucible was restored on ignition in a reducing flame. It is to be noted that the change in weight is positive for the platinum crucible, and negative for all the others.

SODIUM CARBONATE FUSION—The procedure was the same as in the sodium hydroxide fusion except that a temperature of about 1000° C. was maintained for 1 hr. The platinum crucible was badly discolored. The others were rendered dull in appearance, but were discolored only in spots. Ignition did not restore the normal appearance of the platinum crucible. All the crucibles showed a gain in weight. A second carbonate fusion was now carried out, but this time the crucibles were nearly filled with the fused carbonate and placed, uncovered, in the muffle furnace and heated at about 1000° C. for 1 hr. The results were the same

¹ Chem. Abs., 11 (1917), 2163, 2627.

as before, the discoloration of the platinum crucible being especially pronounced at the rim, above the surface of the melt. No note on the change of weight was made. After cleaning the platinum crucible it was again filled with sodium carbonate, covered with a platinum lid, and the fusion this time carried out over a Tirrill burner, the crucible being completely enveloped by the flame. No discoloration appeared in this case and the inner surface of the crucible was only very slightly stained. The change in weight was not recorded. As it is well known that in ordinary sodium carbonate fusions over the burner or blast lamp, the platinum suffers no attack, it appears that the discoloration noted before was due to the peculiar conditions which obtained in heating the crucible in the muffle furnace. The greater dissociation of the sodium carbonate and free access of air may have been the chief factors.

POTASSIUM PYROSULFATE FUSION—Each crucible was immersed in the fused salt contained in porcelain crucibles. These were kept at a decided red heat (about 750° C.) for 1 hr. There was no change in the appearance of the crucibles.

USE AS CATHODE—The crucibles were used as cathodes in an electrolysis of a solution containing 4 mg. copper, 0.02 cc. nitric acid (sp. gr. 1.42), and 0.03 cc. sulfuric acid (sp. gr. 1.84) per cc. of solution. The crucibles were nearly filled with this solution. Platinum rods were used as anodes. The copper was dissolved off in warm dilute nitric acid. There was no change in the weight of any of the crucibles.

USE AS ANODE—The crucibles were nearly filled with dilute sulfuric acid (1 : 8) by volume. Spirals of copper wire served as cathodes. With all the crucibles except the platinum, the surface which acted as electrode was stained brown to black. With low current density, this film did not scale off, but as the current was increased the film adhered less firmly. Very little, if any, of the metal passed into solution, but the brown film produced by the electrolysis was readily soluble in hydrochloric acid.

TABLE I—OBSERVED CHANGES IN WEIGHT OF THE SIX CRUCIBLES

	PLATINUM		PALAU		RHOTANIUM A		RHOTANIUM C	
	Crucible 1	Crucible 2	Crucible 1	Crucible 2	Crucible 1	Crucible 2	Crucible 1	Crucible 2
Hydrochloric acid, sp. gr. 1.18.....	0.40	0.80	0.45	0.40	0.45	0.40		
Nitric acid, sp. gr. 1.42.....	0.00	14.65	12.10	11.05	12.05	12.75		
Nitric acid, sp. gr. 1.2.....	0.05	0.75	1.80	1.65	0.70	0.65		
Sulfuric acid, sp. gr. 1.84.....	23.10	0.95	0.15	0.20	0.70	0.80		
Hydrofluoric acid, 48 per cent.....	0.25	0.30	0.10	0.15	0.25	0.20		
Ferric chloride soln., 10 per cent.....	2.40	34.00	29.10	26.90	27.25	25.45		
Sodium hydroxide soln., 20 per cent.....	+0.05	+0.10	0.05	0.05	0.10	+0.05		
Sodium hydroxide fusion.....	+0.35	7.45	0.15	1.40	6.35	5.85		
Sodium carbonate fusion.....	+0.40	+0.65	+0.50	+0.50	+0.95	+0.60		
Potassium pyrosulfate fusion.....	2.95	10.85	2.60	2.70	28.30	19.20		

TABLE II—WEIGHT CHANGES CALCULATED TO 100 SQ. CM. PER HR. FOR THE FOUR KINDS OF WARE

	PLATINUM	PALAU	RHOTANIUM A	RHOTANIUM C
Hydrochloric acid, sp. gr. 1.18.....	0.2	0.4	0.25	0.25
Nitric acid, sp. gr. 1.42.....	0.0	8.7	8.25	8.9
Nitric acid, sp. gr. 1.2.....	0.05	0.4	1.1	0.45
Sulfuric acid, sp. gr. 1.84.....	13.75	0.55	0.15	0.55
Hydrofluoric acid, 48 per cent.....	0.15	0.2	0.1	0.2
Ferric chloride soln., 10 per cent.....	5.0	70.8	70.0	65.9
Sodium hydroxide soln., 20 per cent.....	+0.05	+0.05	0.05	0.00
Sodium hydroxide fusion.....	+0.75	15.5	4.45	15.25
Sodium carbonate fusion.....	+0.85	+1.35	+1.25	+1.95
Potassium pyrosulfate fusion.....	6.15	22.60	6.65	59.4

The observed changes in weight of the 6 crucibles when treated with the various chemical reagents named are given in Table I. Table II shows these changes calculated to 100 sq. cm. of surface per hr. Weights are given in milligrams. All changes of weight, except those indicated by the plus (+) sign, are losses. In Table II the two results for each grade of rhotanium are averaged.

BEHAVIOR UPON HEATING

The crucibles after the chemical tests were cleaned as follows: The crucibles were immersed in cold chromic acid solution, washed in distilled water, then in cold 10 per cent sodium hydroxide solution. They were once more washed in water, dried with a clean cloth, and ignited to a dull red heat. The crucibles were next boiled for 5 min. in dilute (1 : 4) hydrochloric acid, washed in distilled water, dried, ignited, and weighed after cooling in a desiccator for 30 min.

To compare with previous observations on platinum crucibles,¹ the heating and treatment with dilute acid were carried out as follows: The loss in weight of the 6 crucibles due to heating was determined in a graphite resistance furnace free from metal vapors.²

The two rhotanium C and the palau crucibles were heated at 1200° C., while the rhotanium A crucibles were heated at 1100° C., owing to the danger of melting them at the higher temperature. For comparison, the platinum crucible was also heated at the lower temperature. The melting ranges of the three alloys are as follows:³

ALLOY	MELTING RANGE
Rhotanium A (10 per cent Pd).....	1225°-1275° C.
Palau (20 per cent Pd).....	1350°-1380° C.
Rhotanium C (30 per cent Pd).....	1410°-1425° C.

The crucibles were weighed before and after heating and also after a subsequent immersion of 5 min. in boiling (1 : 4) hydrochloric acid. The observed losses are enumerated in Table III. Table IV gives the data calculated to 100 sq. cm. per hr.

Both rhotanium A crucibles were badly blistered when taken out of the furnace after their first heating, while one of them even showed partial fusion in one portion of the rim after the second heating. In spite of this the losses due to heating at 1100° C. were surprisingly low, and were not only lower than for the platinum crucible containing 0.6 per cent iridium heated to the same temperature, but also lower than those of platinum crucibles⁴ heated at only 1000° C. for three periods of 4 hrs. each. These last-mentioned losses were as follows:

0.8 per cent Ir.....	0.204 mg. per hr. per 100 sq. cm.
0.9 per cent Ir.....	0.374 mg. per hr. per 100 sq. cm.
2.4 per cent Ir.....	0.550 mg. per hr. per 100 sq. cm.

Tables III and IV contain also some results previously published (Columns 4 and 5), and also results on previous tests of a palau crucible. The results obtained

¹ Burgess and Sale, Bureau of Standards, *Scientific Paper* 254, and Burgess and Waltenberg, Bureau of Standards, *Scientific Paper* 280.

² This furnace and method of operation are described in the Bureau of Standards, *Scientific Paper* 284.

³ Ruer, *Z. anorg. Chem.*, 81 (1906), 391.

⁴ Burgess and Waltenberg, Bureau of Standards, *Scientific Paper* 280, 367.

TABLE III—OBSERVED CHANGES IN WEIGHT ON HEATING AND SUBSEQUENT ACID TREATMENT

CRUCIBLE	Platinum with 0.6 Per cent Ir	—RHOTANIUM A—		—PLATINUM—		—PALAU—		—RHOTANIUM C—	
		Crucible 1	Crucible 2	Per cent Ir ¹	Per cent Ir ²	Crucible 1 ³	Crucible 2	Crucible 1	Crucible 2
Temperature of heating, deg. C.	1100	1100	1100	1200	1200	1200	1200	1200	1200
Surface area of crucible, sq. cm.	48	40	40	99	79	78	48	40	40
Loss in weight after first heating, mg.	1.02	0.13	0.13	1.98 ⁴	9.85	7.30	1.82	+0.29 ⁴	1.01
Loss in weight after first acid, mg.	0.10	0.06	0.09	0.16	1.80	0.03	0.20	0.87 ⁴	0.07
Loss in weight after second heating, mg.	0.62	0.20 ⁴	0.15	2.18	8.60	3.32	1.23	2.98	1.77
Loss in weight after second acid, mg.	0.15	0.13	0.04	0.09	0.68	0.13	0.18	0.02	0.02
Loss in weight after third heating, mg.	.....	.....	.....	2.14	4.65	.....	.....	.....	.....
Loss in weight after third acid, mg.	.....	.....	.....	0.07	1.60	.....	.....	.....	.....
Total loss in weight on heating, mg.	1.64	0.33	0.28	6.30	23.10	10.62	3.05	2.69	2.78
Total loss in weight on acid treatment, mg.	0.25	0.19	0.13	0.32	4.08	0.16	0.38	0.89	0.09

¹ Burgess and Sale, Bureau of Standards, *Scientific Paper*, **354**, 304, Table 5.² Burgess and Waltenberg, Bureau of Standards, *Scientific Paper*, **360**, 367, Table I.³ Bureau of Standards, Test No. 20129, Dec. 2, 1916.⁴ Three 2-hr. heating periods.

* The gain in weight may be discounted as all of the gain and more was lost on acid treatment, indicating that some silica from the marquard lining of the furnace stuck to the crucible.

* It was noticed on the completion of the second heating period that partial fusion had taken place in one portion of the rim.

TABLE IV—CHANGES IN WEIGHT ON HEATING AND SUBSEQUENT ACID TREATMENT CALCULATED TO 100 SQ. CM. PER HR.

CRUCIBLE	Platinum with 0.6 Per cent Ir	—RHOTANIUM A—		—PLATINUM—		—PALAU—		—RHOTANIUM C—	
		Crucible 1	Crucible 2	Per cent Ir ¹	Per cent Ir ²	Crucible 1 ³	Crucible 2	Crucible 1	Crucible 2
Temperature of heating, deg. C.	1100	1100	1100	1200	1200	1200	1200	1200	1200
Loss in weight per hr. per 100 sq. cm. after 1st heating, mg.	0.53	0.08	0.08	1.00 ⁴	3.12	2.33	0.94	+0.18 ⁴	0.63
Loss in weight per hr. of heating per 100 sq. cm. after 1st acid, mg.	0.05	0.04	0.05	0.08	0.57	0.01	0.10	0.54 ⁴	0.04
Loss in weight per hr. per 100 sq. cm. after 2nd heating, mg.	0.32	0.13 ⁴	0.09	1.10	2.73	1.05	0.64	1.86	1.09
Loss in weight per hr. of heating per 100 sq. cm. after 2nd acid, mg.	0.08	0.08	0.03	0.05	0.19	0.04	0.09	0.01	0.01
Loss in weight per hr. per 100 sq. cm. after 3rd heating, mg.	.....	.....	.....	1.08	1.47	.....	.....	.....	.....
Loss in weight per hr. of heating per 100 sq. cm. after 3rd acid, mg.	.....	.....	.....	0.03	0.51	.....	.....	.....	.....
Average loss due to heating per hr. per 100 sq. cm.	0.43	0.10	0.09	1.07	2.44	1.69	0.79	0.84	0.86
Average loss due to acid treatment per hr. per 100 sq. cm.	0.07	0.06	0.04	0.06	0.42	0.03	0.10	0.28	0.03

1, 2, 3, 4, 4, 5, 5. See footnotes of Table III.

on the two palau crucibles do not check very well, but the values for the crucible obtained on the open market are much better than those of the previous test.

SUMMARY AND CONCLUSIONS

These tests indicate that rhotanium A ware is superior to platinum ware both of high (2.4 per cent) and low (0.6 per cent) iridium content in respect to its resistance to loss on heating. The losses on treatment with acid, after heating, are about equal. Grade A ware compares favorably with platinum in resistance to boiling hydrochloric and hydrofluoric acids, to boiling 20 per cent sodium hydroxide, and to fusion with sodium carbonate in a muffle, and with potassium pyrosulfate. It is superior to platinum in resistance to the action of boiling sulfuric acid, and inferior in its resistance towards boiling concentrated and dilute nitric acids, boiling 10 per cent ferric chloride solution, and for fusions with sodium hydroxide. The only objection that may be raised to its use is the rather low melting point of the alloy, which makes it impossible to blast or strongly heat the ware without melting it.

As far as resistance to loss in weight on heating to 1200° C. is concerned, rhotanium C and palau wares are about equal, if not slightly superior, to platinum ware containing 0.6 per cent iridium. They are surely superior to platinum ware containing 2.4 per cent iridium. This conclusion leaves out of consideration results obtained in December 1916, on a palau crucible submitted by the makers. Palau¹ and rhotanium C

behave towards reagents in about the same way as rhotanium A, except that they are not suitable for potassium pyrosulfate fusions and are inferior to grade A for sodium hydroxide fusions. The only striking distinction between rhotanium C and palau is the latter's slight superiority in the case of the potassium pyrosulfate fusions.

Palau and both grades of rhotanium may all be used to advantage in the electrolysis of chemical solutions, but only as cathodes. As anodes the alloys are worthless.

The solubility of platinum is recognized and its elimination is provided for in exact methods of analysis. With the palau and rhotanium wares two metals, namely, gold and palladium, may pass into solution, requiring somewhat different treatment for their elimination.

It is believed that in addition to the tests performed upon the palladium-gold alloys, information as to the behavior of these wares in actual service would be of great value. Unfortunately there is little knowledge of this kind at our disposal. A number of users have remarked upon the solubility of palau ware in nitric acid. One has written that he "melted a (palau) crucible by overheating, lost a crucible by alloying with a nichrome triangle,¹ and lost others on account of cracking after a few months' service." It is suggested that any further available information of this nature, both favorable and unfavorable, be communicated to the Bureau of Standards.

BUREAU OF STANDARDS
DEPARTMENT OF COMMERCE
WASHINGTON, D. C.

¹ The action of both concentrated and dilute nitric acid on the second palau crucible was markedly greater than on the crucible tested in December 1916. The results then obtained for concentrated nitric acid were 0.25 mg. per hr. per 100 sq. cm., and for the dilute about 0.1 mg. per hr. per 100 sq. cm. No explanation can be offered for this discrepancy.

¹ It should be stated in this connection that while platinum is less readily attacked by nichrome than the gold-palladium alloys, the use of nichrome triangles with platinum ware is not to be recommended.

A CONVENIENT STOICHIOMETRICAL CALCULATION

By STUART W. MAHER

Received March 29, 1919

In preparing large volumes of standard solutions in works laboratories, it is not convenient to directly determine the volume of solution which is to be diluted to the exact strength desired.

This determination may be conveniently made by titrating the solution as originally prepared against a standard substance, making an insufficient, but known dilution, and again titrating against the same amount of standard chemical.

Let V = the volume of approximately standard solution.

N = the cubic centimeters of water added.

T_1 = the cubic centimeters used in the first titration.

T_2 = the cubic centimeters used in the second titration.

k_1 = the first concentration.

k_2 = the second concentration.

Then, $k_1 T_1 = k_2 T_2$

and $V k_1 = (V + N - T_1 - T_2) k_2 + T_1 k_1 + T_2 k_2$,

whence $V = \frac{NT_1 + T_1 T_2 - T_1^2}{T_2 - T_1}$

and the volume on which dilution is to be figured is

$$\frac{NT_1 + T_1 T_2 - T_1^2}{T_2 - T_1} - (T_2 + T_1) + N.$$

The term $T_2 + T_1$ may be neglected without too great sacrifice of accuracy, making the volume on which dilution is to be calculated equal to

$$\frac{NT_1 + T_1 T_2 - T_1^2}{T_2 - T_1} + N.$$

The work may be carried out with sufficient accuracy on a slide rule.

KINGSPORT PULP CORPORATION
KINGSPORT, TENNESSEE

ADDRESSES AND CONTRIBUTED ARTICLES

INDUSTRIAL GERMANY—HER METHODS AND THEIR DEFEAT¹

By FRANCIS P. GARVAN, Alien Property Custodian

For nineteen months I have been engaged in a study of German industrial life and its manifestations and activities in the United States, and I come here to-night to give you, as briefly as I may, a few of the incontrovertible facts which my experience has made clear.

First and foremost, be it understood that this was an industrial war, brought on by industrial Germany in her lust-mad haste to capture the markets of the world. Industrial Germany in her arrogance and pride preferred the formidable hazard of battle to the progressive and sure infiltration which within ten or twenty years might well have given her the world domination she sought from complacent and unthinking peoples.

Industrial Germany was in control of Imperial Germany. Industrial Germany sympathized and participated in the preparation for this war. Industrial Germany waged this war. Industrial Germany was the first to see defeat and forced the military peace, in order that with her industrial equipment intact she might continue that same war by intensified and concentrated economic measures.

Her ambitions are the same in peace and in war. Her methods are the same in peace and in war. Destroy your business competitor by state aid, cartel combination, dumping, full-line forcing, bribery, theft of patents or inventions, espionage, and propaganda! Destroy your military adversary by tearing up sacred treaties, by unlicensed and unbridled submarine and poisonous gas warfare, by the destruction of factories, mines, and vineyards, by terrorism and vandalism!

You or I have yet to hear one word of a change of heart or purpose; one word of regret or shame; one word of dispraise for any leader in the past holocaust. On the other hand, hold to the fact that at this moment the four men best fitted to conduct a ruthless economic war upon this country, the four men who planned, instigated, and paid for all the black history of lawlessness under which we suffered for two and a half years, Dr. Albert, Dr. Dernberg, Captain Boy-Ed, and von Bernstorff, are the helmsmen of the present German government. Dr. Heinrich Albert is now Under-Secretary of State; Herr Bernhard Dernberg is now Minister of Finance; Boy-Ed is Director of the Intelligence Section of the Foreign Office, the Espionage and

Propaganda Division; and that arch-criminal, Bernstorff, is over them all, directing and leading the new government in many of its departments.

Has the war ended for you?

It was Germany's chemical supremacy that gave her confidence in her avaricious dream of world empire. It was Germany's chemical supremacy that enabled her to wage four years of pitiless warfare. And it is Germany's chemical supremacy upon which she relies to continue this war; and for that supremacy she pays homage to her dye industry, and counts upon that dye industry to maintain it.

Since 1866 Germany has recognized the fact that upon the development of the dye industry rested her entire development of organic chemistry, that upon the development of organic chemistry rested, in an ever-increasing measure, all the development of modern business and modern warfare.

And so she cherished the industry with wisdom and provision while it was still in its childhood, and by her patience, by her persistence, by the willingness of her people to sacrifice in unselfish coöperation, she has gradually transformed the plans made in the year 1866 into the reality of to-day.

She realizes that her dye industry constitutes her keenest wedge with which to force her way back into the world trade. She now calls the dye industry her chief "Protective Industry," and has laid out for it a program of state protection and aid which should startle us. She proposes to use the alleged necessities of the world for her dyes to force all her other exports. In other words, she proposes to use it as a club with which to fight her way back into commercial society.

Prior to the war the German dye industry was united into three cartels with some independent companies outside. All are now one monster cartel, the I. G. Company, with Mr. Weinberg, the old head of the Cassella Color Company, as its president, and a capitalization of hundreds of millions of dollars. Germany has taken it under state aid and protection; she has decided to establish a guaranty fund whereby all industries share the losses the cartel may be compelled to face through dumping, bribery, or other expense incurred in reasserting her dye monopoly of the world. She looks forward to granting it trade export premiums, freight rebates, intensified consular service, and state guarantees against labor troubles.

As a result, our young but vigorous industry stands here today in direct competition, not only with the great cartel I. G., but with that great cartel sustained and supported and subsi-

¹ Address before the National Cotton Manufacturers' Association, New York City April 25, 1919.

dized by the entire strength and wealth of the German kingdom.

Over three billion dollars of annual business in America, including yours, are dependent upon the dye industry. Is there any doubt that the destruction of the American industry means your enslavement to that cartel, and your destruction when it becomes the whim of that cartel?

For years that three billion dollars of annual business was dependent upon the graciousness of German ambition. The time had not come when it seemed to their self-interest to cripple or destroy it, but when the war came on in an instant Germany felt the force of your dependence and attempted to use your necessities to influence the policies of your Government. There was a considerable period when Germany could have relieved your distress; but would not. There was a period thereafter when her branches here might have assisted you; but they would not.

Listen! April 25, 1915, Boy-Ed of ill-smelling fame, writes to Albert: "Very Honorable Privy Counsellor: To-day's *World* prints the enclosed short article on the alleged erection of dye factories in New Jersey by Germans. In case you are not able to take any steps to prevent an undertaking of this kind, I am requesting you to indicate to whose attention I could call the matter. With greetings, etc." Signed, Boy-Ed.

Albert answers, April 28, 1915: "Very Honorable Captain: With regard to dyes, I got into touch with local experts in order to determine what truth there is in the news. According to my knowledge of things, the matter is a fake inasmuch as our factories have bound themselves orally and by word of honor to do nothing in the present situation which might help the United States."

Thank God! That day your independence began. That day our industry was born. And supported by you with loyalty, patience, and sacrifice, it has grown until to-day \$450,000,000 are enlisted in the cause and we see the end forever of the past slavery and we stand unafraid in the face of any threat.

But even greater than the importance of the dye industry in commercial life is its absolute necessity in modern warfare. I quote from Dr. Schweitzer:

In no other field has German efficiency proven its superiority as in that of chemistry. While this was anticipated before the present war, it is no exaggeration to state that the German chemist has so far contributed as much, if not more, to the success of the campaign than the strategist, the army, and the navy, and that, therefore, the present holocaust may be justly called the 'chemists' war."

Eighty per cent of her explosives and all her poisoned gases were manufactured by Germany's dye factories.

And does any one for a moment imagine that you are going to handle, or that the women of America are going to buy or wear the by-product of the destruction of their 70,000 sons?

A commission appointed by the allied governments has just reported to their respective governments:

At first, chlorine and phosgene were the main requirements, but afterwards a variety of organic substances were employed, all of which were made by the factories of the I. G. combination, and many of these substances were new and difficult to prepare, and rapid production was only possible owing to the speed with which the peaceful organization of the dye factories could be utilized for these purposes. When the government wished to introduce a new gas, a conference of the various firms was held at Berlin to determine how the manufacture should be subdivided in order to use the existing plant to the best advantage. For instance, the initial stages of the manufacture of mustard gas were carried on at Ludwigshafen, and the final stage at Leverkusen. * * *

In the future it is clear that every chemical factory must be regarded as a potential arsenal, and other nations cannot, therefore, submit to the domination of certain sections of chemical industry, which Germany exercised before the war. For military security it is essential that each country should have its chemical industry firmly established, otherwise we are leaving

Germany in possession of a weapon which will be a permanent menace to the peace of the world.

The key to Germany's war production of explosives was the Haber process for the production of ammonia from atmospheric nitrogen. With such a process Germany could not have made the nitric acid required for her explosive program, nor obtained fertilizers for good production after the supply of Chile saltpeter had been stopped by our blockade, and it is probable that she could not have continued the war after 1916. In the event of another war, we might be cut off from supplies of saltpeter, while Germany would be independent of them.

Gas warfare, and its development, even if forbidden by the League of Nations, cannot safely be left in German hands, and organic substances will be employed which we do not know to-day. Any country without a well-developed chemical industry is in danger: useless your armies and your navies, your U-boats and your aeroplanes, unless by means of a developed dye industry you keep abreast with modern chemical warfare.

But this industry has had, and now has, another great function in Germany's machine. It was, and is, the basis of her espionage and propaganda system.

True it is that we had in this country the Orenstein Arthur-Koppel Company, a German concern owning a large plant at Koppel, near Pittsburgh. The chief business of that company was the manufacture and installation of what is known as "inside transportation," that is, narrow gauge railways, dump cars, traveling cranes, and machinery of a similar sort used in large industrial plants. It was the American branch of a great German house with connections in all the great countries of the world. For twenty years it has put in bids based upon the plans and specifications of every big industrial plant built in this country; and for that same twenty years, blueprints of these specifications and floor plans and elevations have gone on file in the government office in Berlin.

True it is that in this country we had eighteen branches of German insurance companies, largely engaged in the reinsurance business; and that these companies collected for their own use detailed plans of all property insured by them, with especial reference to the hazard of the insured buildings from fire, explosion, or other causes; and duplicates of these plans and drawings also found their resting place in the Berlin office. And we wondered at the accuracy of our factory fires and explosions!

True it is that Germany, through the Bosch Magneto Company, the Eisemann Magneto Company, and the Boonton Rubber Company, had a practical monopoly of the ignition systems in America, and through this combination the files of the central office in Berlin were kept up to date with all plans for improvements in military trucks, gasoline boats, and aeroplanes.

Let me read you Manager Otto Heins' report to Dr. Albert of the activities of the Bosch Magneto Company in this your country, at that time neutral.

Honored Mr. Albert: In connection with the obstruction policy upon which we agreed at the beginning of the war in matters concerning deliveries of our products, especially the special magneto apparatus, I should like in the following to make several statements from which one will clearly see that the accomplished obstruction policy has in every way been successful. In short, we had great difficulty at the beginning of the war in withholding the much-needed special aeroplane apparatus from the Allies, and in preventing the Allies, especially the English, from immediately attempting to manufacture them for themselves. Special apparatuses are involved in flying machines, airships, and speed boats. These apparatuses are very different from the normal apparatus used on automobiles and motorcycles. We have freely supplied them with ordinary apparatuses; but, in accordance with our agreement, we have entered into apparent negotiations with the representatives of the Allies, creating in their minds the impression that they would receive also the special apparatuses at the present time. These negotiations began immediately after the first declaration of war, and it was possible, on account of their technical character, to extend them many months into the war. Our policy lulled them into the certainty that they would receive the special apparatus and only now, November 30, fifteen months after war began, have they realized our duplicity.

He goes on to state that this policy has been carried out despite the fact that these contracts were in many instances sub-contracts with American firms; and he gloatingly continues that as a result of his activities in this country England, in October 1915, found herself unable to defend London against their air raids, and states that France was in a much better position to protect herself against air raids because of her confiscation of the Bosch factories in Paris at the beginning of the war. I wonder how many women and children were killed!

True it is that the Hamburg-American Line and the Nord Deutsche Lloyd kept faithful tabs for Berlin on a thousand details of our business life which came under their observation; that not a ship left our harbors, not a cargo was loaded or unloaded, but that some member of its organization watched and reported every detail to be sent by code to the German government.

But greater than all, and forming the foundation of her entire espionage and propaganda system, stood the dye industry. Her trained observers enjoyed full access to the businesses they supplied, and regularly and faithfully reported each and every detail of the three billion dollars of annual business dependent upon the dye industry in this country. As long as you were supplied by the "Big Six," your business had no secret unknown to Berlin. In Berlin you will find a card index system which recites every fact connected with each and every one of your concerns that can be of any possible value to your rivals over there.

The head of that system in this country for years before the war was Dr. Hugo Schweitzer, president of the Bayer Company, which company has since been sold to one hundred per cent Americans. He was given his Secret Service number by the Imperial Minister of War, 963,192,637. He came to this country, became a citizen on the instruction of the German government, eventually was made the head of the Bayer Company, and led the espionage and propagandist movements here down to the day of his sudden death in November 1917. His regular reports to Germany are the story of your pre-war slavery and the story of the activity of each and every representative connected with the old "Big Six" to perpetuate that slavery. When Albert came here, to assume the leadership of that system, it was to Schweitzer he first turned. Then we find Schweitzer bringing to Albert's office from day to day those other smiling gentlemen who have been selling you the "peerless dyes" in the past, and from that moment begins the period when Germany's trade outposts in this country turned into ministers of lawlessness and destruction.

A word or two of his activities: Schweitzer was the inventor of the idea of the purchase of the *New York Evening Mail*. Schweitzer was the inventor of the idea of the German Publication Society, formed to publish, for our delectation, the literature of German kultur. Schweitzer, with Henry Weissmann, president of the German-American Alliance, we see forming the Printers and Publishers' Association—another attempt to create an English-language newspaper to present Germany's side of the war. Over thirty trained chemists, his lieutenants, are now interned.

We find Albert, about to go home, in January 1917, turning over to Schweitzer \$1,178,882.08; and again, on February 2, \$300,000, all to be spent in espionage and propaganda. We find Schweitzer using the chemical branches of the "Big Six" in this country to form the Chemical Exchange, by which all available phenol supply in America was turned away from the manufacture of picric acid for explosives for the Allies, with a profit, out of America's pocket, to Germany of \$1,650,000.

Listen to Albert's praise:

The breadth of high-mindedness with which you at that time immediately entered into the plan has borne fruit as follows: One and a half million pounds of carbolic acid have been kept from the Allies. Out of this one and a half million pounds of carbolic acid four and one-half million pounds of picric acid can

be produced. This tremendous quantity of explosive stuffs has been withheld from the Allies by your contract. In order to give one an idea of this enormous quantity the following figures are of interest:

4,500,000 pounds equal 2,250 tons of explosives. A railroad freight car is loaded with 20 tons of explosives. The 2,250 tons would, therefore, fill 112 railway cars. A freight train with explosives consists chiefly of 40 freight cars, so that the 4,500,000 pounds of explosives would fill 3 railroad trains with 40 cars each.

Now one should picture to himself what a military coup would be accomplished by an army leader if he should succeed in destroying three railroad trains of forty cars, containing four and a half million pounds of explosives.

Of still greater and more beneficial effect is the support which you have afforded to the purchase of bromine. We have a well-founded hope that, with the exclusion of perhaps small quantities, we shall be in a position to buy up the total production of the country. Bromine, together with chloral, is used in making nitric gases, which are of such great importance in trench warfare. Without bromine these nitric gases are of slight effect; in connection with bromine, they are of terrible effect. Bromine is produced only in the United States and Germany. While, therefore, the material is on hand in satisfactory quantities for the Germans, the Allies are entirely dependent upon importation from America.

Gentlemen, did you intend by your support of the German dye industry to leave the Allies defenseless against the poison gas made by that German dye industry?

But that is not the worst. At Bogota, New Jersey, in the New Jersey Agriculture Chemical Company, Dr. Schweitzer employed Dr. Walter Scheele, who was the inventor, in that little town of New Jersey, in 1913, of a process for the manufacture of mustard gas, the details of which he transmitted through Captain von Papen to Germany as soon as the war broke out. This is the mustard gas which laid low your brothers on the plains of France. And for Scheele, Dr. Schweitzer laid out the plans for the preparation of the bombs.

Untold millions were spent by this man in propaganda and espionage in the United States. In the two years before we entered the war, the Bayer Company drew \$2,000,000 from the profits of its Orient and South American houses, which money was spent here, for what purposes we can well imagine. It never went through their books. Practically all the dye salesmen you saw were only nominally in the employ of the branches here; all had secret and personal contracts with the home office.

All that I have said of Schweitzer is typical of practically all representatives of German dye houses in this country. Wherever we have found espionage or propaganda activity, there you will find those names so familiar to you in the days of your slavery. You will find the same gang returning, decrying our dyes, selling apparently Swiss or unmarked dyes, telling you tales of German distress, serving as ever their Fatherland. Be on your guard!

Coincident with the development of Germany's dye industry came the general development of her chemical strength. It offered great incentives to young men. It developed a large body of trained scientists. It encouraged and fostered the spirit of research in all lines, and added to the effectiveness of practically every industry in the Empire. Nowhere is this more striking than in the supremacy Germany was attaining in chemical medicine.

One other thought I want you to have in mind is this: For four years now the chemical science developed by the dye industry of Germany has focused its mind largely upon substitutes for the raw material she has hitherto received from the outside world. The leader of her chemical industry in this country, Dr. Hugo Schweitzer, of whom I will have more to say later on, wrote to his Government:

All these endeavors to substitute cotton may appear ridiculous to us who have been brought up with the idea that Cotton is King and that America has been designed by fate to supply this fiber to the civilized world. The farmers who cultivated the madder root, and the planters who raised indigo were also in-

clined to jest when they were apprised of the fact that German chemists had succeeded in reproducing in the laboratories the dyes which their crops furnished; but when the manufactured materials drove the natural products from the market, and left the farmers and planters without a job, hilarity ceased. History may repeat itself and willowbark and nettle, or some other substitute, raised on German soil, may, in the near future, depose King Cotton. The German chemist has a duty to perform, and with his perseverance and application he does not shrink from any problem, however difficult it may appear to outsiders.

Gradually Germany was obtaining control of the pharmaceutical industry of the world, and gradually it was dawning upon her that this development, too, might put in her hands an even more powerful weapon than explosives or poisonous gas in her conscienceless conquest of the world. Most of the great discoveries in chemical medicine came directly from the dye laboratories. Are you content that the development of chemical medicine shall remain the exclusive possession of the German nation as we now know it?

Briefly, then, I have tried to give you a picture of the situation of this country in its relation to the dye industry, as our daily experience of the past eighteen months unrolled it before us. Do you wonder that A. Mitchell Palmer and all those who fought under him were shocked beyond measure, and could not rest until Congress had amended the Act and had given us the power under which we could, and have, rooted out each and every branch of that system and sold it into the hands of patriotic Americans?

But that was not enough! Germany had misused our patent system, just as she had misused and violated our Sherman Law, our anti-dumping laws, our anti-bribery acts, our business code, and our common code of honesty. She had taken out patents for all her developments, covering, in many instances, not only the processes, to prevent manufacture here, but also the product, to prevent our taking advantage of any possible development in the dye industry of other countries.

Forty-five hundred of these patents which applied to chemistry Mr. Palmer has sold for the benefit of American industries to a quasi-trustee corporation, called the Chemical Foundation. This company is capitalized for \$500,000, \$400,000 being six per cent preferred stock and \$100,000 common stock, also limited to dividends of six per cent.

The stock has been all underwritten by members of the Dye Institute, each and all taking their share, and is now in process of distribution through the dye producers and, eventually, through the consumers. It is the intention that ultimately no one will own more than a thousand dollars' worth of stock, eight hundred preferred and two hundred common.

All license fees accruing to the Foundation will be used first to pay back the preferred stock. All surplus then above the six per cent actually invested will be expended for the development of research and encouragement of the chemical industry of America.

Its executives serve with enthusiasm and without pay. All its stock is trustee for a period of seventeen years. Its management and its policies are controlled by a board of trustees, consisting of Otto Barnard, president, New York Trust Company, *Chairman*; Cleveland H. Dodge; George L. Ingraham, late presiding justice of the appellate division, New York Supreme Court; Ralph Stone, president, Detroit Trust Company; and Benjamin Griswold, of Brown & Son, Baltimore. These gentlemen have been serving as the Advisory Sales Committee of the Alien Property Custodian for over a year. They represent the highest standard of American patriotism and disinterestedness. Long lives of manifested ability, long lives of unselfish service to their country guarantee the character of the Chemical Foundation.

Its Counsel is Joseph H. Choate, who as a dollar-a-year man has given eighteen months of tireless and efficient service in the exclusive study of the chemical situation. Its Patent Counsel is the fighting Ramsay Hogue.

This Foundation proposes to license to any competent, equipped, and patriotic American individual, firm, or corporation, such of these patents as, with the help and encouragement of the Foundation, may be utilized. This Foundation proposes to begin to fight at the customs gate against any violation of the patents now owned by it, whether they appear as denationalized or camouflaged products seeking to enter through neutral sources. It proposes to establish an Intelligence Department which will coordinate, preserve, and utilize all the chemical information gathered by every department of the Government during the war, and make that information available to the American public that they may know the exact truth as to the past, and may be kept apprised of all German activity, either through its own agents or its American connections, during every stage in the coming struggle.

It proposes to match with watchfulness and pitiless publicity all future attempts at espionage or propaganda in our land. It proposes to expose all unfounded criticism directed against our productions, and, on the other hand, to do what it can to prevent producers or dealers here casting reflection upon our industry by the marketing of inferior or dishonestly described products.

It proposes to encourage and foster chemical research by cooperation with the forces already at work: by offering some hope of protection and reward to the loyal research men in the United States Government service, who now by department rule have to dedicate their inventions to the public, a course which results only in Germany transferring these inventions to her own laboratory system for development or exploitation.

It proposes to bring about a closer union of the university and the factory. It has taken over all German copyrights, and will thus free much scientific literature from the shackles of the German language. It proposes to place all possible information on our situation before Congress, and ask the passage of a law establishing a license system governing all chemical importations for a period of ten years. It is intended that this license system shall act at one and the same time as a guarantee to you and all other dependent industries of proper importations to enable you to meet the competition of other lands, and to protect and guard our growing chemical independence. In this we ask no more than England, France, Italy, and Japan have already decided to grant on behalf of their own independence. This request we base upon the following grounds:

- 1—Fairness to the \$450,000,000 invested in the chemical business by loyal Americans in the hour of our need.
- 2—Independence and freedom of the textile, leather, paper, paint and varnish, pharmaceutical three-billion-dollar essential American business.
- 3—The necessity of our national defense.
- 4—The destruction and prevention of the German system of propaganda and espionage in our land.
- 5—The advancement of pure science and research.
- 6—The advancement of medical science.

The granting of this license system is not a question of conflicting economic schools. It is the question of our national independence, safety, and education.

Once we are assured time in which to work out our salvation, we hope to turn to our dearest objective. Already we have started to make a survey of our laboratory equipment, governmental, university, and factory. Already company after company have passed resolutions through their boards of directors, placing at the disposal of our trustees, under such terms and conditions as those trustees may dictate, their entire research capacity. Government laboratories and university laboratories have also been assured us. Gentlemen, we know that offer will be unanimous.

We will soon be able to go to the medical profession of America and offer to them the entire capacity of the country for experiment and research for the betterment of mankind. One medical chemist in one dye factory in Germany discovered the cure for

syphilis, the deadliest enemy of mankind. The same medical chemist, in the same dye factory, discovered the cure for the sleeping sickness of Africa which made a continent habitable. What can we not hope for when the American medical profession is given unbounded scope and opportunity?

We are assured that somewhere within that realm lies the hope of the cure for consumption, cancer, and many of the seizures which rob us of our little ones. Can it be that herein lies the opportunity of converting the forces which up to now have been directed only toward desolation and destruction into channels of alleviation and helpfulness to humanity? Can it be that through this medium idealist America may snatch the torch of misapplied science from the barbarian, and place it in the hands of an enlightened civilization?

Gentlemen, Drs. Albert and Bernstorff reported to their government that America could never establish the dye and pharmaceutical industry in this country, as we lacked the moral power for the creation of such an industry; that here each party pursued its own selfish interests, but nobody kept the whole in mind; that this problem could only be solved through regard

for all points of view, and that the conflicting selfishnesses of this country rendered that solution impossible.

The Chemical Foundation answers this statement with a challenge, and if it can only become the coordinating forum for American patriotism, American sacrifice, and American ability, it awaits the issue with serenity.

Gentlemen, we are the boys who stayed at home. True, the reasons seemed sound and sufficient yesterday. But today they seem only excuses, ever decreasingly satisfying. It is not enough that with envious tears we cheer their homecoming.

Would they know our admiration, they must sit by our fire-side and listen to us teach our children the character-building tales of their sacrifice. Would they know our love, they must lean over the cribs of those little ones and listen to the prayers of gratitude those little lips are lisping in their behalf. Would they know the depth of the realization of our obligations, and the strength of our resolve that they shall not have suffered and died in vain, we call upon their spirits to watch us in this fight. Peace, peace, and there is no peace!

SYMPOSIUM ON LIBRARY SERVICE IN INDUSTRIAL LABORATORIES

Abstracts of papers presented before the Division of Industrial Chemists and Chemical Engineers at the 57th Meeting of the American Chemical Society, Buffalo, N. Y., April 7 to 11, 1919

THE PUBLIC LIBRARY IN THE SERVICE OF THE CHEMIST

By ELLWOOD H. McCLELLAND, Technology Librarian, Carnegie Library of Pittsburgh

The use of technical libraries by professional chemists is bound to be greatly stimulated by the present widespread interest in industrial research. Current literature shows that this interest is almost world-wide. Representatives of two foreign governments investigating research work in this country surveyed the technical resources of the Carnegie Library of Pittsburgh only a day apart during the last week in March.

In attacking any problem, whether it be a student's thesis or an industrial research, the first thing is to state the problem fully, define it clearly, and establish its limitations. The next thing, in the opinion of the writer, is to make a systematic survey of the existing state of knowledge of the subject; and in a large majority of cases this can best be done by searching the literature. With this principle in mind the writer had a search made—not with the hope of finding anything very definite regarding what the public library can do for the chemist; but to find, if possible, what chemists themselves consider the most important essentials of research work.

There seems to be absolute agreement among chemists that for research work, scientific and technical literature must be available, but there does not seem to be much unanimity of opinion as to how this literature should be provided. At the annual meeting of the Society of Chemical Industry¹ in 1915 there was considerable discussion of this problem. The resolution finally adopted was, "that the establishment of technical libraries throughout the counties is of urgent material importance," this rather general statement having resulted from failure to agree as to whether the desired collections ought to be established by the government, the county or industrial center, or by the manufacturers themselves. The sentiment was strongly in favor of these libraries in all industrial centers, but as one member stated, "a manufacturer could not be expected to spend \$1000 on a library for only one chemist." The problem is perhaps more difficult in England than in America. Here public libraries

are more highly developed, and a solution exists in the extension and use of these libraries.

Is there not some danger, with at least some chemists, that the important matter of utilizing the existing literature is ignored? A note of warning along this line was given by President Richard C. Maclaurin, of the Massachusetts Institute of Technology, before the New York Section of the AMERICAN CHEMICAL SOCIETY in 1916. The following extracts are from his address, "Universities and Industries:"²

There is of course much that has not yet been done, much that has not even been attempted, but after all perhaps our greatest problem is to make the most of what we already have; certainly we do not do this to-day. Take the matter of knowledge. We rightly lay stress on the importance of research and the advancement of knowledge. We cannot keep this before us too prominently because the spirit of research is the very basis of progress. We must not overlook the fact, however, that too often we treat shamefully the knowledge that has already been garnered. Thousands of useful results are obtained every year that would be helpful to industry were an effective effort made to make them widely known. * * * Even the knowledge that is in the textbooks and that is accessible to everybody is not really used. If we could apply one-tenth of such knowledge, fortunes would be made every year. We must remember that in times of peace Germany became rich by having faith in the *obvious*. In the field of chemistry Germany has not shown any genius for scientific advancement, but she has taken her knowledge seriously and displayed a real and saving faith in the formulae of the textbooks.

We get from President Maclaurin's remarks at least a suggestion that the research chemist can reduce his work in the laboratory by increasing his work in the library—and in the latter case he is at no expense for reagents.

In 1912, Mr. William C. Ferguson outlined "A Plan for Organized Research and Analytical Chemistry in Successful Chemical Manufacturing,"³ in which he seems to state the desiderata quite fully. He sets forth nine points, the first four of which are quoted below, since the means for best carrying on the work stipulated would seem clearly to indicate a well-equipped technical library.

¹ THIS JOURNAL, 8 (1916), 59.

² 8th Int. Cong. App. Chem., 2, 95; also THIS JOURNAL 4 (1912), 905.

RESEARCH DEPARTMENT

The organization of this department should include:

1—Systematic abstracting from the principal foreign and American journals and patents of all subjects of interest to the corporation; copies of these abstracts should go weekly to all who can use them, with instructions to study them carefully and to immediately advise the department of any subjects that seem to warrant investigation.

2—Thorough abstracting from the literature in the case of new work undertaken, thus becoming familiar with all that has been published relating to the subject. Repetition of the work of others is thus saved, valuable suggestions received, and general knowledge of the subject enlarged.

3—Systematic information should be constantly and promptly obtained of all records of imports and exports and duties on all finished products and raw materials that would interest the corporation in connection with its current business or as suggesting new articles of manufacture.

4—Pamphlets describing machinery, structural materials, etc., are many years in advance of books upon identical subjects. A pamphlet library should be maintained in cooperation with the engineering department.

All of the above work of translating, abstracting, etc., should be in charge of one competent man, with assistants if necessary.

The first point—the abstracting of current literature for the research organization—can perhaps best be carried on within the organization itself if library resources are adequate, and valuable work of this kind is now being carried on by many organizations. Yet there are at the present time at least three important organizations in the Pittsburgh district which are looking forward to the issuing of regular bulletins to certain employees, and each of these projects contemplates extensive use of the public library in carrying out the work.

The second point consists mainly in systematic searching of the older literature in broad fields—work in which the technical collections of large libraries afford the best working material.

The third and fourth points refer, respectively, to commercial literature and trade catalogues. To the present-day chemist the value of literature in both these fields is inestimable; but as the necessity for this material is by no means confined to the research chemist the problem will be briefly discussed later with the purpose of showing that the public library is the proper field for literature in both these classes.

However interesting and exacting his problems, the chemist must avoid the tendency to become so engrossed in his immediate work that he will fail to keep in touch with the advance in his own and allied lines. The best way to keep the desired contact is through scientific and technical periodicals and the man who fails to keep in touch with these is in danger of falling behind the procession.

In addition to the professional periodicals to which every live chemist doubtless has access, the collections in large general libraries are to be recommended, partly because of the accessory material formerly far outside the chemist's field of endeavor, but now close to or within its boundaries, due to the constant extension of this field. Much of this material, though not labeled as chemical, is of undoubted value to the chemist, and some of it is in most unexpected places.

In the work of examining the current literature of chemistry, the AMERICAN CHEMICAL SOCIETY has simplified matters and saved much time for the individual by the excellent work done in *Chemical Abstracts*, and there would seem to be little argument for referring the professional chemist to the public library for this set. If any member of the AMERICAN CHEMICAL SOCIETY does not have his own volumes bound with the indexes—he should have. But he will find it worth while to consult the library for original articles, while for supplementing this set, for comparison, and for the literature prior to 1907, he will probably need to consult some of the foreign abstracts.

Abstract publications such as these are of inestimable value in scientific advancement and they are very infrequent outside the field of science. But there are several not distinctly chemical,

but so close to the borderland of chemistry that they should not be ignored. The scientific control of chemical industry is closely tied up with the measurement of temperature, and thus the current literature of physics must be followed. Electrochemistry has become one of the largest consumers of electric energy, and thus the current literature of applied electricity becomes of importance to the chemist. An easy method of assimilating this physical and electrical literature in tabloid form is afforded by the semi-monthly publication, *Science Abstracts*, produced co-operatively by American and foreign societies. Space will not permit the mention, even, of all the abstracts and digests which are of significance to the chemist, but excellent work is being done in abstracting the current literature of pharmacy, ferrous and nonferrous metallurgy, agriculture, etc., and in indexing the literature of engineering. Recently there has been a growing recognition of the importance—the necessity, even—of these abstract journals, and within two years new ones have appeared in the fields of botany, bacteriology, and glass technology.

It may seem superfluous even to refer to these publications. All chemists know some of them, and some chemists know all of them, but the point to be made is this: Not all these abstracts and digests are likely to be in professional chemical libraries but they should be available in the public libraries of important industrial centers.

Even the corporation which has a special business library can ill afford to overlook the public library collections. The *Journal of Electricity* will begin in the April issue a series of articles by Louise B. Krause, one of the most competent business librarians in America. While dealing particularly with the special library, Miss Krause says that her articles will also "suggest helpful information to be found in public libraries, which are invaluable aids both to the business man and to organized business libraries."

One recent abstract journal is the *Business Digest*, a publication which for the first time summarizes the literature in commercial journals, official reports, and some trade journals. Another index, which costs \$100 a year and is not frequently found in private libraries, is called *Public Affairs Information Service*. It appears weekly and gives timely information regarding much current trade and commercial material. These publications may at first seem irrelevant here, but a modern chemical industry is chemistry, plus engineering, plus business, and the chemist is frequently called upon to supply the requisite knowledge of all three subjects. The function of the industrial chemist has been described as "the introduction of the dollar sign into the chemical equation" and in order that this suggested introduction may be properly performed the chemist may need more than the proper chemical procedure to guide him. Thus he cannot afford to overlook the commercial factors of his particular industry. Business methods, export and import practice, insurance risks, industrial accidents, and market conditions—all may have an important bearing on his work. Freight rates alone may determine the success or failure of an undertaking. Price lists and trade catalogues have much value.

Such compilations as the *Chemical Engineering Catalog* and the *Annual Chemical Directory of the United States* have, of course, obviated the necessity of duplicating the work in their respective fields, but the Carnegie Library of Pittsburgh still enjoys a very gratifying use of its general collection of trade literature. This collection contains about 12,000 catalogues, card-indexed by firm name and subject. (This number represents only volumes, but as many of these are binders containing sets of pamphlets, there are actually some 60,000 separate pieces of trade literature.) The library has numerous telephone inquiries, such as "Who manufactures filter presses?" or "What is the address of the John Smith Company?" To get the answers from trade directories is, of course, only a matter of a few seconds, but in most of these cases the trade literature collection is now

sufficiently comprehensive to make it possible to say to the inquirer that the library will be glad to show him or lend him the catalogue of the firm in question. Not very many public libraries have yet given serious attention to trade catalogues, but the interest seems to be increasing, judging from the fact that this library has had to use a form letter in answering inquiries regarding its method of handling these catalogues.

This library also receives regularly about 300 house organs; card indexes them by title, subject, and firm name; and for the past two years has kept a card index to the separate articles in the more important ones—probably the only extensive index of its kind in existence. Many of these house organs contain valuable technical information which appears here long in advance of its inclusion in books or trade journals. The latest issue of *The Little Journal*¹ contained two items each likely to interest a patron of the library. Both were notified by telephone and both came to see the items.

A number of these house organs are devoted to the drug and chemical industries. Some are primarily price lists.

This subject of trade literature opens up an enormous reference field which is not likely to be covered in its entirety by any one industrial corporation and, as in the case of magazines, dependence on a special collection is to run the risk of missing material outside this special field. Modern industry is so diversified and manufacturers are developing so many new lines that it is difficult to keep up a special collection of catalogues which thoroughly covers even its own specialty. Then, too, in the industrial corporation these catalogues are frequently the perquisite of the purchasing agent, and when a new catalogue comes the old one goes into the waste basket. Thus the public library, which has room to store back files, will find considerable use for old editions. Sometimes these are of great value in patent litigation, and their use is likely to be all the greater since the advertising pages of magazines are usually discarded when binding.

Industrial chemistry, like research work, usually presents problems in more than one field and even the chemist who relies mainly on a well-equipped private library will find it profitable to keep in touch with his public library if only to learn of new publications from various scattered sources. He will probably find that not the least of the results attained is the knowledge of the work of federal departments and bureaus. The Department of Commerce, for example, is seeking in many ways to aid the chemical industry.

The U. S. Government is now the world's greatest publisher, exceeding in output any half-dozen publishing houses in America. In Washington's administration there was an authorization for the expenditure of \$10,000 for "firewood, stationery, and printing."² In 1918 the cost of government printing was approximately \$12,000,000. In the government printing bureau, 12½ tons of type metal are used and remelted daily, and 150 tons of franked mail is the daily average at the Washington post office. Despite some absurdities and abuses (such as the obligation to print 8,000 copies of the eulogies on every deceased senator or representative) the Government issues an immense amount of valuable material, and much which is of more or less direct interest to the chemist is scattered through these official publications. Many of the larger libraries are designated government depositories which receive all the more important government publications, but smaller libraries are able to keep regularly in touch with the material published and should be able to give information in regard to it and to secure such publications as are of interest to their particular communities.

Perhaps the chemist has found his local library unable to give the service he needs. For this undesirable state of affairs there may be several reasons. One may be the regrettable fact that

the financial support of libraries is often disproportionate to the support of other local activities, and the remedy for this may rest with the chemist himself and other influential members of the community.

It may not be amiss here to reverse the title of this paper and consider for a moment the chemist in the service of the public library. Chemistry is still a "new" subject in some small libraries, and the librarian may be afraid of it. Certainly the library school gives the student less training in the evaluation of scientific literature than in the selection of fiction, but the American Library Association and some of the larger libraries are now publishing aids to the selection of technical literature. The Carnegie Library of Pittsburgh has a small share in this service through its *Monthly Bulletin* and through the publication of a *Technical Book Review Index*. This *Index* is the only publication in any language devoted to recording reviews of scientific and technical books. But aids to book collection are not enough. The librarian needs the advice of well-informed specialists and a rather intimate knowledge of local industries.

The writer of this paper occasionally has a question from some smaller library regarding "good books on chemistry" or "the best book on chemical analysis." These questions, of course, admit of no definite answer without some knowledge of the use to which the books are to be put, and in making suggestions the scope and purpose of each book must be carefully explained. But the head of a small library may be pardoned for failing to make the proper distinction between an elementary text for students beginning analytical work and a specialist's treatise on commercial analysis, when the titles of the two works are very similar. Here is an opportunity for the chemist to render useful service to the library. Any librarian will welcome the friendly interest of the specialist and will be exceedingly grateful to the chemist who will be willing to spend a little time in appraising the existing chemical collection, if one exists, showing where it is weak with respect to local industries, and, if need be, explaining to the library staff a little of the terminology of chemistry—what is meant by "applied" chemistry, organic and inorganic, quantitative and qualitative, etc. This is not at all meant to suggest any instruction in chemistry, but merely a simple outlining of the relation to each other of the various fields of chemistry, with a suggestion as to which are of local importance. A better grasp of these conditions is certain to stimulate in the librarian a more intelligent interest in the literature of the subject if not in the subject itself. It may be thought that the librarian should dig up his own information on the subject, but in many cases he is too busy digging up other things for the public.

The chemist will, perhaps, find that his local library, while weak in chemistry, has spent considerable sums to aid the china collector or the print collector. This will be because the dilettante has more time to use the library, is probably enthusiastic about his hobby, insists on the literature, and magnifies its importance; while with the librarian, of course, there is likely to be a tendency to rate the importance of literature according to what people ask for.

In an article on "Vain Pursuits and Their Relation to Public Libraries,"¹ Mr. A. J. Hawkes states the hypothesis that the success of the public library movement is to be measured in terms of community, not individual value, and argues that "when discrimination between two books becomes necessary, the one most likely to create a new value to the community at large should be chosen."

This is, in most communities, a strong argument for equipping the library with literature on applied science and industry rather than on antique vases or Hepplewhite chairs. It is, moreover, the attitude reflected by the normal librarian, and its realization is dependent largely on the library interest shown by the

¹ Arthur D. Little, Inc., Cambridge, Mass.

² H. L. West *Bookman*, December 1918.

¹ *Library Assistant*, March 1914, p. 45.

chemists and other scientific men of any community. The public library is theirs; why should they not assist it and make it assist them?

The value of a library to the community consists not in the acquisition of literature but in its use, and the modern library is not satisfied with merely building up a strong collection. If the library is to fulfill its mission the librarian must know his collection intimately so that both personal and telephone inquiries may be handled with accuracy and despatch. He must also know his public, if the literature and the readers are to be brought together to the best advantage.

Christopher Morley, in an essay in the *Bookman*¹ a few months ago, portrayed one of his characters—Roger Miffin—in the rôle of a second-hand book dealer, with high motives which might well be emulated by the librarian. Roger Miffin says:

I am not a dealer in merchandise but a specialist in adjusting the book to the human need. Between ourselves, there is no such thing, abstractly, as a "good" book. A book is "good" only when it meets some human hunger or refutes some human error. A book that is good for me would very likely be punk for you. My pleasure is to prescribe books for such patients as drop in here and are willing to tell me their symptoms. Some people have let their reading faculties decay so that all I can do is hold a *post-mortem* on them. But most are still open to treatment. There is no one so grateful as the man to whom you have given just the book his soul needed and he never knew it. No advertisement on earth is as potent as a grateful customer. * *

The hunger for good books is more general and more insistent than you would dream. But it is still in a way subconscious. People need books, but they don't know they need them. Generally they are not aware that the books they need are in existence.

This last characterization of Roger Miffin's scarcely applies to the chemist, for generally the user of chemical literature knows what he wants and realizes when he has found it; and having found it, is content to use it as it appears, without demanding that an English translation or a popularized version be substituted. Though the well-informed man usually submits the knottiest problems, the librarian finds the work with these problems preferable to the work of ministering to the wants of aimless readers, such as the perpetual-motion "artist," who is not yet extinct, or the man who spent some time in the writer's department in a vain endeavor to discover some method of magnetizing liquids.

But the librarian must see that material is made so accessible that even the unskilled reader can find what he wants. Methods of cataloguing literature must keep pace with progress in the fields which that literature represents. These methods must be such as will expedite the getting of new books to the shelves and such as will make the entire resources of the library readily available to readers.

The Technology Department in Pittsburgh makes use of a special classified card catalogue which experience has shown to be better adapted to handling technical literature than is the "dictionary" catalogue in use elsewhere throughout the library system.

New technical books are secured promptly through an arrangement with several of the largest publishers by which one approval copy of each new book is mailed to the library as soon as it is off the press; this means that usually by the time a book is reviewed and an interested patron asks if it will be purchased, he can be shown that it is already in the library.

If, however, a patron inquires or telephones about a book in advance of its receipt his name is attached to the order slip, goes with the book through the process of cataloguing, etc., and a postal is mailed to him the day the book is ready for use. If the book may be borrowed it is reserved for him for two days.

Much use is also made of a "form" postal announcing new reference books and magazine articles to readers whose interests are definitely known. This service as relating to magazine articles

is probably not afforded by any other public library to-day, and it meets with a very gratifying response. Readers are encouraged to recommend books for purchase, a specially printed slip being provided for this purpose. Occasionally a few blank slips are mailed to some one, partly for the purpose of getting him in touch with the library.

The library has its own printing plant and prints a weekly list of new books. Copies of this list are promptly mailed to places where they are likely to be seen by technical men; for example, the Bureau of Mines, Bureau of Standards, Engineers' Society, various municipal and industrial laboratories, important consulting firms, etc. A *Monthly Bulletin* listing all new books added each month is also widely distributed, copies frequently being sent out with certain titles checked. This *Bulletin* is provided with annual author and subject indexes thus furnishing an up-to-date supplement to the Library Catalogue published in book form. Copies of special lists and bibliographies are mailed to men known to be interested.

A letter received last week revealed on the letterhead the personnel of a newly created committee of a technical society, not yet announced in the society's *Proceedings*. Advantage was promptly taken of the opportunity to send to each member a copy of one of the library's publications having some bearing on the proposed work of the committee.

Many bibliographies are compiled by the Technology Department, some of the most recent subjects being "Sodium Silicate," "Lampblack," "Industrial Porcelain," and "Pulverized Fuel." During the past year there has been little opportunity to print these, but several have been published elsewhere. Two will appear in books which are now in press in the East. Earlier ones have been reprinted elsewhere both in English and French.

In the library care is taken to let nothing impede the progress of the prospective reader toward the Technology reading room. On the way out, however, he comes face to face with a large bulletin board on which are posted titles of a few striking magazine articles, notices of a few new books, etc. This bulletin board frequently lures the departing patron into a decision to linger longer. On this board are posted, also, notices of the local meetings of scientific and technical societies, and an endeavor is made to have all these societies keep in touch with the Technology Department. In serving a clientele composed largely of live technical men it is advantageous to secure notices of forthcoming society meetings and, if possible, advance information from local technical journals. It occasionally happens that the advance notice of some society meeting announces a paper on some topic on which the library has a printed bibliography or at least a brief list of references resulting from a recent search. In such cases an effort is made to bring this material promptly to the attention of the prospective author. The library goes still further than this, as its Technology Department now has on file the names of a number of technical men scheduled to read papers three or four months from now. In due time material will be looked up on the respective subjects and notices sent to them regarding the material available.

The main idea, however, is not necessarily to bring the reader to the library for reference work but when possible to get him in touch with the literature with the least inconvenience to himself. Occasionally a man who telephones from the business section two miles away is given a definite reference and advised to consult it in the rooms of the Engineers' Society of Western Pennsylvania, down town. Incidentally this Society frequently calls the library for references, preferably in its own library. Telephone service is frequently instrumental in referring some one to just the information he needs, which will be in a hand-book or directory in his own office; less frequently in locating for an editor material in the files of his own publication, or identifying for an author the location and date of his own paper which

¹ *Bookman*, September 1918.

he only vaguely recalls. This is as it should be, and the wonder is not that such questions should come to the library but that there should not be more of them. Authors and editors in the aggregate furnish the material which makes the library possible. The library should then become the custodian of this material and the source of knowledge regarding it; and this knowledge, thanks to modern facilities, need not be confined to the immediate vicinity of the library. The printed catalogue of the Carnegie Library of Pittsburgh is used in India and in South Africa. The Technology Department has sent photostat prints to Canada, and has answered letters from most of the states of the Union and from points as far distant as Trinidad, China, and Russia.

The service of the public library is popularly supposed to be confined to supplying the printed word, but the progressive library is a general information bureau furnishing many answers which have not been reduced to print.

Occasionally luck favors the librarian. For example, during the last week in March some one telephoned to learn the name of a Canadian who was conducting certain scientific investigations. It happened that the Canadian gentleman himself had just visited the States and had spent two days in the Library a few weeks before. As the subject of his investigations was not intended to be kept secret it was not unethical to give promptly information which it would probably have been impossible to find in print.

Not long ago a Pittsburgh engineer telephoned for an opinion as to the best advertising medium for a certain purpose. A New York publication was recommended and the inquirer seemed both surprised and gratified on being told that an advertising representative of the journal recommended was in Pittsburgh for two days, and could be reached at a certain local hotel. Some time ago another local engineer telephoned to see if there was any chance of his being able to locate, in the original, a thesis in Russian, just abstracted in a German electrical journal. On looking at the abstract it was found that the author was a regular patron of the Technology Department—had, in fact, been there earlier in the day. When consulted, he was perfectly willing to get in touch with the man interested in his thesis.

These few instances are, of course, nothing but pure accidents, but they are pleasant ones and the chance of their occurrence is facilitated in direct ratio to the extent to which the library keeps in close touch with its patrons.

Furthermore, it is only by this close touch with an intelligent reading public that the librarian can estimate the real value of his technical collection and determine the strong and weak spots, for there are bound to be weak spots—weak spots and complete gaps. Very recently the writer was consulted by a publisher of technical books in regard to existing gaps in the literature of applied chemistry, and was glad to have the opportunity of suggesting several subjects on which good American books are much needed.

But the library in the service of the chemist may be of more than chemical service. The chemist's tendency toward diversion is illustrated by a calendar now being distributed by a well-known journal in the field of applied chemistry. This illustration, entitled "A Great Discovery," shows the interior of a chemical laboratory in which the young chemist has just discovered his great affinity for the co-ed assistant.

After his arduous professional labors, the chemist will probably find something to interest him in the lighter literature of the library. As Morley's Roger Mifflin says:

It's a good thing to turn your mind upside down now and then, like an hour-glass, to let the particles run the other way.

The public library can tell you how to manipulate your backyard to make two radishes grow where only one grew before; or how to supervise the landscape work on a thousand-acre estate if you are *that* kind of a chemist.

Again quoting the fictitious Roger Mifflin:

We have what you want, though you may not know you want it. * * * Malnutrition of the reading habit is a serious thing; let us prescribe for you.

SOME AXIOMS OF SERVICE IN THE USE AND ABUSE OF SPECIAL LIBRARIES

By HELEN R. HO-MFR. Dr. Geo. W. Crile Laboratory, Cleveland, Ohio

The special library is a storehouse of facts and owes its value, unlike the general library, not so much to its general educational and inspirational qualities as to its prompt presentation of the facts required in each specific instance at the proper moment and in the form most ready for use. It is not a browsing place for the idle-minded nor an enticement away from either the sorrows or the sins of life. On the contrary, it is a place where busy consultants go to find out definite things.

It is the librarian's task to receive their questions, and answer them promptly with the best material in the library, or with exact information as to better sources of information.

Now, what are the sources of information available to the librarian for the purpose? In the first place, there are the general handbooks and textbooks of the general subject, next special treatises on the specific subject, and then the journal articles of recent date. Of these the last, when available, are by far the most valuable both because they are the latest word and because, when properly written, they serve as a guide to earlier sources of information on the same subject. Of special treatises the most up-to-date should receive next consideration and then where these fail or are insufficient, one must fall back upon general textbooks with their necessarily much more limited treatment of individual subjects. But all these sources should be gleaned unless the question is answered earlier.

But suppose the special library in question lacks the needed data? Does the librarian's responsibility end there? By no means, unless the conditions of isolation are exceptional. There are the other libraries of the town and of adjacent towns. With these the librarian should be sufficiently conversant to know their possibilities and sufficiently familiar either to get the information by letter or to send the consultant with assurance of his ultimate satisfaction. Even where the other libraries are private property it is seldom that more than reciprocation in such service is required in return for free access or assistance.

In other words, when the librarian closes the case of a consultant it should be only after intelligent consideration of every source within possible reach.

While the librarian may now and then sin by omission, there are, on the other hand, the sins characteristic of the consultant which are even more difficult to meet with patience and overcome by persistence. The average consultant looks upon the librarian as a vessel of ignorance and does not always well conceal the thought. Or, again, the consultant may be a little stupid or even ignorant himself. Either of these conditions has to be met, privately analyzed, and treated accordingly. It is in regard to the first that a special plea may be of benefit. As may be inferred, a special librarian cannot be ignorant. If she is so during her apprenticeship she must outgrow it before she can become a special librarian. She must know her books and the general relationship between the subjects of which they treat. If need be she must study the contents to some extent.

This does not mean a knowledge of the actual facts but an acquaintance with their drift. It does not necessitate the retaining within one's mind of great collections of data but does involve the evolution of some system of record, such as a general subject index, which will serve as a guide to such locations as are too specific to carry in mind. Each librarian may make her own system for this. The form matters little so long as it works. Nor is a long, laborious preparation of such a subject

index to be presupposed. Rather it should represent the by-products of each day's work.

One thing, which no efficient special librarian can escape doing personally, is the constant reviewing of the periodicals received by the library day by day as they come in. If their number is too great for this, the library is too large to be called a special library and should be so subdivided according to subject as to bring its departments back into the category where special library methods may apply. From such daily service all points of possible interest to the clientele of the library should be noted and not only referred to the persons concerned but also recorded in the library's subject index.

In the special library convenience of arrangement is not an insignificant matter and yet how commonly it is found sacrificed to some arbitrary system, product of undue subservency to library school ideals or to symmetry of appearance.

The consultant enters a special library with a certain subject in his mind. He wants to get at that subject directly and likes to find it concentrated within a reasonable amount of space. He does not want to have to hunt through a hundred journals on different subjects arranged alphabetically to find the latest issues of three on chemistry. He will see no reason why chemical journals cannot be kept together, and rightly. Nor does he see spontaneously why the *Journal of the American Chemical Society* falls under A when the *Journal of Industrial and Engineering Chemistry* is in J. Of course, there is a reason perfectly satisfactory to a librarian but it is not one that appeals to the logic of the average searcher for scientific facts. Neither will he see at once why the decennial index of *Chemical Abstracts* should occupy a shelf far away from *Chemical Abstracts* but in close propinquity to the *Engineering Index*. He may perceive the manner of operation of the librarian's mind but it will not evoke great sympathy. These are only a few of the many lapses of reason one meets in the average special library.

The special library is, above all, not a suitable refuge for the victim of the routine habit. For efficiency its methods must be flexible and capable of adjustment to circumstance and of expansion to meet new needs. Its director must not only be ready to supply facts but also to receive ideas from the day's experience and to apply them to the advancement of the service, for the service may frequently, through such means, rise far superior in value to the material equipment.

THE KODAK PARK LIBRARY

By GERTRUDE REISSMAN, Research Laboratory, Eastman Kodak Company, Rochester, N. Y.

Our company being a photographic concern, the main feature of the Kodak Park Library is the completeness of the works on photography. Not that the books on photography outclass the others in number; on the contrary, photography is a young science, and all the literature written on the subject can be housed on comparatively few shelves. Whereas the books on physics and chemistry are mostly of a modern character, in photographic literature we endeavor to obtain everything ever published, be it of actual value for our work or merely of historical interest.

Our books on physics comprise various subheadings, the most important of which is optics—lens design and geometrical optics—to which science we devote almost as much attention as to photography. On subjects such as colorimetry, photometry, illuminating engineering, microscopy, crystallography, spectroscopy, general theory of heat and heat measurements, electrical measurements and X-rays, we possess a good assortment of the most up-to-date books, in addition to the usual handbooks, general textbooks, and physical and mathematical tables.

In chemistry we do not specialize in any particular field, but try to have a well-balanced library on organic, physical, and in-

organic chemistry. In technology we have, besides the general handbooks and textbooks, an exhaustive collection of works on subjects of special interest to us.

In addition to these three main groups, we have a few small collections on engineering, efficiency and business management, and a good assortment of dictionaries of foreign languages.

One of the most useful and generally read portions of our library is the journal section. We subscribe for over 200 journals on the above-mentioned topics in almost every living language, and much care is taken in their digestion, in which task we are greatly supported by the staff of the research laboratory. Each member of the scientific staff is requested to read carefully and regularly the journals in his particular line of work and make an abstract of every article pertaining to information of interest to our industry. Patents and newly purchased books are also briefly abstracted by the various experts and the abstracts are then collected and published in the *Abstract Bulletin*, copies of which are sent to interested parties. The abstracts are provided with a classification number and are so arranged that they can be cut apart, pasted on a card and filed according to a numerical classification, especially worked out for the purpose. By simply quoting the reference given with each abstract the original article can be obtained from the library, subject, of course, to the library rules. If the article is needed for an extended period, or for permanent use, we have a photostat copy made, or, if it is written in a language which the employee does not understand, we furnish a translation.

If an employee asks for information which we cannot supply from our shelves, we try to obtain it elsewhere. Either we buy a book on the subject, or we borrow it from another library; or, if the book is owned by an institution which does not loan books, we try to obtain a photostat copy. The Chemists' Club in New York has rendered us much valuable assistance in this direction. The search for information is often very lengthy and disappointing, but we either get it, or make quite sure that it cannot be obtained.

While the librarian is responsible for keeping the library up to date and in accordance with the needs of the various departments, the employees are urged to recommend anything which they think would be of use.

The books and pamphlets are arranged on the shelves according to their subject matter, and bound periodicals are kept as near as possible to the books dealing with the same general branch of science. The classification is based on that generally used in the universities, modified to suit our trade.

Our loaning rules are very simple.

Reference books, as, for instance, Allen's "Organic Chemistry," Beilstein, *Berichte*, handbooks, back numbers of periodicals, cyclopedias, dictionaries, must not be taken out of the room at all, and for this reason investigators are allowed to spend as much of their working time as necessary in the library.

Current numbers of periodicals must not be taken out during working hours, but they can be taken home over night. Books on special topics can be borrowed for a reasonable length of time, and if the book is needed for permanent work, or for a prolonged investigation, we buy a second copy, or, if the required information is contained in a certain chapter, we have it photostated. Translations are made as necessary.

The library is open during the working hours and at the noon hour. Everybody can go to the shelves and take out what he wants, but he is requested to fill out a card when taking the book out of the room—a request which the busy man sometimes forgets. The system is very lenient indeed, but it works well, and we are proud to say that in spite of these liberal rules, our loss in books averages only three a year. (The figure for lost current numbers of periodicals is not quite as phenomenal, but still, it is very good.)

While the library, as a whole, is intended for scientific men

and manufacturing experts, one corner of it is set apart for the working men without any scientific training. This little department contains a few elementary books on the science of photography and color photography, many on photographic manipulations and motion picture work, a few elementary works on general science, some on physics and chemistry, a large number for the electrician, the mechanic, the draftsman, the carpenter, etc., as well as some popular books on personal and business efficiency and geometry. The books can be changed twice weekly during the noon hour and we take great care in directing the people to the reading matter they need most. In this department the books are charged to the borrower in the usual way. The little educational library has proved quite a success.

THE FUNCTIONS OF THE INDUSTRIAL LIBRARY

By E. D. GREENMAN, Arthur D. Little, Inc., Cambridge, Mass.

Research investigations are now carried on jointly in the library and in the laboratory, and the amount of time, labor, and money saved by first making a state-of-the-art search will usually well repay the investigator for his efforts.

As the ultimate function of any library should be service, we find this function responsible for the existence of the industrial library and here it should be developed to the highest possible degree.

A properly functioning industrial library should include the dispensing of information, both solicited and unsolicited. It should serve as a reference department where definite questions are answered and where definite lines of thought may be investigated. In addition to this it should distribute unsolicited information, a function in which many of our libraries are woefully lacking. By the distribution of unsolicited information I mean that the library should constantly bring to the attention of every patron, any book, article, reference, or note of interest or value to him. In order to do this the librarian must be kept informed as to the lines of interest each man has.

The working functions of an industrial library are well illustrated by the library of Arthur D. Little, Inc. The library occupies three rooms and stacks adjoining the research laboratories. The main room consists of two alcoves used for reading and study, and a reference section containing the card catalogue and the librarian's desk. The other rooms are used for pamphlets, special data file, and for workrooms.

All material is divided into five classes: (1) Books, (2) Pamphlets, (3) Trade Catalogues, (4) Clippings, (5) Blueprints. There are 4000 selected volumes, 6000 pamphlets, 20,000 clippings, 10,000 patents, and 800 blueprints, all classified according to the Dewey system. The books are arranged in the main reference room and stacks by classification number, pamphlets are filed in pamphlet boxes; clippings, memoranda, and special data are mounted on manila sheets, placed in classified folders, and arranged in letter-file cabinets by class number. Trade catalogues are placed in folders and arranged alphabetically. Owing to the wide range of subjects included in industrial chemistry, the collection of this material necessitates careful selection. Only the best books are purchased and only the articles of unusual value are clipped or carded.

All this material is carefully indexed by a dictionary catalogue which now contains over 100,000 cards. For each book, pamphlet or clipping, cards are made giving author, title, source, date, and classification number, with a special designation for each class of material. Pamphlets are designated by P, clippings by S, blueprints by Bp, etc. Letters, memoranda, and notes containing any information of unusual value are also carded in this catalogue. Authoritative works and standard reference books not in the library, but which may be consulted at nearby libraries, are indexed, the cards indicating where such books may be borrowed or consulted. All books on chemistry published

in this country since 1917 have been listed, whether the books are available in this locality or not.

The librarian serves as the eyes of the organization, searching for literature of interest and value to twenty specialists engaged in relatively different fields of chemical research. There are chemical engineers, analysts, paper chemists, metallurgists, textile experts, microscopists, fermentologists, and research chemists in organic, inorganic, and physical chemistry, and each one must be supplied with the latest literature on his special line of investigation. As a means of keeping in touch with this literature, the library currently receives sixty technical periodicals and society publications. Each is carefully examined by the librarian who indicates on attached slips the page number of the article, note, or reference of interest to each individual. These magazines are then routed to the men whose names appear on the slips and for whom references have been indicated. As soon as the man has examined the reference he initials it and the magazine is sent to the next name on the list. Clippings, memoranda, and special data material are treated likewise. The library also issues a biweekly bulletin listing new books, pamphlets, and trade catalogues. This is sent to each member of the company who indicates the titles he wishes to examine.

The largest and most important part of the work of the library, however, consists in serving as a bureau of information for the purpose of answering staff inquiries. At any time we may be concerned with a new tropical fruit, a new paper-making material, a problem effecting economy of production, or the utilization of waste products, and information on these subjects must be quickly available. Illustrative of the variety of questions which have come to the library recently have been requests for literature on bullet piercing steel, metal soaps, vegetable ivory, resiliency tests, synthetic ammonia, raffinose, artificial catgut, filtermasse, chlorination of wool, sericite, money value of the nitrogen unit in fertilizers, factors in the luminosity of flame, etc.

The compilation of bibliographies forms a very important and essential part of our work. When a new subject comes up for investigation the library is requested to compile a list of references to the important literature on that subject. This list is submitted to the investigator who calls for such references as he wishes to examine. Experience indicates that the chemist prefers to personally examine and digest the literature on a subject under investigation rather than to have someone do this for him.

As the state-of-the-art is frequently several years in advance of its published literature, treasures of inside information have been collected and carefully preserved by industrial companies as a result of their researches and investigations. Our own library contains 150 volumes representing the results of 30 years of research work. They comprise over 50,000 certificates of analysis and 40,000 typewritten pages of technical reports dealing with problems of industrial chemistry. This material is carefully indexed and comprises a vast encyclopedia of confidential information.

The library seeks to serve all the members of the company from president to office boy. The janitor has been given reading matter on the care of furnaces and boilers, the stenographers have constant use for books giving them chemical terms, the office boys are keen for books on chemical analysis, and the research chemists are always present.

THE FUNCTIONS OF A RESEARCH LIBRARY IN THE DYESTUFF INDUSTRY

By JULIAN F. SMITH, National Aniline and Chemical Co., Inc., Buffalo, N. Y.

The Schoellkopf Research Library, so named in honor of the pioneer makers of American synthetic dyes, began to take form in August 1916. Its organization was so planned as to conform as nearly as possible to that of the best institutional and reference libraries.

With this idea in view, the entire library has been classified according to the Dewey decimal system, which is used by most public and educational libraries. No classification method is perfect; but any system has advantages over no system, and the Dewey plan has the advantages of wide usage and exceptionally thorough subdivision in nearly all classes. The chief disadvantage is that some of the sections in chemistry and technology are urgently in need of revision.

Minor details, such as arrangement on the shelves, pamphlet filing, etc., are made to follow as nearly as possible the best current usage. Custom, however, is made subordinate to convenience. The system is shaped to fit the library, not the library to fit the system.

The plan of administration, or method of making the library useful, is of course intended to render the maximum of service. With the exception of the standard reference works, nearly all the literature is freely loaned to accredited users of the library, with the understanding that it shall be returned in seven days. Renewal of loans is permitted, and is quite commonly requested. A custodian has charge of the loaning and returning. She is generally kept quite busy between times typing the various documents prepared by the librarian, and keeping up the routine work of the library.

The library room is large enough to provide ample study space, in addition to the stacks. Most of the men who read there are familiar enough with the shelf arrangement to find the volumes they need; but the custodian is always ready to give such information on request.

Although on casual inspection ours looks like a decidedly chemical library, there is much other material. All of Dewey's ten main divisions of human thought and study are represented, except philosophy and religion. Rough grouping of the literature on the shelves reveals the following dry but instructive figures:

Chemistry, of the variety often misnamed pure, makes up about 40 per cent of the texts and reference works, 20 to 25 per cent of the pamphlets and unbound periodicals, and nearly 75 per cent of the bound periodicals. Technical chemistry occupies some 30 per cent of the text and reference shelves, 25 per cent of the pamphlet and unbound periodical files, and 25 per cent of the space devoted to bound periodicals. This branch maintains the least erratic ratio of any.

Physics comprises about 5 per cent of the texts and reference works and of the unbound periodicals, hardly more than 1 per cent of the pamphlets, and a small but slowly increasing proportion of the bound periodicals.

Engineering forms some 5 per cent of the texts and reference works, 10 per cent of the pamphlets, and 15 per cent of the unbound periodicals, but considerably less than 5 per cent of the bound periodicals.

A wide variety makes up the remainder. Library science, business, finance, legislation, insurance, labor problems—all the subjects that interest a large manufacturing establishment must needs be more or less thoroughly represented.

In order to keep abreast of the times, 67 periodicals are currently received, and we have a waiting list of about 20 more to be added to our subscription list as soon as we can begin to get them from Germany and Austria. Partial files of about 30 others, not currently received, are on the library shelves.

There is plenty of variety in the types of service expected of a research library, but they naturally group themselves into only two classes: first comes the duty of providing references, and second that of facilitating their use.

The members of a live research organization would like to have at hand all the literature needful for the solving of any problem. Failing of this ideal, which is not likely to be attained this side of the millennium, the next best method is to know the habitat of all existing literature needed but not possessed.

Once discovered, references can usually be purchased or borrowed; if neither of these is possible, a copy or abstract can nearly always be obtained. The cameragrams furnished by the John Crerar Library of Chicago constitute one of the best sources of copies; but there are many others.

Providing the literature is only the beginning of the twofold service to be rendered, bibliographies, abstracts, translations, indexes, and other aids are constantly needed to increase the usefulness of the library's treasure-house. An alert watch must be kept for new developments.

Patents form a problem by themselves. The conditions under which patents and their records may be useful vary so much with different companies, that each must needs work out its own plans for handling the problem. The most crying need is adequate indexing of U. S. patents, a task which our Government has not yet taken very seriously to heart.

Improvements are needed in both divisions of research library service. In the providing of literature, resumption of mail service from Central Europe will open up sources of some of the valuable reference work published there. But a much better prospect is the production, in English, of more thorough and reliable chemical literature than the Germans ever wrote. We hope great things from the tentative plans for compiling English reference works in the various fields of chemistry; and we anticipate that research libraries will be called on to contribute their share toward the compilation thereof.

In the second class, the facilitation of reference work, the prominent need is indexing. If all the technical literature of the world could be card-indexed and if the cards could be distributed by subscription, like Library of Congress cards, the research librarian's life would be a garden of roses. Since that cannot be, each library must do large quantities of indexing for itself, or lose the benefits to be gained thereby.

All the above observations have been made with the dyestuffs industry in mind but in the main they are equally true for any research organization. A research library is a highly specialized reference library; but it dares not be narrowly specialized. It must reach into nearly as broad a field as its greater cousin, the public reference library. The latter must serve many industries more or less superficially; the former must serve one industry thoroughly in its main interest and must make some provision for its occasional interests.

INTERNAL PUBLICITY AS AN AID TO THE LABORATORY

By S. M. MASSE, Publicity Department, National Carbon Co., Inc.
Cleveland, Ohio

The nature of publicity work, as generally understood, is to circulate information. Advertising is one form of publicity; newspapers are another source. In both these instances the information is sent from the place of business to the outside world. This might be termed external publicity. Now, how about reversing the process, that is, bringing the information from without the plant to the organization within? This is internal publicity. It has been said that in order to stabilize business there should be just as much intake of publicity as there is output.

My mission to-day is to tell about the use of internal publicity as an aid to the laboratory.

The busy chemist has not the time and opportunity to keep in touch with all the latest technical and trade paper information. Oftentimes the most timely subject may be found in some seemingly obscure magazine, or some foreign topic may have a valuable application to the process at hand and be contained in an article which would probably be the last place the chemist would be apt to look.

This brings me to the issue of most vital interest in this discussion. It is the *Weekly Index* service of the National Carbon Co., Inc., and concerns the relationship of the industrial library

to the laboratory. Of course we have other departments to serve at the same time so that the *Weekly Index* is not limited to the laboratory alone but serves all departments of the company.

Instead of placing this work in direct charge of the library staff we employ the services of technical men. These men are either chemists or electrical engineers. Together with the advertising personnel and library staff they comprise what is known as the Publicity Department.

We subscribe to approximately 90 publications, technical, trade, and business papers. Of the more important publications we get a number of magazines to take care of the demand. The work of the publicity men is to go through these various publications each week and choose therefrom the articles of interest to the various departments. A comment is then made on each article so as to bring out its special application to the organization. These articles are then listed under their respective publications on what we call our *Weekly Periodical Index and Review*. The *Index* also includes all new books received, pamphlets, patents, etc. Printed copies of the *Index* are then distributed among all interested employees, including all of our several plants scattered throughout the country. Space is provided at the left of the *Index* page for the recipient of the sheet to fill in his name and department. Then, by checking the desired articles and sending the sheet back to the library, the person receives the magazines, books, patents, or whatever he has checked.

It is often true that the articles checked are not necessarily in chemical publications but still contain information which the chemist can appreciate. The *Index* includes foreign articles which are translated on request. Although it might be pointed out that *Chemical Abstracts* would cover much of the technical information, our local index presents the desired reference in a nutshell and we feel that we can give as a comment an application with a more direct bearing than what would be construed from reading the comments given in *Chemical Abstracts*. Moreover, articles of a purely business point of view are included and often used to good advantage by the laboratory staff.

We also keep a regular mailing list comprising names of all those who are interested in certain publications and wish to secure them regardless of their appearance on the *Weekly Index*. This list is carefully selected and includes only those persons who, through their type of work, would be expected to keep in touch with the particular magazine in question. Other persons would have to take their turn farther down in the list.

After the *Weekly Index* has been entirely circulated, all articles are filed according to the Dewey decimal system on large manila cards. Thus, if at any time one wishes to review any articles under a particular heading, he can receive this information from the library files. Another phase of our information stock may be gathered from the catalogue files in which are found all descriptive literature of products related to our own.

Sometimes someone desires special information on a particular subject. In this event he simply calls on the phone or writes the Publicity Department and the information is gathered by the technical force. Quite often this requires immediate service, as, for instance, when a laboratory man needs certain information which he would otherwise have to secure for himself by leaving his work. If desired, a bibliography on any subject will be formulated although by now we are equipped with practically all bibliographies of interest to the company. In spite of the fact that we have over 4000 volumes in our library the technical force sometimes has to seek information from outside sources or correspond with related industrial concerns. In respect to this latter, we have been agreeably surprised at the responsive spirit to cooperate which emanates from outside concerns.

Bulletins, abstracts, tables, etc., are formulated from time to time, one example being a small booklet called "Technical

Periodicals." In it are listed about 500 technical periodicals giving the library where each one may be found, and also from what date these periodicals have been kept. The libraries include about ten of the various public, college, and commercial libraries scattered throughout the city of Cleveland. There is also our company publication—the *Carbon News*—which is entitled to much consideration as establishing an *esprit de corps* among our workers and no doubt this family style of house-organ is being used in the majority of industrial concerns to-day.

One thing more must be mentioned as included in our publicity service. It is the photographic studio which functions as a means of visualizing so much better than written words will sometimes do. When someone desires a permanent copy of material which the library reserves for reference purposes only, we can supply photostatic copies from our studio. This is especially advantageous for taking care of the needs of our distant factories.

I want to say in closing that the Publicity Department of the National Carbon Co., Inc., is at all times glad to help any industrial establishment or interested persons on questions of which we have a specialized knowledge. Our business is carbon manufacture, yet this entails a number of related subjects which should cover points of interest to many of those present here.

LIBRARY SERVICE OF THE NEW JERSEY ZINC COMPANY

By LEONORE A. TAFEL, New Jersey Zinc Company, New York City

The library system of the New Jersey Zinc Company grew out of the need, which made itself felt at different points throughout the Company, of having close at hand working collections of books. These collections were at first small and disconnected, but as the interests of the Company grew, the demand arose for books on a greater number of technical subjects, and a means of carrying on systematized research work. The need of library service proved to be threefold: (1) The need of standard reference works for constant use; (2) provisions for systematic research work, which includes the compilation of bibliographies, access to sources, and translating and abstracting of material; (3) contact with current technical literature.

In order to extend these advantages to all members of the Company, and at the same time to administer the work in the most efficient and economical manner, these scattered libraries were organized, in 1917, into one Company library, centralized in New York, with branches throughout the Company. The library is organized directly under the Technical Department, which department has charge of all research work. The administrative work is centralized in the New York library, including the ordering, classifying, and cataloguing of material for all libraries. Two branches have been entirely reorganized according to modern library methods, and it is planned to reorganize others and establish new centers as the need makes itself felt. Union catalogues of all books, pamphlets, and magazines in the Company library are maintained at four different points, and this material may be borrowed by any member of the Company. This organization work has proved worth while in making the library resources most accessible.

In ordering books, duplication is avoided as far as practicable, except in the case of standard reference books which are of constant use and must be near at hand when needed. These are duplicated freely and kept up to date. Of the newer technical books which may not prove of lasting interest, one copy is bought, as a rule, routed among the men interested, and finally placed in the branch where it will prove most useful, to be sent out on request to anyone desiring to read it.

Having established these reference collections at different points in the Company, and having arranged a system by which the reference work was coordinated, it was soon found necessary to render further aid to the research worker in the compilation

of bibliographies, in order that he might have a résumé of the literature of a subject to compare his experiences with those of others engaged in the same work. These bibliographies are compiled on request by the local branch, or by the New York library. Brief abstracts and translations are added to these lists to increase their usefulness. The research worker is often located at a distance from his sources of information, and it is of inestimable value to him to know that any material which he needs in his research will be brought to him through the Company library system. Requests for material which is not on file in the Company libraries are forwarded to the New York branch, which is in a position, through its contact with the large libraries of the city, to furnish copies of this material in photostat or typewritten form, or to purchase the material in a short time. We have had excellent cooperation from the libraries of New York and Brooklyn, from Lehigh University, the Library of Congress, and government departments, and from editors and publishers.

In a commercial library one of the most important phases of the work is with current periodicals and society publications. It is of the utmost importance for our men to be kept in constant touch with the latest developments in their special lines from day to day. It was to meet this need, and to get the information to the men as soon after publication as possible, and in convenient form, that our *Library Bulletin* was established. This publication indexes regularly about 125 technical publications, and includes library notices, an alphabetical list of magazine articles briefly abstracted, book reviews, and bibliographies. A convenient blank for calling for this material, on which the articles desired may be noted by number, as 86—Steam Engines, is included in each issue, and is much used by the men. These blanks are sent, through the local branch, to the library having the material on file, and the requests filled as rapidly as possible, the men cooperating by returning the magazines as soon as read. In this way many of our magazines have a circulation of fifteen, twenty, or even twenty-five readers. Articles in special demand are typed or photostated, and circulated in this form.

Our present Company library is thus the result of actual needs which grew up, little by little, through the Company. It has expanded from several small collections of a hundred books each to a series of branch libraries, of which the two largest have a collection of 2300 and 1800 books, respectively. It has extended this threefold library service to all points in the Company, and fills requests from Colorado, Oklahoma, Illinois, Virginia, New Jersey, Pennsylvania, and New York.

LIBRARY SERVICE IN THE INDUSTRIAL LABORATORY

By G. W. LEE, Stone and Webster, Boston, Mass.

The laboratory of Stone and Webster has a fair collection of books and periodicals for handy reference, and in consequence its use of the general library of the organization is comparatively slight. Moreover, none of the general library staff have had more than nominal training in chemistry, so that I need to interpret the title of this paper with much freedom, and to deal with principles that apply to library service of almost every description, whether for industrial chemists and chemical engineers or for political economists, students of history, or for the so-called man on the street. I would also justify such interpretation from my belief that library service is still in its infancy.

The term "service" savors of more than the mere performance of duty. At any rate, for the purposes of this paper, I would have it signify the endless persistency to give satisfaction; hence above all things the habit of putting one's self in the position of the questioner, and the enthusiasm to anticipate what questions are likely to arise.

Let me cite, with comment, a few questions from the record of the Stone and Webster library, not merely to show examples

of actual service, but, still better, to suggest possibilities of a larger service than we have enjoyed, but which seems well within the possibilities of realization at an early date.

1915—*The Chemical Composition of Water Gas Tar.* A reference was found through the *Industrial Arts Index*. Other indexes were also consulted; and the time taken for this was 25 minutes. It is a simple illustration, and one suggestion is that the record of sources should be painstaking, since it makes the answer available as a time saver, should the question arise again. Another suggestion is that the method of recording and classifying the record, to promote "findability," should be standardized.

1913—*Information on Cyanamid.* A trip to the laboratory was needed, where plenty of references were found in familiar technical journals, and the suggestion follows that to cross-reference the library with the various departments of the organization is an essential of good service.

1917—*Information on Sulfur Dioxide, if there is such a thing, and if so, its characteristics.* Asked by an outsider and referred to a member of the office, who dealt directly with the questioner. Library time, 2 minutes. Suggestions: (a) The importance for the library to know and make a record of who's who in the organization, because, in this instance, supposing that A, B, and C, any one of whom could well have answered the question, were all away, it is convenient to know that D, not being away, could supply the answer. (b) The importance of serving all who ask, whether outsiders, insiders, heads of departments, or the youngest office boy, i. e., the importance of having an all-round reputation for enthusiasm to be of use. Such reputation is an asset; it helps to create an atmosphere, a general desire to be of mutual service, which you will agree is decidedly worth while.

1916—*The Commercial Process of Making Caustic Soda.* An office member had a book that contained the information, and the obvious suggestion is that the library should make record of personally owned books and personally subscribed-for periodicals.

I recall an instance of our wanting a map of Shanghai. It was borrowed from someone known to have lived in Shanghai for many years; and herein we have the suggestion of developing the vast field of community resources—personal, institutional, and commercial. To a certain extent and in a casual way, we have been making note of such resources on colored cards, which we insert in our library catalogue. This, therefore, which we do casually, should be done systematically.

1914—*Fixation of Nitrogen.* Plenty of references. The question, however, was referred to the Boston Coöperative Information Bureau; and quite likely for the reason that it did not seem worth while for us to spend much time on routine when there existed an organization to take such matters off our hands. The cumulative experience of drawing upon the community resources was well illustrated in the history of this information bureau, an undertaking that proved to be in advance of the time. People had not been sufficiently educated in the use of research for business purposes to give it due financial support, so that today it is merely the service of courtesy, entered in the telephone book under its later name of Information Clearing House of Boston, with the same telephone number as that of Stone and Webster. We hope the time is nearly ripe for transferring it to the Public Library or Chamber of Commerce or other organization that will revive it on a going basis.

1917—*Consumption of Chloroform and of Carbon Tetrachloride per Annum.* Twenty-five minutes spent in the library when the question was referred to the Information Bureau, but without getting much satisfaction. A dealer who was asked for information said, in effect, "We know but are unwilling to tell;" and this opens up the big question of the trade secret;

and trade secrets, as many of us have found, impede the research man, though, of course, there are two sides to the question.

1919 *The Use of Water Glass to Prevent Rust.* A question that apparently can be answered by somebody, but the answer not found as yet; hence we are minded of the question box, the ways and means of readily advertising the unanswered question, and thus of getting in touch with sources of needed information.

More questions illustrating one point or another could readily be cited; but let these seven suffice to suggest how much more a library service is than a general or special collection of books, periodicals, indexes, and a staff to consult them.

What can this convention do to perfect the ways and means of getting information? Can it, by resolution, encourage the librarians of the country, through the American Library Association (having headquarters at 78 East Washington Street, Chicago), to act as a great clearing house of information and of research? I believe that those headquarters would, if appealed to in this capacity, take adequate means to build up a service that would give sensitive response to seekers for information who have not been successful through local resources.

Perhaps a very simple way to stimulate the big library industry I have hinted at, is for each delegate here to-day to remember to send to the American Library Association headquarters at least one question that he has found to be a puzzler, with the expectation that the Association will show itself eager to render the service of securing the answer. It would be well to include return postage with the question. If satisfaction is not obtained by this means, then, as sponsor for the suggestion, I would ask to be informed of the fact myself; and if I am thus informed before the middle of June, it should be in time for me to report the complaint to the general convention of librarians, which is to be at Asbury Park the last week in June.

WORK OF THE LIBRARY OF THE SOLVAY PROCESS COMPANY

By W. L. NEILL, Solvay Process Co. Syracuse, N. Y.

The collecting of books and journals for this Company began more than thirty years ago. Ours is particularly a special library, mainly on chemical subjects, which contains some 1200 volumes, including bound volumes of the principal English and German chemical journals for some years past. It is in constant use by our staff of chemists. It is indexed on the Dewey system, with the usual cards.

We have also, as a second part of the library, files of the principal technical journals, both American and foreign. From these we make abstracts, which are printed and sent out to about 100 men in our employ, one-half of whom are in the local office and one-half in our other works. We also circulate among the officials here about twenty of the journals, which are carried out and brought in daily after two days' use.

SPECIAL LIBRARY SERVICE IN THE BARRETT COMPANY

Not only has this firm realized the value to be derived from a permanent library service bureau with headquarters in the main office but has recognized the necessity for attaching to the personnel of the Research Laboratory a "library chemist" whose time is exclusively devoted to the compilation of literature references pertaining to subjects under investigation or to be investigated. The bibliographies thus compiled are put into ring binders, each abstracted reference having its separate sheet. The main classification of the references is chronological and each year is again classified alphabetically by authors. Classification is followed by pagination and then the bibliography is ready for the preparation of both author and subject indexes. The subject index is cross-indexed to the minutest detail and some-

times covers as much as 15 pages for a bibliography of 150 to 250 pages.

The above remarks are not intended to serve as an outline of our Research Information Service, but are merely given to illustrate our view as to the simplicity and serviceability of any such scheme.

LIBRARY SERVICE IN THE CHEMICAL DEPARTMENT AND CHEMICAL DEPARTMENT LABORATORIES OF E. I. DU PONT DE NEMOURS & COMPANY

By F. L. GALLUP, E. I. du Pont de Nemours & Co., Wilmington, Del.

In answer to a request for a paper describing any special features of the library of the chemical department of E. I. du Pont de Nemours & Company which are helpful to us or may be helpful to others, it is necessary to describe briefly the library organization in the chemical department of the Company.

The department is composed of some ten divisions whose executive heads are in the main office of the Company. The department maintains, outside of the city of Wilmington, four experimental laboratories, each of which is in itself a large organization. Each of these laboratories has a library and a librarian.

Each of the five libraries of the department is a special library and really special unto itself for the following reason. Particular lines of work are delegated to each laboratory organization which may be briefly summarized as follows:

EXPERIMENTAL STATION—Smokeless powder, black powder, artificial leather, and some special chemicals.

EASTERN LABORATORY—Commercial dynamites and high explosives.

JACKSON LABORATORY—Dyes.

DELTA LABORATORY—Pyralin products and pyroxylin compositions.

It is natural that each library should specialize along the lines its men are interested in. The Main Office Library functions for the executives who direct the activities of the several laboratories and as a result the Main Office Library directs its attention more particularly to the broader aspects of the subjects the department is interested in and less to material required in laboratory investigation and routine.

The Main Office Library of the department has no authority in the direction of the other libraries but a serious effort is made among the several libraries to cooperate, each to be helpful to the others as occasion permits. This cooperation is a very hearty one and much good comes from it.

Our library organization is not old, in fact is comparatively young, but a serious effort is being made to develop our libraries along common-sense lines and to have as librarians those who know not only the principles and rules of library economics, but who can study their problem from the service standpoint and discount the requirements of the library to the extent of anticipating the needs of the chemists on old and new problems.

We believe in this connection that it is of decided importance to have means provided by executive heads which shall supply a librarian serving industrial laboratories as promptly as possible with as much information as possible to aid in placing in the library needed information on new subjects for investigation in the laboratory. It is of prime importance to provide, as far as possible, in advance, library requirements of an industrial laboratory. It is a source of added stimulation to the investigator to be able to find his information at hand at the time wanted and not to have to wait until it is ordered and received and perhaps in the meantime have led himself into unnecessary expenditure of time in trying to produce the information through laboratory experiments, or lost in some degree his enthusiasm.

There are several features in our library organization that are particularly helpful. There is a monthly exchange of accession

reports between the five libraries of the department. A review of these may bring to the attention of the libraries material that has been overlooked in the routine review of current publications. There is prepared and distributed to the libraries a very complete monthly compilation of abstracts which have to do particularly with those subjects in which the chemists of the department are interested. We believe that this is an especially valuable aid to an industrial laboratory in that the efforts of one person are directed to supply specific information, digested and classified, to relieve the busy chemist of the necessity of reviewing periodic literature. He may, through the perusal of this publication, direct his attention to only those matters which are of moment.

Another important feature which is undergoing development and perhaps has reached a higher stage of usefulness in our Main Office Library than in our laboratory libraries, is the maintenance of patent files covering the subjects in which the department is interested. The patents are filed in the vertical files in their numerical order, are catalogued according to author and subject, and a numerical card index is maintained which allows the librarian or her assistants at a glance to answer 'phone inquiries in regard to our patent resources. We must recognize the development of the prior art in its relation to present-day chemical research and a review of the patent situation, we believe, is quite as important a feature as the review of literature. For this reason we believe that an essential feature in the library service in the industrial laboratory is the maintenance of careful cataloguing and filing of patents issued on the subjects in which the laboratories are interested. We charge out and credit the return of patents in exactly the same way as books and periodicals are charged and credited.

Another helpful feature is the maintenance in the catalogue of each library of a record of the resources of the other four libraries. This is economically and readily maintained by placing on the card distinguishing letters which represent the other libraries and having a distinguishing color card with distinguishing letters for those items which are not a part of the resources of the home library. This puts before each librarian a nearby source for material which may be urgently needed.

We are getting ready to organize and maintain a "special research" catalogue of references. The ground work is being laid to make this a valuable adjunct to the library service in the five libraries. This effort will include the classification and indexing of the information in our chemical department reports which are prepared by special investigators. This work may not perhaps be properly classed as library work but we maintain that

in an industrial laboratory the library must be turned to as the chief source of information of a technical character. A great many instances have arisen, particularly during the recent emergency, which have shown that it is highly desirable to maintain an index of classified information covering the results of work that our men have done as distinguished from indexed classified information obtained from sources outside of our own laboratories.

New men come with us who may be put on problems that have been previously undertaken and temporarily dropped, or work may be required on problems that were thought to have been finished several years ago. We believe it is essential to have in the libraries, readily available, a classification of the results of work previously done in order to avoid unnecessary duplication of effort which means loss of time and unnecessary expenditure of money. Another feature which is being developed in our Main Office Library and which may be extended to our laboratory libraries is to compile our catalogue in such a way that it will give the user information in the way our men naturally look for it in view of the nature of the subjects we have to deal with. We believe that any material worth keeping is worth cataloguing and the catalogue should be a directory to all the resources of the library. Many instances have come to our attention to show that a "one man" system is not of much value if the "one man" dies or is suddenly removed from his position, and we are bending our efforts to produce a system of classification and indexing in our libraries which will be self-explanatory.

One of our libraries has a member on its staff who is engaged in bibliographical work on subjects under investigation. You will appreciate the value of a person capable of doing this kind of work in the library staff which serves an experimental laboratory engaged in a wide range of activities. The advantage is self-evident. Not only may the chemist's time be devoted to his actual work but the search of the literature is in the hands of one trained to this kind of work.

It goes almost without saying that a feature in library service at the laboratory which must not be overlooked is the employment of those to conduct the library who have an enthusiasm for technical work and who have a disposition to encourage a research chemist to feel that an effort is being made to put the resources of the library at his disposal in the most convenient way. It is truly stimulating to feel that the library corps is willing to be of service, and the selection of a librarian who has the ability to study the dispositions of the people whom she serves, as well as the pure library problems, is to be very much encouraged.

FOREIGN INDUSTRIAL NEWS

By A. McMillan, 24 Westend Park St., Glasgow, Scotland

SOUTH AMERICAN TRADE

According to the *Times Trade Supplement* for March, the Republic of Ecuador offers a very attractive field for most kinds of manufactured articles. Practically anything that the country requires—except food—has to be imported, since there are hardly any local manufacturers. The purchasing power of the inhabitants may not be great, but the custom is good, because all transactions are done in cash and the mining trade in the country has lately flourished greatly. In addition to articles of apparel, building materials, for example, iron, steel, and cement, are largely in request, the market being steady all the year round. Wood is not imported as a soft white oak grows in abundance, but most kinds of implements, tools, and ironmongery, are in great demand and, up to the beginning of the war, the Germans had this in their hands. In Chile, where agriculture is chiefly developed, there should be a ready market for farming machinery. Effective demonstration would

be needed but once they were convinced of the merits of the farm tractor, the question of expense would not stand in the way of the wealthy ranch-owners. There is also considerable scope for irrigation equipment, engine-piping, etc. Chief among the agricultural implements imported last year were cultivators and ploughs. Other articles of machinery, apart from sugar refining machinery, which found a market, were mowers; reapers, threshers, planters, and seeders.

LARGEST MOTOR MADE

What is claimed to be the largest motor made, says *Engineer*, 127 (1919), 201, has recently undergone its trials at the Stafford works of Siemens Bros., England. It is a direct current machine of 20,000 horse power and is to be used in drawing a rolling mill. The machine is virtually three separate motors on one shaft and weighs about 300 tons. Current is supplied to it at 440 volts.

ALLOTROPIC TRANSFORMATION OF NICKEL

Nickel, says *Engineering*, 107 (1919), 326, becomes magnetic at about 350°C ., and this transformation is associated with changes in the electric resistance and in other properties, also probably in length though not in form of crystallization, as to which allotropic forms of other metals frequently differ. The change in length had so far not been actually established, but Prof. Jänecke (*Z. angew. Chem.*, 1918, 229) has succeeded in demonstrating it with the aid of a testing machine. He placed the cylindrical specimen—45 cm. in height—between two pressure plates, kept the lower plate fixed and observed the movement of the upper plate when the specimen was heated by means of an electric furnace surrounding it. Readings could be taken within 0.007 mm. and temperatures were determined with the help of a gold and constantin thermocouple. The expansion curve consisted of two straight lines meeting near 350°C . and at an obtuse angle above that temperature. The rate of expansion was more rapid. A jump of 0.01 mm. was observed between 347°C . and 356°C . and a rod of nickel 5 in. long should in passing from α -nickel to β -nickel increase by about 1 mm. The method is recommended for observing both gradual and sudden transformation.

OIL-PALM PRODUCTS

The Colonial Institute of Marseilles has published a detailed description of the machines which have been made for the extraction of oil from the fruits of the palm and for the crushing of kernels. A number of hand machines are given with full illustrations and also of the heavy machines suitable for factories. The first equipped factory was set up by a Frenchman at Cotonou, in 1908, but the Germans subsequently took the matter up and made the most of the system, helped by large concessions of land. It is a curious fact, however, that the hand-produced oil of Lagos is of a better quality than that produced by the machines. The publication referred to above seems to be the fullest investigation of the subject that has been made.

AÉROPLANE INDUSTRY IN INDIA

Investigations have been proceeding, says a contemporary, during the past year for the purpose of obtaining timber suitable for aeroplane construction not only for use in India but also for export purposes. Some success has already been attained, and when it is stated that there are 2,500 classes of timber in the country it will be realized that there are great possibilities. Teak, which is available in large quantities, is not suitable, being too brittle, while spruce is also for the most part unsatisfactory. Some of the rosewood has been found to be very good, and the well-known blackwood is being used with great success for the construction of propellers. It is probable that aeroplanes will be built in India in the near future, except for the engines, which will have to be imported. At Lahore 200 men are employed on the repair of army aeroplanes and the excellence of their work justifies a belief in the future of the aeroplane industry in India.

FIREPROOFING MATERIAL

According to *Chem. Trade J.*, 64 (1919), 280, coating or impregnating with precipitated double borate of zinc and aluminum in a colloidal medium is a new fireproofing patented by S. A. Walton, London. A mixture of zinc sulfate and aluminum sulfate is dissolved in hot water, the double borate being next precipitated by adding a suitable proportion of borax and the precipitate is then suspended in a colloidal solution such as that formed by dissolving 4 oz. of gelatin in a gallon of water at 90°C . and adding 12 oz. of ammonium chloride. On strongly heating, the compound is converted into an amorphous glass which is very resistant to high temperatures.

RAW MATERIAL IMPORTS

The British Board of Trade have announced that general licenses have now been issued to the customs which, together with the general licenses already in existence, will exempt all raw material from the operation of the prohibitions of import. The following are among the raw materials which have from time to time been under prohibition and are now free: Antimony ore, diatomite or infusorial earth, gum copal, gum kauri, jute, stones and slates (including hewn and sawn, but not dressed), wood and timber of all kinds, hardwoods and sleepers (not including pit props and pit wood). Inquiries as to whether any article is raw or semi-manufactured should be addressed to Department of Imports, 22 Carlisle Place, London.

BRITISH MAGNETOS

How wide the range is of British-made magnetos now available is indicated by a catalogue issued by the British Lighting and Magneto Co., of 204 Tottenhamcourt Road, London, an undertaking owned by Messrs. Vickers. Over two dozen types are illustrated, the pictures being one-third or one-quarter full size. The first section of the catalogue deals with motorcycle magnetos, the second with those suitable for motor cars, marine and aero engines, with numbers of cylinders varying from one up to nine; and the third with low-tension instruments for large stationary gas engines with three, four, five, six, and eight cylinders, the low-tension current being transformed to high-tension by means of a coil.

STEEL FOR PARAVANES

One of the secrets of the British navy which has come to light since the armistice is the use of otters or paravanes in enabling ships to go through mine fields with safety. These devices were towed in pairs, one on either side, from a point as low down as possible on the ship's bows in such a way that they were not in the ship's wake, but stood out obliquely away from the hull. When a mine-mooring cable was encountered it was forcibly deflected from the ship and along the whole length of the towing rope until it came to the paravane itself. Here it encountered scissors or shear blades which, although it was made of steel $1\frac{1}{2}$ in. in diameter, cut it as easily as a pair of scissors cuts a piece of string. These blades, which were only $10\frac{1}{2}$ in. long, with a section about $1\frac{1}{2}$ in. wide by $\frac{1}{2}$ in. thick, had to be made of exceedingly fine and strong steel and, according to the *Times Engineering Supplement*, the "Triumph Superb" high-speed steel made by Messrs. Saville and Co., Sheffield, was exclusively adopted for them. The whole efficacy for the paravanes, so far as mines were concerned, depended on these cutter blades, for, if through becoming blunt or breaking they failed to cut the cable, the mine remained submerged, whereas if it were released it rose to the surface and could be destroyed.

GERMANY AND ALSACE-LORRAINE

Engineering, quoting from the *Frankfurter Zeitung* of January 25, 1919, says that in regard to the Thyssen interests in Lorraine, the German industry will not be robbed entirely of the fruits of its intensive work in that region. Thyssen and Company had secured large concessions on both sides of the frontier so that the ore deposits controlled covered an area of 14,800 acres. These ores had become valuable after a modification of the Bessemer process for iron ores with high phosphorus content had been introduced. France has now put under controlled administration the important Thyssen steel works at Hagendingen, consisting of smelters, basic steel works, and rolling mills which were started in 1910 with a capital of \$200,000, and now have smelters and mines valued at \$16,600,000 and claims amounting to \$10,966,000.

NEW SOURCE OF TURPENTINE OIL AND RESIN

Turpentine oil and resin are already being produced on a commercial scale in India by the distillation of pine resin. A new source of supply which, though comparatively small, may be valuable, especially for Indian use, has now been found in Indian frankincense. This material is obtained by the natives by making a cision in the stems of *Boswellia serrata*, a tree widely distributed throughout the dry zone forests of central India. The resinous substance which exudes from the cuts contains a kind of turpentine, a resin, and a gum. Investigations of the methods of separation of these constituents in a marketable form as to their commercial uses and value and on the methods of tapping the tree have been conducted since 1912 by the forest authorities in India in cooperation with the Imperial Institute, London, and the results have been published in a paper by R. S. Pearson, Forest Research Institute, Dehra Dun. The general conclusion reached is that the turpentine is equal to good quality American turpentine oil, and that it could be used in place of the latter in the manufacture of paints and varnishes. The Imperial Institute also reports that the resin would be quite suitable as a substitute for pine resin (colophony) in the manufacture of varnishes, being equal in value to grade "G" of American resin.

OBERHOFFER'S ETCHING REAGENT FOR STEEL

In 1916, says *Engineering*, 107 (1919), 343, Oberhoffer proposed a modification of Stead's reagent for the detection of phosphorus in steel. In steels containing not more than 0.9 per cent of carbon this reagent readily allows of distinguishing between areas rich and poor in phosphorus. The micrographs obtained look, as Bauer stated some time ago, like negatives of specimens etched with copper ammonium chloride. This statement is confirmed in *Stahl und Eisen* of November 21, 1918. Etched with Oberhoffer's reagent the low phosphorus dendrites of a steel casting look dark on the background of the higher phosphorus area, when the illumination is vertical. With oblique illumination the appearance is reversed. The high phosphorus area forms a perfect negative of the same section when etched with copper ammonium chloride, the illumination being vertical in both cases.

CUTTING CAST IRON

In discussing the possibilities of cutting cast iron by the acetylene blowpipe, *Teknisk Tidsskrift* says that heavy castings can be perforated in a few seconds by blowing the flame through a wrought iron tube in which iron wires are inserted. The part to be operated on is first brought to a bright red heat with an ordinary flame and immediately oxygen at an initial pressure of 15 atmospheres is admitted the molten metal is thrown out with such force that the work cannot be performed without asbestos clothes and gloves. Castings 2 ft. thick, it is said, can be perforated in 2 min. and large castings removed in pieces by fusing holes in suitable places and allowing the castings to crack as they cool.

AN IMPROVEMENT IN REGULATING CONTACTS

According to *Electrician*, 82 (1919), 344, a recent German patent taken out by the Siemens-Schuckert Company proposes a novel method of improving regulating switches. In the ordinary way the contacts in such switches are exposed to burning while the switch is moved from one contact to the next; but this can be prevented by diverting the current to an alternative path before the contact opens. According to this device, hot cathode tubes are connected in series with the switch contacts. These tubes carry current in one direction only when the cathode is glowing. The switch breaks the heating circuit of the cathode before the main circuit is opened.

ELECTRIC TERMINALS

Some details of a new form of terminal for connecting conducting wires to electrical appliances are sent by its inventor, Mr. Y. J. Hadfield, of Becles. The essential principle on which it is based is that the hole in the pillar into which the wire is inserted is made flared or trumpet-shaped at each end. A collar, which is flared or dished to the same curve, slides upon the pillar and is pressed against the wire with sufficient force to bend the latter into a curve that follows the contour of the hole. The collar is forced against the wire either by a screw-nut working on a screwed portion of the pillar or by a spiral spring. If the latter arrangement is employed, it is stated that the grip, even with a weak spring, is surprisingly great, while, for fine wires, the pillar need be no more than $\frac{1}{8}$ in. in diameter, giving a much smaller and lighter construction than is ordinarily employed. The advantage claimed for the arrangement is that it provides a large area of electrical contact between the wire and the terminal. Several wires can be readily secured together in one terminal, so that branch wires can be taken off without soldering. To facilitate the insertion of wires in the hole, a slot may be cut in one side of the hole in such a position as to be covered by the collar when screwed up or pushed home by the spring.

CONTACT BOWS FOR ELECTRIC VEHICLES

When the ordinary metals such as copper and aluminum became scarce in Germany, experiments were made with contact pieces of carbon for contact bows for aerial railways. Zinc bows it was found did not last more than 8000 car-km., while the average for aluminum was 11,000 car-km. According to D. Strojohann (*Zeitschrift für Kleinbahnen*) some of the carbon bows had reached a life of 110,000 car-km., the average being 75,000. The carbon was first greased but this was found to be unnecessary. Bows have length of 1 m. and are built up of sections of carbon. The whole is mounted on a flat strip of steel plate which is turned up on both sides so as to grip the carbon pieces. Bars of cast iron are interposed between the carbon and the steel edges so as to secure good contact. In cross section the carbon is not solid and a tension service adjustable by means of screws is fitted into the hollow to press the carbon against the holder. There is less sparking than with aluminum bows and worn-down carbon sections can be renewed so that the carbon of the whole length of the bow is utilized.

SUBSTITUTES FOR SHELLAC

Shellac substitutes are produced from natural resin, water resin, or colophony, by a process patented by J. R. Kohler of Stockholm. The oxidized resin acid is extracted by first treating with ether, benzol, or oil of turpentine and then treating the residue with ethyl or methyl alcohol. The product is a shellac-like solution which may be used as a polish or converted into an insulating solid by evaporating the alcohol.

CARBIDE OF CALCIUM

A large electric works with a capacity of 25,000 kw. has been erected during the war at Katlowitz, Silesia, close to the Polish frontier. It supplies power to a carbide factory which is now running regularly and has an annual output of 20,000 tons. This enterprise uses coal from the Prince-Pless mines. The directors of these mines have also come to an agreement with the metallurgical firm of Beer, Sonderheimer and Co., Frankfurt, for the formation of a company to unite the mines with a smelting works. The new factory will run the carbide factory and the electrical power works. The capital, according to *Oil and Color Trade J.*, 55 (1919), 1126, will be \$200,000 and the shares will be held exclusively by the two companies and no bank will participate in the flotation.

SCIENTIFIC SOCIETIES

FIFTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES

The Fifth Annual National Exposition of Chemical Industries will be held this year in Chicago at the Coliseum and First Regiment Armory during the week of September 22, and as usual there will be a number of society meetings held jointly with it. It is an encouraging sign that the American Institute of Mining Engineers is among the number. We hope that this contact of the mining engineers with things chemical, chemists, and chemical engineers will be to their increasing and mutual advantage. We know there is much that the mining engineers may gain from the Chemical Exposition, and without doubt they will leave behind something of value.

The movement to Chicago was decided unanimously last September at a meeting of the Advisory Committee of the Exposition with the managers of the Exposition for two reasons: The U. S. Army commandeered the Grand Central Palace immediately upon the close of the last exposition, to be converted into a receiving hospital, use for which has now, happily, nearly ceased. The Chicago Section of the AMERICAN CHEMICAL SOCIETY had been active in its interest in the Exposition and was keenly interested in having it held in the city of Chicago; the Association of Commerce felt a keen interest in welcoming the Exposition; it was the thought of all that the Exposition would stimulate development along chemical lines in the Chicago district and the adjoining states.

The Advisory Committee of the Exposition consists of:

CHARLES H. HERTY, *Chairman, Editor, Journal of Industrial and Engineering Chemistry*.

RAYMOND F. BACON, *Director, Mellon Institute*

L. H. BACKELAND, *Member, Naval Consulting Board*

W. D. BANCROFT, *President, American Electrochemical Society*

HENRY B. FABER, *Industrial Filtration Corporation*

ELLWOOD HENDRICK, *President, The Chemists' Club*

BERNHARD C. HESSE, *General Chemical Company*

A. D. LITTLE, *President, Arthur D. Little, Inc.*

WM. H. NICHOLS, *President, American Chemical Society*

R. P. PERRY, *Vice President, The Barrett Company*

H. C. PARMELEE, *Editor, Chemical and Metallurgical Engineering*

C. W. THOMPSON, *President, American Institute of Chemical Engineers*

T. B. WAGNER, *United States Food Products Corporation*

M. C. WHITAKER, *President, United States Industrial Alcohol Co.*

CHARLES F. ROTH

FRED W. PAYNE

There is also added a special Chicago advisory committee consisting of L. V. Redman, W. D. Richardson, A. V. H. Mory, Carl S. Minor, F. W. Willard and Wm. Hoskins. The managers, as in the past, are Charles F. Roth and Fred W. Payne, and the general office is at 417 South Dearborn St., Chicago, Ill.

When the move to Chicago was first planned it was decided to use the largest available exposition building there, the Coliseum, which is conveniently located for the business, hotel, residence, and industrial centers of the city. It soon developed that the space in the building was inadequate and shortly after the signing of the armistice when government property again became accessible, the management made arrangements to engage the First Regiment Armory for exhibits and meetings of some of the societies. The armory faces the next parallel street, which is Michigan Boulevard, and is separated from the Coliseum by only a narrow alleyway. The managers report that a considerable part of this space is already engaged, much of it by Chicago concerns, promising a creditable showing for Chicago industrial progressives.

The number of exhibitors is already larger than at the same time last year and includes many new companies who have not formerly exhibited. There are also on the list the names of regular exhibitors who have become inseparably connected with the Exposition and who have become established as the bulwarks of the American chemical industry.

Of the meetings to be held in connection with the Exposition a splendid program is in preparation which includes the general meetings of the American Electrochemical Society, the American

Institute of Mining Engineers, and the American Ceramic Society. The Technical Association of the Pulp and Paper Industry is planning to meet with the Exposition in several technical sessions. The Chicago Section of the AMERICAN CHEMICAL SOCIETY will have headquarters at the Exposition where it is probable that a meeting will be held. There are already indications that these meetings will be interesting ones. The Mining Institute is arranging a pyrometry symposium which will consider such questions as: Methods of Pyrometry, Industrial Pyrometry, Pyrometry and Its Relation to Science. Special stress will also be laid upon the iron and steel industry by the Institute. The American Electrochemical Society is planning an interesting program; so, too, is the Ceramic Society. Details of the programs will be announced in subsequent issues of THIS JOURNAL.

AMERICAN CHEMICAL SOCIETY ADVISORY COMMITTEE MEETINGS

The Advisory Committee of the AMERICAN CHEMICAL SOCIETY met in Buffalo at the Statler Hotel at 2:00 P.M., Monday, April 7, 1919, with President Nichols in the chair and Messrs. Herty, Hesse, Stieglitz, and Parsons present.

A communication was presented from the Engineering Council, regarding a meeting of the Engineering Council to be held in Chicago, April 23 to 25, to consider the question of the establishment of a department of public works. After discussion, President Nichols appointed Professor Julius Stieglitz as the delegate to attend this session.

A communication was also read from the American Welding Society, regarding the appointment of a director from the AMERICAN CHEMICAL SOCIETY on their board. It was decided to hold the matter in abeyance pending further information, the opinion of the Committee, being, however, that it was a matter without the province of the AMERICAN CHEMICAL SOCIETY.

The Committee decided to call a meeting for April 26 at 5:30 P.M. at the residence of President Nichols in New York City. The meeting then adjourned.

The Advisory Committee met at the residence of President Nichols, 420 Park Avenue, New York City, Saturday, April 26, at 5:30 P.M., with President Nichols in the chair, and Messrs. Herty, Hesse, Stieglitz, Whitaker, and Parsons present.

In accordance with the vote of the Council at the Buffalo meeting, the following new committees were appointed:

Committee to Formulate Specifications for the Construction of a Polaroscope for Laboratory Use: W. D. Bigelow, A. H. Bryan, C. E. Coates, W. L. Howell, S. J. Osborn, G. W. Rolfe, John M. Stillman.

Committee on Resolutions in Continuation of Chemical Work Affecting Military Preparedness: The president referred this matter to the Advisory Committee for final disposition at its next meeting and requested B. C. Hesse to prepare a draft for final discussion and disposition at that meeting.

It was voted to enlarge the Committee on Nomenclature and Spelling to add to its duties the pronunciation of chemical terms.

With the advice of the Committee the following committees were appointed by President Nichols to hold office until the spring meeting of 1920:

Advisory Committee: Wm. H. Nichols, Chas. H. Herty, Julius Stieglitz, B. C. Hesse, M. C. Whitaker, Chas. L. Parsons.

Committee for Annual Report on Atomic Weights: G. P. Baxter, Coolidge Memorial Laboratory, Cambridge, Mass.

Bureau of Mines Advisory Committee: Chas. H. Herty, *Chairman*, L. H. Backeland, W. R. Whitney.

Coöperation between Industries and Universities Committee: W. A. Noyes, *Chairman*, R. F. Bacon, W. D. Bancroft, C. G. Derick, Edward Ellery, John Johnston, G. N. Lewis, Wm. H. Nichols, Julius Stieglitz, Ethel M. Terry, T. B. Wagner, Wm. H. Walker, W. R. Whitney.

Committee on Educational Problems to Coöperate with the Society for the Promotion of Engineering Education: R. H. McKee, *Chairman*, S. W. Parr, R. M. Bird.

Endowment Committee: I. K. Phelps, *Chairman*, Ellwood Hendrick, F. R. Eldred.

Exchange Committee: E. J. Crane, *Chairman*, A. B. Lamb, Chas. H. Herty.

Finance Committee: E. G. Love, *Chairman*, G. C. Stone, J. E. Teeple.

Committee on Foreign Chemical Trade in Its Relation to Our Merchant Marine, to Coöperate with the U. S. Shipping Board: T. B. Wagner, *Chairman*, L. H. Baekeland, Wm. Hoskins, A. H. Jacoby, C. W. Merrill, H. S. Miner, C. W. Nichols, W. B. D. Penniman, G. D. Rosengarten.

Committee on Guaranteed Reagents and Standard Apparatus: W. D. Bigelow, *Chairman*, W. D. Collins, L. M. Dennis, M. J. Falkenberg, H. N. McCoy, F. W. Smither.

Holmes Memorial Committee: Chas. Baskerville.

Import Statistics Committee: Chas. H. Herty, *Chairman*, Vice Presidents of the SOCIETY, B. C. Hesse.

Committee on Institute for Drug Research: Chas. H. Herty, *Chairman*, J. J. Abel, R. F. Bacon, F. R. Eldred, Reid Hunt, T. B. Johnson, P. A. Levene, F. O. Taylor.

Institute of Metals Advisory Committee to the Bureau of Standards: Wm. B. Price, A. C. S. member.

Membership Committee: W. D. Bigelow, *Chairman*, Chas. L. Parsons, F. G. Cottrell.

Metric System Committee, to Coöperate with the American Metric Association: R. V. Arny, *Chairman*, E. C. Bingham, Wm. Blum, H. P. Talbot, S. W. Young.

Nomenclature, Spelling, and Pronunciation Committee: E. J. Crane, *Chairman*, Editor of Chemical Abstracts, Board of Editors of the *Journal of the American Chemical Society*, Editor of the *Journal of Industrial and Engineering Chemistry*, and A. M. Patterson.

Occupational Diseases in Chemical Trades Committee: Chas. Baskerville, *Chairman*, G. P. Adamson, H. K. Benson, C. E. Coates, W. L. Evans, H. W. Gillett, F. W. Frerichs, Edward Gudeman, M. I. Hersey, E. B. Phelps, F. R. Scholes, F. H. Smalley.

Paper Committee: F. P. Veitch.

Patent and Related Legislation Committee: E. J. Prindle, *Chairman*, B. C. Hesse, E. A. Hill, A. D. Little, Edmond O'Neil, C. P. Townsend, W. R. Whitney.

Perkin Medal Committee: A. M. Comey, *Chairman*, R. F. Bacon, C. H. Herty, B. C. Hesse, L. C. Jones, A. D. Little, E. G. Love, J. C. Olsen, L. V. Redman, G. D. Rosengarten, M. Toch, T. B. Wagner, D. Wesson, Wm. McPherson.

Priestley Memorial Committee: F. C. Phillips, *Chairman*, M. T. Bogert, E. D. Campbell, C. F. Chandler, F. W. Clarke, E. C. Franklin, J. Lewis Howe, E. W. Morley, A. A. Noyes, W. A. Noyes, Ira Remsen, E. F. Smith, Alfred Springer, F. P. Venable.

Committee on Publication of Compendia of Chemical Literature: Julius Stieglitz, *Chairman*, C. L. Alsberg, A. B. Lamb, E. C. Franklin, John Johnston, James Kendall, J. C. Olsen.

Committee on Preparation of a List Recommending Chemical Texts for Libraries: W. A. Hamor, *Chairman*, L. C. Newell, A. M. Patterson, W. Segerblom.

Committee on the Revision of Methods of Coal Sampling and Analysis (Joint with the Society for Testing Materials): W. A. Noyes, *Chairman*, Perry Barker, A. C. Fieldner, W. F. Hillebrand, A. H. White.

Committee on Supervision of Chemical Engineering Catalog: E. R. Weidlein, A. C. S. representative.

Supervisory Committee on Standard Methods of Analysis: W. F. Hillebrand, *Chairman*, C. L. Alsberg, G. C. Stone, A. C. Langmuir, H. P. Talbot.

The following committees were discontinued:

Committee on Allocation of Federal Grants for Scientific and Industrial Research.

Committee to Coöperate with National Academy of Sciences on General Lines.

Committee to Coöperate with War Committee of Technical Societies.

Committee to Coöperate with Chemical Society of London and Allied (English) Societies in Publication of Chemical Bibliographies in English Language.

Committee on Coördination of Chemical Work within the War Department.

Committee on Duty-Free Importation of Chemicals.

Committee on Inventions by Government Employees (to coöperate with American Electrochemical Society, American Institute of Mining Engineers and American Institute of Electrical Engineers).

Committee on Methods of Analysis for Potable Waters and Sewage.

Committee on Method of Coöperation with the National Research Council, National Research Council Committee.

Omnibus Committee for Spring Meeting.

Publicity Committee.

Committee on Supply of Organic Chemicals for Research during the War.

Committee on War Service for Chemists.

It was voted to instruct the secretary on behalf of the AMERICAN CHEMICAL SOCIETY to send letters to President Wilson and to Premier David Lloyd George, transmitting the resolution passed by the AMERICAN CHEMICAL SOCIETY affecting the adoption of the metric system, as per the request of the World Trade Club of San Francisco.

It was voted that the SOCIETY should put on deposit with the Division of Chemistry and Chemical Technology of the National Research Council a set of its current journals and such of its back journals as are available in sufficient quantity to warrant such action, it being understood that the journals remain the property of the AMERICAN CHEMICAL SOCIETY and are to be duly cared for by the National Research Council.

On recommendation of Dr. Chas. L. Reese, *Chairman*, the Section which is to meet at the Philadelphia meeting to consider the question of dyes and intermediates will be known as the "Dye Section" rather than the "Dyestuff Section."

The Committee voted to authorize the formation of a local section of the AMERICAN CHEMICAL SOCIETY to be known as the Oklahoma Section, embracing the territory of the state of Oklahoma, with headquarters at Stillwater.

The president appointed Chas. L. Parsons and E. G. Love as the two representatives of the AMERICAN CHEMICAL SOCIETY as trustees handling the business side of monographs to be undertaken by the SOCIETY (Div. 3, Sec. 1, Report of the Committee on Compendia of Chemical Literature, *J. Ind. Eng. Chem.*, May 1919), and Julius Stieglitz as trustee to represent the SOCIETY on the board of three trustees under the auspices of the National Research Council (Div. 2, Sec. 4, *Ibid.*).

The selection of editors and committee on technological chemical monographs and scientific chemical monographs was held in abeyance pending further search for the proper men to handle this important development.

WASHINGTON, D. C.

CHAS. L. PARSONS, *Secretary*

ANNUAL MEETING OF THE CHEMISTS' CLUB

The Annual Meeting of the Chemists' Club was held at the clubhouse on Wednesday, May 7, 1919. The treasurer's report showed the finances of the Club to be in a flourishing condition. The secretary reported a total membership of 1635 distributed as follows: 527 resident, 954 non-resident, 115 junior, 24 foreign, 10 life, and 5 honorary.

The Committee on Scholarships reported that whereas the Bloede Scholarship had remained vacant for the two years 1917-1919 and the Hoffmann Scholarship for the year 1918-1919, it is now proposed to award both scholarships for the year 1919-1920. Also it is planned, if the founders approve, to use the surplus funds of these scholarships to aid other young men, besides the incumbents of the two scholarships, in pursuing their studies in chemical engineering.

The report of the House Committee, among other things, stated that the matter of erecting the Frasch conservatory, which had been postponed on account of war conditions, had

been taken up again only to find that building prices are still too high to admit of its immediate erection.

The Committee of Tellers reported election of officers for the year 1919-1920 as follows:

President: Elwood Hendrick.

Vice Presidents: Resident, William F. Hoffmann; Non-resident, Victor G. Bloede.

Secretary: J. R. M. Klotz.

Treasurer: Henry M. Toch.

Trustees: Edward Weston, Allen Rogers.

We print below the report of the Bureau of Employment and the address of President Hendrick

PRESIDENT'S ADDRESS

From the secretary's report you learn that the Club is in a flourishing condition as to membership. Indeed our capacity is often strained to provide adequate accommodations for members. From the treasurer you have learned that we have kept on the right side of the balance sheet in our operations. I shall now make it my province to tell you of some problems in administration which have been met by the trustees, to outline certain others that we have still to meet, and to offer a proposal for your consideration.

A subject that has given us no little concern is the bequest of our benefactor, the late Morris Loeb, of \$25,000, to found a chemical type museum for the use of chemists engaged in research. At the time of the probate of his will the Club as an institution was born, but it had not completely found itself. Members came to stated meetings, but did not avail themselves of its social features from day to day. In order to bring chemists in, elaborate library service was provided, and the museum which was to be administered by either the Chemists' Club or the Smithsonian Institution or the American Museum of Natural History was accepted as a charge by our trustees. The funds were left to be administered as to principal by the AMERICAN CHEMICAL SOCIETY. The advent of the war made it impossible to secure the material from universities and research laboratories, inasmuch as substantially all the chemical talent of the country was engaged in war work, and nothing was given out. During this time, however, the Club found itself, showing its maximum usefulness to consist in providing the social opportunity for chemists to meet and get acquainted with one another; to exchange views as they desire and according to their pleasure. In the meantime the interest on the bequest had accumulated sufficiently to start the museum by employing an agent to visit the sources of supply for materials and to make a good beginning. On the other hand, if the accumulated funds were to be expended in this way, the future interest on the principal would suffice to pay the running expenses, but it would not provide for a salaried curator of ripe scholarship to devote the time needed to fulfill the donor's intent. This would have been possible had the development of the Club been along the lines of a chemical bureau, but not otherwise. In other words, we were in a position to start the museum, but not to keep it up unless some member of adequate chemical scholarship should offer to give the large amount of time necessary for its continuance and growth. Therefore, after the signing of the armistice, the trustees concluded that the museum might be better administered by an organization equipped with museum facilities, and the secretary was instructed to advise the AMERICAN CHEMICAL SOCIETY, as trustee of the fund, that the Club would forgo its privilege of conducting the museum, leaving this to either of the other organizations named in the will, and would turn over the funds, furniture, and equipment it has on hand, on receipt of proper notice.

Our library has grown, but not so rapidly as might be wished, for we still lack a considerable number of important volumes of

chemical literature. It is visited frequently, and from those who find what they want there we hear no complaint. It is planned during the coming year to have it professionally overhauled by some leading authority on library administration, with a view to providing improved service, and, by eliminating material of questionable value, to increase our available shelf space.

Lack of space has been, and still is, a serious problem with us. We need at least one more billiard table, and for this we have not room, unless we remove the books under the stacks in the billiard room. We must provide for the leisure of our members, and we must also make the development of our library progressive in its nature, and see to it that it does not become obsolete. These problems may be left, I think, to your trustees for their proper solution.

In 1917 the building at 46-48 East 41st Street was leased for a term of ten years by the Club, with an option to purchase for \$200,000 which expires October 1, 1920. The excessively high cost of building restricted us to the least possible construction, but thanks to the wisdom of the House Committee, the repairs were so intelligently carried out that the rooms are constantly rented to members. Thanks also to the diligence of our secretary and the generosity of our members, the repairs were paid for by donations.

During the coming year the trustees have before them the serious problem of determining what to do with this Godwin property now under lease. It is most desirable that the Club should have as many laboratories as possible at its disposal, because these professional establishments add to the use of the Club by its members. Therefore the trustees have looked with disfavor on any increase of Club facilities at the expense of laboratories. Sleeping rooms also constitute a leading convenience to out-of-town members. If we had a complete ten-story building in place of what is called the Annex, equipped as is our main building with laboratories and sleeping rooms, there is every reason to believe that we could keep it permanently filled.

The lease of the Club building from the Chemists' Building Company expires in 1921. Our trustees are now in negotiation with the directors of the Company, looking to a revision of terms, and to extensions.

Mrs. Herman Frasch generously gave the Club \$10,000 with which to build what is to be called the Frasch Conservatory, as a memorial to her late husband. It is designed to have it serve as an extension to our frequently overcrowded dining room. The extraordinary costs of building operations, and the opinion that it was contrary to public policy to use up building materials during the war caused this improvement also to be delayed. Steps are now being taken to have the work done, should the cost be found to lie within our means.

There is a subject that I believe to be of great importance to which I invite your attention. This has to do with the greater participation of chemists in public and corporate affairs. We have seen the bill providing for the use of our water powers killed by the neglect of the late Congress of the United States. This was an omission for which no political reason is adequate. Had there been a few chemists of character and ability in that body I believe they would have shamed their fellow members into action. We must avoid partisanship in politics; we cannot undertake the work of caring for special interests; we shall surely fail to establish ourselves in the public confidence if we are narrow, or adopt any slogan that does not call for earnest and scholarly thought in its every application; but I am convinced that we should participate in far greater measure than we do in matters relating to the general welfare.

It is better for the Club to remain silent than to make a false move, or to engage in any kind of local or national partisanship, but it does behoove us to speak in no uncertain voice when the

health or well-being of the city or country is menaced by neglect of chemical control of chemical matters, or by the utterances of men in authority which are contrary to scientific fact. By carefully prepared and digested memoranda, put forth officially at the proper time, the Club can be of marked usefulness in adding to the public enlightenment.

I respectfully solicit your favor for the increase of our standing committees by one on Public Affairs.

In corporate affairs we older men can remember when it seemed necessary for a man to be a lawyer in order to be entrusted with authority in office. Later the idea obtained that bankers were ideal administrators. Still later it appeared that the profession of mechanical engineering was the best warrant for responsibility. Now we know that it is a man's natural capacity to administer affairs which, coupled with the needful experience, best fits him for the post. As presidents of universities we find chemists among the leaders, but in corporations engaged in industry, commerce, or banking it is remarkable how few of them may be discovered where they are most needed. Of course a degree in chemistry does not make a man a good administrator, but neither should it unfit him for such work. Errors of a preposterous nature, predicaments that would be comedy situations if it were not for the tragic losses involved, are frequently seen in large corporations because nobody on the board of directors or in authority knows any better. These same corporations usually employ chemists—if they must—at the lowest salaries they can induce them to accept, and then deny them a voice in council because they are cheap men.

Now this Club can take no part in any attempt to unionize a profession. Neither can it make efforts toward increasing the pay of the incompetent, or of drudges without imagination, but I believe we can emphasize the chemist's work where it needs to be emphasized. It is in every-day affairs that his work is most pressing, and yet the fact seems to remain a secret to the majority of men in office and authority. The Club, let us hope, will do what it can to spread enlightenment in this connection but the greatest influence will proceed from us if, as individual members, we pass the word along wherever and whenever we find an opportunity, in explanation of the help that is available from men who bring chemical understanding to bear upon chemical problems.

In conclusion, I want to thank the members for their cordial support, and the Trustees for their cooperation during the past year. We have a successful institution that is an active force in the work of bringing chemists together. With united efforts and high ideals we can increase our usefulness, and extend our welcome beyond our fondest imagination when we moved into these quarters on St. Patrick's Day in 1911. And in looking to the future, let us strive to realize the vision of our chemists as leading in enlightenment and service. The general welfare of our country is largely dependent upon us. May we prove equal to our obligations in the serious responsibilities of peace, even as we did in the emergency of war!

139 EAST FORTIETH STREET
NEW YORK CITY

ANNUAL REPORT OF THE BUREAU OF EMPLOYMENT FOR THE YEAR ENDING APRIL 30, 1919.

The interest of the Club in the Bureau activities naturally centers this year principally in the effect of the war and the cessation of the war upon openings and upon registration.

Nothing of an unexpected nature has happened in our routine. We could and did anticipate the trend of action, although all of us were surprised *quantitatively*, if not *qualitatively*. My own supposition was that a large proportion of returning men would enter their old positions and that cogs in the industrial wheel would mesh quite noiselessly. To our amazement, 1274 men have registered since the signing of the armistice and, of these,

378 have the red tab on their card indicating that they are still unemployed. Exclusive of men doing government work in a civilian capacity, 465 of this total number were in service. With such a large number of men still needing our help, I make an earnest appeal to all Club members to let us know of vacancies in their own organizations or wherever they may hear of them.

A war-time policy adopted by the Bureau may interest you. We soon made the rule that commissions would be waived in the case of any man appointed through our efforts to a uniformed position. This was something of a financial sacrifice to the Bureau, but seemed only just as a war-time measure. We have thought of the possibility of acting similarly in the case of uniformed men returning to civilian duties, but from the foregoing figures you can see that that would be a sacrifice well-nigh fatal in results, for we have a narrow margin of annual income.

I wish to bring to your attention another phase of our work. This is the elimination, or at least shelving, of the less fit. We feel that this is a marked advance in our efficiency. We are now in a position to definitely trace each registrant's professional history. With much labor and expense, investigation is made of each stage of his work and the result is that a positive statement can be made as to the success or failure of the applicant with each of his former employers. This is annoying to the type of man who tries to bluff his way, but it is a source of gratification to the Bureau to be able to stand squarely behind its recommendations.

In this connection I wish to call attention to the staff of the Bureau. First, the greatest credit must be given the executive secretary, Miss Cramer, and her associate, Miss Riley. They have most successfully carried on the work under the stress of war conditions and during the somewhat prolonged absence of the chairman in Washington. Too great appreciation of their ability cannot be given. It is also noteworthy that our junior staff must be of special grade. The correspondence involves technical terms and in all ways the work is quite unlike ordinary business routine. Consequently, these young women are selected with care and must be capable of more than average work and should be paid accordingly, but unfortunately we have not a sufficient surplus to do so and consequently have lost one of the most efficient members of that staff.

The presence of women in chemical industry is certainly an interesting phase of the development of our work. Eighteen months ago employers were unable to get men. Conditions would grow worse instead of better as long as the war continued and women chemists would become increasingly necessary. The staff of the Bureau was so impressed by the need that we approached various women's colleges to see how courses could be improved to meet the demand of industrial conditions. The colleges met this new demand for their graduates with new courses and extended laboratories. Smith College, in particular, expanded its chemical department and they are now training women for routine factory work instead of confining their technical courses to the chemistry of foods and similar lines. During the chairman's recent trip through southern mills, the report in all sorts of places was that women chemists were eminently satisfactory and many employers said that they proved superior particularly for analytical work. The general feeling is that they are notable for neatness, accuracy, and reliability, and that they are not so prone to leave and pursue a vacancy which has fancied superiority. It certainly seems to me only fair that the qualifications of women should not be overlooked. While they cannot be said to be in any sense competing with men, yet a tendency is noticed to consider them a distinctly available factor. In good faith many women students have entered this field in which experience proves they are by no means a mere substitute. Why not try them? We have a number on file and can get in touch with more.

Another interesting feature of the present time is the salary schedule. The following data will show the trend before the war, during it, and since the armistice:

SALARIES ATTACHED TO POSITIONS FILLED					
SALARIES	1915 %	1916 %	1917 %	1918 %	1919 %
Less than \$500.....	2	4	3	2	0
\$500 to \$700.....	9.5	10	6	3	2
700 to 1000.....	42	36	27	20.5	15
1000 to 1200.....	11.5	13	15	18	8 5(a)
1200 to 1500.....	14	12	19	21	20
1500 to 1800.....	13	11	12	16.5	19
1800 to 2400.....	5	7	13	11	22
2400 to 4000.....	2	5	5	7	8.5
4000 and over.....	1	2	0	1	5

(a) As observed in the office, this is probably due to the fact that very few of the men back from service would consider less than \$125 a month

As it is impossible to keep these figures in mind, we may summarize this table as follows: The percentage of calls filled at less than \$1000 has fallen steadily since 1916 and the percentage filled at more than \$1000 has increased. In 1915 and 1916 more than 50 per cent of the calls filled were at salaries under \$1000 a year; in 1917 and 1918 it will be noticed that one has to go through \$1200 to reach 50 per cent of the calls, and in 1919 through \$1800, while in this last year only 17 per cent of the calls are below \$1000. We would call attention to the fact that the figures for 1919 are for three months only and consequently this ratio may not hold throughout the year.

During the year about 1072 new men have registered. This number represents men who have never been on the Bureau's lists.

Positions pending May 1, 1918.....	231
Positions reported to the Bureau during the year 1918-19.....	760
Positions filled during the year.....	274
Positions withdrawn and in which no man was chosen.....	148
Positions not filled during the year.....	436
Positions pending May 1, 1919.....	133

YEAR	1913	1914	1915	1916	1917	1918
PER CENT OF CALLS FILLED	47	40	43	45	40	38

In connection with the above table, I want to call attention to the following facts:

(a) Many positions continue on our lists for months and therefore are not filled during a definite calendar year. Percentage results then are often changed after the annual report.

(b) Calls formerly were largely confined to the Metropolitan district. Our field of action is now much wider and the opportunity to fill a vacancy in Omaha is less than in New York, since inevitably a considerable period of time must elapse between the occurrence of the vacancy and the receipt of the application of even the first candidate.

(c) During the present time, when so many men are actively searching for work, necessarily many apply for consideration who are not sent by us. Therefore, our applicant's chances are reduced.

(d) The slightly lower per cent for 1918 is easily traceable to war conditions under which very often there were no applicants suitable for the places.

HERBERT R. MOODY, *Chairman*

NEW YORK CITY
May 1, 1919

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

The Eleventh Semi-Annual Meeting of the American Institute of Chemical Engineers will be held in Boston, Mass., June 18 to June 21, 1919. Headquarters: Lenox Hotel.

PROGRAM

WEDNESDAY, JUNE 18

9:00 A.M.—Registration at Engineers' Club.

9:30 A.M.—Welcome by the mayor or his representative, and response.
Business Session.

10:00 A.M.—SYMPOSIUM ON ELECTRIC FURNACES.

The Future of the Electric Furnace. C. T. BRAGG, Michigan Smelting & Refining Company.

Utilization of Electric Brass Furnaces. H. W. GILLETTE, Bureau of Mines.

Problems Encountered in Electric Furnace Practice. P. E. MCKINNEY, Washington Navy Yard.

Electric Furnaces of the Resistance Type. (Motion Pictures.) T. F. BAILEY, The Electric Furnace Company.

12:30 P.M.—Luncheon at Engineers' Club.

2:30 P.M.—SYMPOSIUM ON ELECTRIC FURNACES (continued).

Ajax-Wyatt Induction Furnace. (Slides.) G. H. GLAMER, Ajax Metal Company.

Some Practical Results Secured with High-Frequency Induction Furnaces. DR. EDWIN F. NORTHERUP, Palmer Physical Laboratory, Princeton University, Princeton, N. J.

Booth-Hall Rotating Furnace. (Motion Pictures.) CARL H. BOOTH, Booth-Hall Company.

The Rocking Electric Arc Furnace. E. L. CROSBY, The Detroit Electric Furnace Company.

8:00 P.M.—Smoker in Assembly Room, Arthur D. Little, Inc., with inspection of museum and laboratories. The paper mill will be in operation, and arrangements made for special laboratory demonstrations.

THURSDAY, JUNE 19

9:30 A.M.—Board tug for tour of inspection of industrial plants along Boston water front, Commonwealth and Fish Piers, the largest fish-handling pier in the world.

Victory Shipbuilding Plant at Squantum.

Revere Sugar Refinery.

Buffet lunch on tug.

Edison Power Plant.

New England Gas & Coke Company.

Trip by tug to Marblehead.

Dinner at Eastern Yacht Club. (Informal.)

Return to Boston by tug, train, or auto.

FRIDAY, JUNE 20

9:00 A.M.—Business Meeting at Massachusetts Institute of Technology Room 10-250.

10:00 A.M.—Reading of the Following Papers:

Growth and Development of the Manufacturing Plant of the Providence Gas Company. W. H. RUSSELL.

Flash and Burning Points of Gasoline-Kerosene Mixtures.

JAMES T. ROBSON and JAMES R. WITROW.

The Manufacture of Castor Oil in the United States. J. H. SHERADER.

Chemists Should Be Registered and Licensed. EDWARD GUDEMAN.

State Licensing of Engineers and Chemists. JAMES R. WITROW.

Chemists Should Not Be Licensed. A. W. SMITH.

12:30 P.M.—Luncheon at Walker Memorial, M. I. T.

1:30 P.M.—Inspection of Laboratories Massachusetts Institute of Technology or Harvard University, including the Peabody Museum, the Wolcott Gibbs Laboratory of Research Chemistry, and the Jefferson Laboratory of Physical Research.

4:30 P.M.—Historic Boston by Sight-Seeing Auto.

7:00 P.M.—Dinner at Brookline Country Club. (Informal.)

SATURDAY, JUNE 21

All day excursion by train to Lawrence, Mass., for inspection of plants. Champion International Company (paper) and some of the largest textile plants in the world. The Pacific Mills, the largest paint works in the world. The Arlington Mills (cotton and woolen), American Woolen Company. Return to Boston by train.

AMERICAN CERAMIC SOCIETY

The Fifth Meeting of the Northern Ohio Section of the American Ceramic Society was held on April 28, 1919, at the Portage Hotel, Akron, Ohio.

In the morning a visit was made to the plant of the Goodyear Tire and Rubber Company. After lunch at the hotel a trip was made through Plant No. 1 of the Robinson Clay Products Company. This plant is devoted to the manufacturing of stoneware including large and intricate chemical shapes.

A short business meeting preceded the program.

The first paper of the afternoon was given by Prof. Hewitt Wilson, Ohio State University, on "Glaze Studies." This was followed by a talk on "The Present Trend in Porcelain Manufacture," by Mr. E. T. Montgomery, of the Jeffrey-Dewitt Co.,

Detroit, Mich. Mr. William P. Blair, secretary of the National Paving Brick Manufacturers' Association, gave a very interesting talk dealing with present-day requirements for both art and utility in all kinds of brick construction. The program closed with an illustrated talk by Mr. E. P. Poste, Elyria Enamelled Products Co., Elyria, Ohio, on "The Manufacture of Enamelled Ware."

INTERNATIONAL CHEMICAL COUNCIL

At an organization meeting of the International Chemical Council, held in London on April 18, provisional organization for the interim was formed as follows: Honorary Presidents, Haller and Le Chatelier; Secretary, Gerard; Executive Committee—for America, Zanetti and Cottrell; for France, Kastner and Moureu; for Great Britain, Sir William Pope and Henry Louis; for Italy, Patterno and Parodidelsino; for Belgium, Chavane and Crismer.

It was decided that the Chemical Council should cover the whole field of chemistry, including both technological and non-technological chemistry, and one of the first activities in which the Council will engage will be the matter of documentation.

The permanent organization will be formed at a meeting to be held in London in the middle of July. The International Chemical Council will affiliate with the International Research Council as soon as that organization is completed.

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS

The American Institute of Mining and Metallurgical Engineers will hold its convention in Chicago, September 22 to 26, 1919.

This meeting promises to be one of decided importance to the industry, as subjects of vital concern to modern metallurgy will be under discussion.

In addition to the technical talks, an elaborate social program is being arranged and excursions by the Institute as a body are planned to many points of interest in the vicinity, including the steel mills at Gary, the oil refineries at Whiting, metallurgical plants at East Chicago and North Chicago, and the LaSalle district, where the cement, coal, and zinc industries are represented.

CALENDAR OF MEETINGS

American Society of Mechanical Engineers—Spring Meeting, Detroit, Mich., June 16 to 19, 1919.

American Institute of Chemical Engineers—Summer Meeting, Boston, Mass., June 18 to 21, 1919.

American Society for Testing Materials—Twenty-second (Annual) Meeting, Atlantic City, N. J., June 24 to 27, 1919.

Society for the Promotion of Engineering Education—Twenty-seventh (Annual) Meeting, Johns Hopkins University, Baltimore, Md., June 25 to 28, 1919.

Society of Chemical Industry—Annual Meeting, London, July 15 to 18, 1919.

American Chemical Society—Fifty-eighth (Annual) Meeting, Philadelphia, Pa., September 2 to 6, 1919.

American Institute of Mining and Metallurgical Engineers—Chicago, Ill., September 22 to 26, 1919.

National Exposition of Chemical Industries (Fifth)—Coliseum, Chicago, Ill., September 22 to 27, 1919.

NOTES AND CORRESPONDENCE

CHEMICAL WARFARE SERVICE OVERSEAS

COL. EDWARD N. JOHNSTON,
Chief of Chemical Warfare Service,
American E. F., Tours

My dear Colonel Johnston:

Now that active operations have ceased and many of the personnel of the Chemical Warfare Service are returning to the United States, I desire to express to you and through you to all of your officers and enlisted men my appreciation of the valuable assistance they have rendered to the American Expeditionary Forces.

Upon our entry into the war we were faced with the problem of a new service in the organization of which the experience of our Allies was so new and so limited that there were few precedents to follow. The best brains and experience among our students and teachers of chemistry were called into service, and by rapid establishment of gas schools and the aid of specially trained personnel, all combat troops were instructed in the necessary defensive measures against poisonous gas. The first gas regiment was trained and equipped, and rendered good service in the two American offensives of St. Mihiel and the Meuse-Argonne.

Due to the energetic coöperation of all ranks, much was accomplished in a very short time, for which it gives me great pleasure to extend to you all the thanks of your comrades of the American Expeditionary Forces. Will you convey this especially to Brigadier General Fries, whose enthusiasm and energy were such great factors in the successful organization and development of the service.

AMERICAN EXPEDITIONARY FORCES
OFFICE OF THE COMMANDER-IN-CHIEF
March 2, 1919

Sincerely yours,
(Signed) JOHN J. PERSHING

LETTER ADDRESSED TO THE RECTOR OF THE UNIVERSITY OF UPSALA BY THE PRESIDENT OF COLUMBIA UNIVERSITY

To the Rector of the University of Upsala, Sweden:

I have the honor to acknowledge your letter addressed to Columbia University in the City of New York, bearing date February 1, 1919, sent in the name of the Senate of the University of Upsala.

You were good enough to transmit therewith a copy of an open letter from the Rector and Senate of the University of Leipzig, addressed to the Universities of Switzerland, Holland, Denmark, Sweden, and Norway under date of December 23, 1918, together with a copy of a letter dated December 30, 1918, testifying that the University of Heidelberg and the Heidelberg Academy of Sciences wished to associate themselves with the University of Leipzig in forwarding the open letter just mentioned.

The open letter from the University of Leipzig complains to the universities in neutral lands of the outrageous action (das unerhörte Vorgehen) of the French High Command toward the German scholars and men of science in Strasbourg. It is alleged that these scholars and men of science have been compelled to leave the University of Strasbourg on twenty-four hours' notice, in many cases to the grave damage of the studies and investigations which they had under way. Such treatment is made the ground of sharp protest in the name of science, and the universities in neutral lands, to whom the letter of the University of Leipzig is addressed, are asked that the facts laid before them be spread abroad in the press and brought immediately to the attention of the universities and academies of France, England, and America.

Whether or not German scholars and scientists formerly resi-

dent in Strasbourg have been harshly treated by the French High Command we do not know. We should wish to have some more convincing evidence than the mere allegation of the Rector and Senate of the University of Leipzig.

Meanwhile we invite attention to the fact that it is an established principle in England and the United States that anyone who comes into a court of equity seeking relief must come with clean hands. Before the Rector and Senate of the University of Leipzig can expect the court of public opinion to sympathize with their allegations, the people of France, England, and the United States will certainly wish to know what measure of protest, if any, the Rector and Senate of the University of Leipzig recorded against the cruel and inhuman treatment in 1914, by the German High Command, of the scholars associated with the University of Louvain and against the wanton and barbarous destruction of the library of that University. They will also wish to know what measure of protest, if any, the Rector and Senate of the University of Leipzig have recorded against any or all of the following thirty-one kinds of offense which it has been proved on indisputable evidence, gathered formally by national and international commissions, were committed by German armies and German agents and their allies in one or more of the countries invaded by them during the war whose issues are now in process of settlement:

- Massacre of civilians
- Putting to death of hostages
- Torture of civilians
- Starvation of civilians
- Rape
- Abduction of girls and women for the purpose of enforced prostitution
- Deportation of civilians
- Internment of civilians under brutal conditions
- Forced labor of civilians in connection with military operations of the enemy
- Usurpation of sovereignty during military occupation
- Compulsory enlistment as soldiers among the inhabitants of occupied territory
- Pillage
- Confiscation of property
- Exaction of illicit or exorbitant contributions and requisitions
- Debasement of currency
- Issue of spurious currency
- Imposition of collective penalties
- Wanton devastation and destruction of property
- Bombardment of undefended places
- Wanton destruction of religious, charitable, educational and historic buildings and monuments
- Destruction of merchant ships and passenger vessels without examination or without warning
- Destruction of fishing boats and a relief ship
- Bombardment of hospitals
- Attack on and destruction of hospital ships
- Breach of other rules relating to the Red Cross
- Use of deleterious and asphyxiating gases
- Use of exploding and expanding bullets
- Directions to give no quarter
- Ill-treatment of prisoners
- Misuse of flags of truce
- Poisoning of wells

The Rector and Senate of the ancient University of Upsala might render great service, not only to science and to scholarship, but to the cause of civilization itself, if they would bring to the attention of the Rector and Senate of the University of Leipzig, as well as to that of the proper authorities of the University of Heidelberg and the Heidelberg Academy of Sciences, the fact that acknowledgment of wrong-doing on the part of the German government, the German armies and the German people, and contrition for that wrong-doing, are the first and necessary steps in the rehabilitation before the world of German scholarship and German science. It is probably within the truth to say that the universities of France, England, and the United States are awaiting, with deep interest and no small measure of anxiety, some sign that German scholars and men of science realize the enormity of the offenses, public and private, that have been committed by Germans and in the name of Germany during the war now ending, and some evidence that these scholars and men of science feel sincere regret for them.

We have not forgotten the amazing prostitution of scholarship and science to national lust marked by the formal appeal to the civilized world made by German professors in September 1914. That appeal was an unmixt mass of untruths, and the stain

which it placed upon the intellectual and moral integrity of German scholars and men of science will forever remain one of the most deplorable and discouraging events of the war which German militarism and Prussian autocracy forced upon the peaceful and liberty-loving nations of the world.

I have the honor to be,

Your obedient servant,

NICHOLAS MURRAY BUTLER

President of Columbia University

NEW YORK CITY

April 15, 1919

POLARISCOPES AND INTERNATIONAL SACCHARIMETRIC SCALE

Editor of the Journal of Industrial and Engineering Chemistry:

We have read with much interest the recent article by Dr. C. A. Browne in THIS JOURNAL, 10 (1918), 916, on polariscopes.

We are in entire agreement with the French makers in their protest against adopting the German scale and we would further advise that German instruments should not be copied either in design or in arrangement of optical parts. It would perhaps be well to remember that the present high quality of the German polariscopes is due to the forty years' work which has been spent in perfecting a particular arrangement of optical parts, the Nicol prisms and the wedges for instance being brought to a state of perfection to suit their standard optical train after no doubt considerable labor and expense.

No new polariscope has been introduced for some considerable time with the exception of the Bates instrument, but even this we believe has the German optical arrangement. We would venture to suggest that if the Allies wish to produce an instrument which shall compete with the German and eventually surpass it in sensitiveness and accuracy it will be absolutely necessary to produce one of new design.

From our own experience with sugar solutions we believe that special optical tests other than those of polarization could with advantage be applied, for it is doubtful if the actual accuracy of measurement found in practice justifies the excessive care which has been taken in making the instrument read to the accuracy claimed. Concerning the possibility of producing a polariscope built on new lines, this firm has been carrying out experiments over a number of years and our investigations in search of a more perfect instrument may be of interest to you and are as follows:

1—To eliminate the errors due to want of homogeneity in the long quartz compensation wedge.

Quartz is a most unsatisfactory material as far as its optical properties are concerned and although we have examined a large quantity of quartz we have not yet seen a slab which is perfect enough when properly examined with suitable optical means to cut wedges of the length of those employed in the German type of instrument, that is, if such an accuracy is desired as can be reached with a high-class polarimeter. Our experience has been fully confirmed by Dr. Lowry in his long researches on the optical rotatory power of quartz.

2—To improve the figure of the optical surfaces of the wedge.

One of the most difficult examples of optical working is the production of thin plates or wedges of either glass or quartz owing to the absence of any suitable support. The wedges may be increased in thickness but errors due to want of homogeneity would be increased.

3—To design an instrument in which the scale length could be set finally at an independent testing station such as the National Physical Laboratory or the Bureau of Standards against a standard so that all instruments would read alike.

We have realized the importance of this for some considerable time and were gratified to see pointed out the advantage that would accrue if such an adjustment could be adopted.

The most satisfactory method of accomplishing this is the rotation of the wedges in their own plane, but long narrow wedges cannot be adjusted in this manner without considerable difficulty.

As a result of these investigations we have built a polariscope in which

- (a) The compensating wedge is reduced to a length of 20 mm.;
- (b) The wedges are moved by an accurate micrometer screw carrying a large drum on which the scale is engraved;
- (c) The short wedges are mounted in plates which may be rotated by known amounts by means of set screws.

This wedge system has a great advantage over the old type in so far as errors due to want of homogeneity in the quartz are almost entirely eliminated, as areas of this size of the required purity can generally be found in crystal plates if sufficient care is taken. Further as the angle of the wedges is increased difficulties in the manufacture are greatly reduced so that the surface may be worked plane to $1/10$ of the wave-length of sodium light. These short wedges are 12 mm. wide and may be rotated over several degrees without decreasing the aperture. In fact there is no reason why they should not be angular discs and the scale length could then be varied at will from the minimum, depending on the angle of the wedge, to infinity. We have compiled tables for giving the necessary angular rotation to the wedges to increase or decrease the total scale length by any required amount. If, for instance, the normal plate should read 0.2 high a rotation of a few minutes will be necessary to make the reduction. These adjustments can be carried out from the outside of the wedge box with the greatest ease.

F. STANLEY, *Director*

BELLINGHAM AND STANLEY, LIMITED
LONDON, ENGLAND, February 27, 1919

THE MOHR AND THE METRIC MILLILITER

Editor of the Journal of Industrial and Engineering Chemistry:

A matter regarding which there is now a good deal of confusion and which badly needs standardization is that which refers to the basis of graduation of volumetric glassware. The older standard is the so-called Mohr cubic centimeter, which is the volume occupied by 1 g. of water at $15^{\circ}\text{C}.$, weighed in air with brass weights. The cubic centimeter still widely employed in the sugar industry is, however, based on a temperature of $17\frac{1}{2}^{\circ}$ instead of 15° . The Bureau of Standards has for some time advocated the adoption of the metric cubic centimeter, or, to be exact, the metric milliliter, which is the volume occupied by 1 g. of water at $4^{\circ}\text{C}.$ weighed *in vacuo*, the standard temperature for the use of the apparatus being specified as $20^{\circ}\text{C}.$ The newer normal weights for saccharimeters, 26 and 20 g., refer to a volume of 100 metric milliliters at $20^{\circ}\text{C}.$

Those in the sugar industry have a special reason to adopt the metric milliliter, because it simplifies the value of the normal weight, and they perhaps are as much to blame as any one for the adherence to the old standards. While the use of the metric milliliter in the sugar industry was recommended some time ago, the writer hesitated to adopt the metric milliliter for sugar flasks and still be forced to accept other kinds of volumetric apparatus graduated in Mohr cubic centimeters, as the existence of two standards for volumetric apparatus in the same laboratory would lead to worse confusion than already has previously prevailed.

It should be unnecessary in this communication to present any of the arguments in favor of the metric milliliter. The very complete tables which have been published by the Bureau of Standards eliminate any inconvenience which the calculation to working conditions may cause. Probably the reason that the Mohr cubic centimeter has lasted so long is that until recently most volumetric glassware has been imported from countries

where the Mohr standard is prevalent. Now that this condition has disappeared, it is to be hoped that American chemists will unite in adopting and specifying the metric milliliter as the basis of graduation of all volumetric apparatus, and that domestic manufacturers will do their part in eliminating the Mohr cubic centimeter as rapidly as possible.

That the situation is still hopelessly confused is shown by the replies received to a recent letter of inquiry sent to three of the most prominent dealers in laboratory supplies. Two of them state that all volumetric glassware is now, unless otherwise specified, graduated on the basis of the metric milliliter, and urge its adoption. The third replies that all regular stock volumetric ware is calibrated according to the Mohr cubic centimeter, and that, on account of the fact that volumetric analysis in general is still based on this, it would be a mistake to change to the metric milliliter.

It would be a desideratum if the AMERICAN CHEMICAL SOCIETY and other associations would keep this question alive through suitable committees. In the meantime let the chemists do their part in rejecting and eliminating an unfortunate and unscientific standard.

It is also to be hoped that American manufacturers will make an effort to furnish accurately graduated volumetric apparatus. It has unfortunately been too true in the past that one is almost always right in assuming all volumetric glassware to be incorrect. It is also unfortunate that so many chemists, even in analytical work demanding high accuracy, accept the manufacturer's graduations as correct and never take the trouble to verify for themselves the accuracy of such apparatus. In many cases their education is at fault, for the verification of apparatus is one of the first tasks which the student in quantitative analysis should be given, and is too often slighted or even entirely neglected.

SIDNEY J. OSBORN

THE GREAT WESTERN SUGAR COMPANY,
DENVER, COLORADO
February 25, 1919

UNIVERSITY OF VIRGINIA DEPARTMENT OF CHEMISTRY

At the University of Virginia, the School of Analytical and Industrial Chemistry and the School of Chemistry have been merged. Its affairs will be managed by a committee of the chemical faculty.

Five new research fellowships have been established by the Board of Visitors. Applications for these should be filed with Dr. Gardner L. Carter, secretary of the chemical faculty.

LIBRARIANS FOR RESEARCH LIBRARIES

Editor of the Journal of Industrial and Engineering Chemistry:

A striking feature of the Symposium on Library Service in Industrial Laboratories,¹ presented before the Industrial Division at the Victory Meeting in Buffalo, was the exclusive use of feminine pronouns in referring to librarians. Why bar the men from this complex and interesting profession?

Another equally impressive feature was that, with scarcely any exception, no mention was made of any training other than in library science for librarians of research libraries. It was tacitly assumed that the unfortunate lady (always a lady) must enter upon her duties under the handicap of entire and unilluminated ignorance of the science upon which her library is based.

Why should it be so? With all respect for library science, it seems to the writer that in choosing a research librarian, primary emphasis should be on training in the library's own science and secondary emphasis on library training.

¹ "Standard Density and Volumetric Tables," *Circular 19*.

² See p. 578, this issue.

Discussion of this subject would be both interesting and helpful. We would like to be favored with the viewpoints of other libraries and librarians.

JULIAN F. SMITH

NATIONAL ANILINE AND CHEMICAL CO., INC.
BUFFALO, N. Y., April 11, 1919

JOHNS HOPKINS UNIVERSITY GRAFLIN SCHOLARSHIP AND RESEARCH ASSISTANTSHIPS

Through the generosity of the late Mr. Wm. H. Graflin, of Baltimore, a scholarship, to be known as the Graflin Scholarship, and three assistantships, have been established in the department of chemistry of the Johns Hopkins University.

The Graflin Scholarship will be awarded annually to a candi-

date having a training equivalent to that leading to the Ph.D. degree and who therefore has had experience in research. It may be awarded twice to the same candidate. The holder of the scholarship will receive \$1000 a year and will be expected to devote his entire time to research.

The three research assistantships each pay \$750 a year and are open to chemists having the equivalent of a Ph.D. degree. The holder of a research assistantship will not be required to do any formal teaching but will be given the opportunity to devote his entire time to research and to assist in the direction of research.

Applications for the above positions for the year 1919-1920 should be sent to the department of chemistry, Johns Hopkins University, 321 Druid Hill Avenue, Baltimore, Md., before August 1.

WASHINGTON LETTER

By PAUL WOOTON, Union Trust Building, Washington, D. C.

Recommendations, as to what German dyestuffs may be imported to advantage to the nation, are to be made by an advisory committee to be appointed by the War Trade Board. In addition, the advisory committee will make recommendations as to means which will insure equitable distribution of such dyes as are imported and will prevent speculation and hoarding. The advisory committee is to consist of eight members, four of whom will represent producers and four, consumers.

In the so-called Brussels declaration made to Germany it was provided that Germany would be allowed to export various commodities to any country. That is, there was no objection to such exportation from Germany on blockade grounds. No individual country, however, was under obligation to receive any such goods. That made it necessary for the War Trade Board to determine a policy on dyestuffs. The "Trading with the Enemy" Act prohibits such imports except under license. The licensing power was placed in the hands of the President. He in turn delegated it to the War Trade Board.

The War Trade Board has refused consistently to use any of its powers for tariff purposes. Its concern has been with the national defense and with matters which clearly were of benefit to the nation. Great care has been taken not to encroach upon the jurisdiction of Congress.

Since it is evident that certain dyes should be allowed to come into the country, it was recognized that the matter of their distribution offered an intricate problem. Even of the much needed products, the imports will be greatly restricted. If hoarding and speculation are avoided and proper distribution assured, it will be necessary that they be imported under a guarantee. The precise form of the guarantee has not been worked out at this writing. The War Trade Board has requested the Chemical Foundation, Inc., to act as consignee for all German dyes.

Thus steps have been taken to meet the situation until the new Congress can provide such statutory safeguards as it may feel inclined to extend to the dye industry. There seems to be little difference of opinion, however, between Democrats and Republicans with regard to the necessity of maintaining in this country a permanent dye industry. One of the difficulties which is giving members of the Ways and Means Committee concern is the fact that some of the dyes would require a duty of 300 to 400 per cent in order to grant them the protection needed. Some are hopeful that a licensing plan will be worked out. It is known that Mr. Joseph H. Choate, Jr., now is engaged in drafting a bill which will provide a licensing arrangement. The Tariff Commission, however, is understood to be rather dubious as to the practicability of any licensing plan. Representative Nicholas Longworth, of Ohio, who does not believe it likely that any general tariff revision will be attempted at this session of Congress, but who is very anxious that essential war-born industries should be safeguarded, expressed the following opinions to the correspondent of the *Journal of Industrial and Engineering Chemistry*:

Immediate protection should be extended to the dye industry in which some \$300,000,000 have been expended since the beginning of the war. This mammoth activity soon would be helpless without legislative assistance.

Generally speaking, we ought not to be dependent on any other country for necessities. This applies with special force to all coal-tar products.

Just how to handle the coal-tar product situation must be threshed out. In an industry so young, there is no definite basis as to costs. The difficulty of tariff legislation, where costs are so different, is that the granting of reasonable protecting duties would, in some cases, have to be 300 or 400 per cent. A licensing system presents numerous administrative difficulties. It probably is wise to introduce the bill recommended by the Tariff Commission. The fact that the textile manufacturers will no longer oppose duties on dyes will make it much easier to enact proper legislation of that character.

Democratic members of the Ways and Means Committee apparently agree that tariff protection must be extended to the coal tar and other industries in the same situation, but they fear that advantage will be taken of the situation to foist higher duties on the country than are necessary to prevent the dumping of European accumulation. For that reason they expect to go into the matter very carefully but are willing that temporary safeguards be provided in the interim.

Representative Fordney, of Michigan, who announced in March that he would be satisfied with nothing less than general tariff revision at the coming session, has not returned to Washington at this writing, but it is regarded as probable that he will not insist upon such a course in view of the prevailing sentiment against it.

The United States Tariff Commission expects to have ready to place in the hands of Congress shortly after it convenes the 1918 dyestuff census.

Recognizing that there is much uncertainty as to the status of stills or worms adapted to the production of distilled spirits, the Commissioner of Internal Revenue has promulgated a statement covering the use, manufacture, and sale of stills. The statement is as follows:

Under federal laws and regulations manufacturers of stills are required to pay an annual special tax of \$50, and in addition thereto \$20 for each still or worm for distilling made by them. All persons, firms, or corporations thus manufacturing a still or worm to be used in distilling are deemed manufacturers of stills. This applies to all stills capable of the production of distilled spirits, but does not apply to small laboratory stills (usually glass) for legitimate laboratory purposes, or to water stills which are not capable of and intended for the production of distilled spirits. Ordinarily, laboratory stills are small, constructed of glass, and not adapted to the production of distilled spirits in commercial quantities, and many water stills are also of such construction that they are not adapted to the commercial production of distilled spirits.

Any stills or worms adapted to the production of distilled spirits for commercial or beverage purposes are presumed to be intended for such use, and in consequence the manufacture thereof involves the manufacturer in special tax liabilities as above. In order to remove such presumption in the case of stills and worms intended to be used in the manufacture of essential oils, vinegar, and lie products, and in purification of water (other than small glass laboratory stills), the person for whom such still is made will be required to submit to the Collector evidence under oath showing that the still is not to be used for the production of spirits and setting forth specifically the actual purposes for which it is to be used.

The manufacturer of any still, boiler, or any vessel to be used for the purpose of distilling must, before the same is removed

from the place of manufacture, notify in writing the Collector of the district in which such still, boiler, or other vessel is to be set up, by whom it is to be used, its capacity, and the time when the same is to be removed from the place of manufacture. Manufacturers of stills for industrial distilleries are exempt from the special tax for the manufacture of such stills, but they are required to obtain permit for their removal in the usual manner. Penalty for failure to file return of special tax within the time prescribed by law is 25 per centum of the amount of tax. Penalty for carrying on the business of manufacture of stills without having paid the special tax required by law is a fine of not less than \$100 or more than \$5,000, and imprisonment of not less than 30 days or more than 2 years.

All stills set up, whether intended for use or not, must be registered with the Collector of the district on Form 26 in duplicate. This applies to all stills of whatever size or for whatever purpose intended, whether for distillation of spirits or for pharmaceutical or other purposes, except as to small glass laboratory stills. Penalty for failure to register still is forfeiture of the still or distilling apparatus which is not so registered, together with all personal property in the possession or custody or under control of such offender and found in the building or in any yard or inclosure connected with the building in which the same may be set up. The person whose duty it is to register such still, for failure to do so, is subject to a penalty of \$500 and a fine of not less than \$100 or more than \$1,000, and imprisonment of not less than 1 month or more than 2 years.

A person who makes a mash fit for distillation is held to be a distiller, even though he does not vaporize or condense the spirit. A mash fit for distillation is a fermented beer in which alcohol is generated and from which such alcohol may be removed or separated by use of a still or otherwise. Obviously, the making of such a mash is not permissible in the home brewing of beer or home production of spirits since it renders the manufacturer liable as an illicit distiller. Penalty for illicit distillation is forfeiture of the distillery and distilling apparatus and all distilled spirits and raw materials for the production of distilled spirits found on the distillery premises, and a fine of not less than \$500 or more than \$5,000, and imprisonment of not less than 6 months or more than 3 years.

In addition to penalties above cited, attention is called to Sub-section 12 of Section 1001 of the Revenue Act of 1918, which establishes additional special taxes in certain cases and which reads as follows:

Every person carrying on the business of a brewer, distiller, wholesale liquor dealer, retail liquor dealer, wholesale dealer in malt liquor, retail dealer in malt liquor, or manufacturer of stills, as defined in Section 3244 as amended and Section 3247 of the Revised Statutes, in any State, Territory, or District of the United States contrary to the laws of such State, Territory, or District, or in any place therein in which carrying on such business is prohibited by local or municipal law, shall pay, in addition to all other taxes, special or otherwise, imposed by existing law or by this Act, \$1,000.

The so-called war-time prohibition law imposes for its violation a penalty of imprisonment not exceeding 1 year, or \$1,000 fine, or both.

During the week ending May 9, sales of surplus war materials were made amounting to \$77,901,960.18, a large figure as compared to the amount realized from the sales of the preceding week which was approximately one and one-half million dollars. The larger part of the figure represents sales made through the Ordnance Department which reported a sales total of \$45,883,995.74 for the week, over half of which was realized from the disposal of ammonium nitrate, of which the Government had a large quantity and which was made surplus to the War Department when munition manufacturing ceased.

It is planned to convert this chemical into dynamite and the Department of Agriculture has purchased a large quantity for \$10,320,000, which, when converted into dynamite, will be

used in clearing land for agricultural purposes and will also be extensively used in the building of better roads. Large quantities were also sold to the Allied Nitrate Commission and the Importers' Association, which, it is planned, will be used for similar purposes in foreign countries. The Ordnance Department also sold \$15,000,000 worth of copper.

The Surplus Property Division reported a total sales figure for the week of \$31,908,197.58. The principal items which comprised this figure were the amounts realized from two public auction sales of wool held in Boston. At the first sale \$17,019,801 was realized, and at the second, sales were made which amounted to \$13,765,812. These figures bring the total sales of the War Department surplus material sold through the Office of the Director of Sales from January 1 to May 9 to \$236,162,143.07 and represent 88 per cent of original cost to the Government.

The disposition of the War Department's surplus supply of alcohol was considered at a meeting of a committee representing producers of alcohol, with representatives of the Director of Sales.

The Committee representing the producers found that the Government surplus of alcohol was not large enough to warrant their taking it over and selling it in the open market for the Government and it was their opinion that a large proportion of this surplus should be held for the account and use of other government departments. It was agreed, however, that the surplus remaining after all the bureaus of the Government were amply supplied with alcohol to take care of their requirements over a long period, should be disposed of by selling it back to the producers.

Any undenatured alcohol sold back to the producers would, of course, have to be sold for other than beverage purposes. The Government surplus of denatured and rectified alcohol would have to be processed before being marketed. The quantity of alcohol in the hands of the War Department, after the needs of the various departments of the Government are taken care of, will be made known to the committee representing the alcohol producers.

Much credit is given to industries by the Bureau of Chemistry for the remarkable success which has attended the administration of the Food and Drugs Act. Practically the entire substantial portion of the industries affected by this law have co-operated with the Department in its enforcement and in discouraging violations. Occasionally sporadic instances on the part of widely scattered dealers to adulterate and misbrand in the old way are detected, but such practices no longer are general. The campaign against false statements on labels of proprietary medicines has been so effective that the country has practically become rid of that evil.

While the Bureau of Chemistry occasionally finds it necessary to prosecute flagrant misbranding or adulteration, the average case is corrected by serving notices on the parties responsible without recourse to formal legal action.

Scientists in Washington took an unusual step on May 8 when some five hundred of them met in the auditorium of the National Museum and voted to affiliate with organized labor. The step was taken in order that more effective means might be employed to secure better pay and improved working conditions. The meeting was attended by chemists, botanists, zoologists, physiologists, pathologists, bacteriologists, physicists, and various other research workers employed by the Government. Dr. E. B. Rosa, of the Bureau of Standards, was the principal speaker at the meeting.

Ninety-three per cent of the contracts entered into by the Bureau of Aircraft Production for chemicals and chemical plants have been suspended. Total obligations amounted to \$15,285,255. The suspensions to April 26 total \$14,203,006.

INDUSTRIAL NOTES

The annual report of the American Zinc, Lead and Smelting Co. for the year ending December 31, 1918, shows net profits from operations of \$857,193.13; miscellaneous profits, \$54,222.85. Total surplus at that date was \$4,421,721.56. During the year the natural gas zinc smelter at Neodesha, Kan., was dismantled; also the plant at Dearing, Kan., in large part. Additions were made to the zinc oxide plant at Hillsboro, Ill., and to the sulfuric acid plant at East St. Louis. Pumps were installed and further developments made at No. 4 shaft, Mascot, Tenn.

The establishment of a council of industrial relations, giving representation to all employees over 18 years of age who are American citizens and have had six months' continuous service or one year's total service with the factory, has been announced by the Goodyear Tire & Rubber Co., Akron, O. This move concerns more than 20,000 Goodyear workers, who will in the future have a large voice in shaping the policy of the factory on such subjects as employment and working conditions and reconstruction problems generally.

LIST OF APPLICATIONS MADE TO THE FEDERAL TRADE COMMISSION FOR LICENSES UNDER ENEMY-CONTROLLED PATENTS PURSUANT TO THE "TRADING WITH THE ENEMY" ACT

YEAR	PAT. No.	PATENTEE	ASSIGNEE	PATENT	APPLICANT
1915	1,128,843	Carl Bosch and Alwin Mittasch, Ludwigshafen - on - the - Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the - Rhine, Germany	Production of ammonia	Semet-Solvay Co., Solvay, N. Y.
1915	1,148,570	Carl Bosch, Alwin Mittasch, and Hans Wolf, Ludwigshafen-on-the-Rhine, Germany, and Georg Stern, Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen - on - the - Rhine, Germany	Catalytic agent for use in producing ammonia	Semet-Solvay Co., Solvay, N. Y.
1915	1,149,510	Fritz Haber, Berlin, and Carl Bosch and Alwin Mittasch, Ludwigshafen - on - the - Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the - Rhine, Germany	Producing ammonia	Semet-Solvay Co., Solvay, N. Y.
1915	1,152,930	Carl Bosch, Alwin Mittasch, Hans Wolf, and Georg Stern, Ludwigshafen-on-the-Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Production of ammonia	Semet-Solvay Co., Solvay, N. Y.
1915	1,158,167	Carl Bosch and Alwin Mittasch, Ludwigshafen - on - the - Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the - Rhine, Germany	Production of ammonia	Semet-Solvay Co., Solvay, N. Y.
1916	1,173,532	Alwin Mittasch, Ludwigshafen-on-the-Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the - Rhine, Germany	Catalytic agents and process of making them	Semet-Solvay Co., Solvay, N. Y.
1916	1,175,693	Carl Bosch and Alwin Mittasch, Ludwigshafen - on - the - Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the - Rhine, Germany	Process of producing tungsten	Semet-Solvay Co., Solvay, N. Y.
1916	1,202,995	Fritz Haber and Robert Le Rossignol, Karlsruhe, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the - Rhine, Germany	Production of ammonia	Semet-Solvay Co., Solvay, N. Y.
1917	1,225,755	Carl Bosch and Alwin Mittasch, Ludwigshafen - on - the - Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on - the-Rhine, Germany	Catalytic production of ammonia	Semet-Solvay Co., Solvay, N. Y.
1917	1,243,382	Carl Bosch, Ludwigshafen-on-the-Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the - Rhine, Germany	Producing ammonia	Semet-Solvay Co., Solvay, N. Y.
1917	1,244,580	Carl Bosch and Alwin Mittasch, Ludwigshafen - on - the - Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the - Rhine, Germany	Producing ammonia	Semet-Solvay Co., Solvay, N. Y.
1904	778,670	Ilijinsky	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the - Rhine, Germany	Orthodioxanthraquinone sulfo-acid and process of making same	National Aniline & Chemical Co., Inc., New York City
1904	772,775	Behaghel and Schumann	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the - Rhine, Germany	Process of making indoxyl compound	National Aniline & Chemical Co., Inc., New York City
1904	778,772	Behaghel and Schumann	Badische Anilin & Soda Fabrik, Ludwigshafen - on-the-Rhine, Germany	Process of making hydroxyalkylanilin	National Aniline & Chemical Co., Inc., New York City
1907	845,129	Scholl and Kunz	Badische Anilin & Soda Fabrik, Ludwigshafen - on-the-Rhine, Germany	Process of preparing anthraquinone compound	National Aniline & Chemical Co., Inc., New York City
1908	876,190	Isler	Badische Anilin & Soda Fabrik, Ludwigshafen - on-the-Rhine, Germany	Anthracene dye and process of making same	National Aniline & Chemical Co., Inc., New York City
1913	1,055,701	Bohn	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the - Rhine, Germany	Pigment and process of making same	National Aniline & Chemical Co., Inc., New York City
1915	1,150,863	Just and Eckhard	Badische Anilin & Soda Fabrik, Ludwigshafen - on-the-Rhine, Germany	Pigment and process of making same	National Aniline & Chemical Co., Inc., New York City
1903	723,125	Bally	Badische Anilin & Soda Fabrik, Ludwigshafen - on-the-Rhine, Germany	Green anthracene dye and process of making	National Aniline & Chemical Co., Inc., New York City
1903	738,614	Isler	Badische Anilin & Soda Fabrik, Ludwigshafen - on-the-Rhine, Germany	Anthracene dye and process of making same	National Aniline & Chemical Co., Inc., New York City
1904	749,913	Bally	Badische Anilin & Soda Fabrik, Ludwigshafen - on-the-Rhine, Germany	Anthraquinone dye and process of making same	National Aniline & Chemical Co., Inc., New York City
1904	753,657	Bally	Badische Anilin & Soda Fabrik, Ludwigshafen - on-the-Rhine, Germany	Anthracene dye and process of making same	National Aniline & Chemical Co., Inc., New York City
1904	754,264	Weltz	Badische Anilin & Soda Fabrik, Ludwigshafen - on-the-Rhine, Germany	Anthracene dye and process of making same	National Aniline & Chemical Co., Inc., New York City
1904	763,233	Weltz	Badische Anilin & Soda Fabrik, Ludwigshafen - on-the-Rhine, Germany	Anthracene dye and process of making same	National Aniline & Chemical Co., Inc., New York City
1904	767,259	Bohn	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the - Rhine, Germany	Anthracene dye	National Aniline & Chemical Co., Inc., New York City
1905	779,825	Weltz	Badische Anilin & Soda Fabrik, Ludwigshafen - on-the-Rhine, Germany	Anthraquinone dye and process of making same	National Aniline & Chemical Co., Inc., New York City
1905	786,085	Bally	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the - Rhine, Germany	Violet anthracene dye and process of making same	National Aniline & Chemical Co., Inc., New York City
1905	791,869	Bohn	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the - Rhine, Germany	Brown anthracene dye	National Aniline & Chemical Co., Inc., New York City
1905	793,558	Bally and Wolff	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the - Rhine, Germany	Anthracene dye and process of making same	National Aniline & Chemical Co., Inc., New York City
1905	795,751	Bally	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the - Rhine, Germany	Compound of the anthracene series and process	National Aniline & Chemical Co., Inc., New York City
1905	798,104	Isler	Badische Anilin & Soda Fabrik, Ludwigshafen-on - the-Rhine, Germany	Anthracene compound and process of making same	National Aniline & Chemical Co., Inc., New York City
1906	809,893	Bally	Badische Anilin & Soda Fabrik, Ludwigshafen-on - the-Rhine, Germany	Anthracene compound and process of making same	National Aniline & Chemical Co., Inc., New York City

LIST OF APPLICATIONS MADE TO THE FEDERAL TRADE COMMISSION FOR LICENSES UNDER ENEMY-CONTROLLED PATENTS PURSUANT TO THE "TRADING WITH THE ENEMY" ACT (Continued)

YEAR	PAT. NO.	PATENTEE	ASSIGNEE	PATENT	APPLICANT
1906	809,894	Bally and Wolff	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene compound and process of making same	National Aniline & Chemical Co., Inc., New York City
1906	811,471	Bally and Wolff	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene dye and process of making same	National Aniline & Chemical Co., Inc., New York City
1906	814,137	Isler	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthraquinone compound and process of making same	National Aniline & Chemical Co., Inc., New York City
1906	820,379	Bally and Isler	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene dye and process of making same	National Aniline & Chemical Co., Inc., New York City
1906	828,741	Isler	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthraquinone aldehyde and process of making same	National Aniline & Chemical Co., Inc., New York City
1906	831,002	Isler	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene derivative and process	National Aniline & Chemical Co., Inc., New York City
1906	837,775	Bally	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Halogenated dye and process of making	National Aniline & Chemical Co., Inc., New York City
1906	837,840	Isler	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene dye and process of making same	National Aniline & Chemical Co., Inc., New York City
1907	855,248	Isler	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Process of making anthracene dye	National Aniline & Chemical Co., Inc., New York City
1907	860,480	Isler	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene dye and process of making	National Aniline & Chemical Co., Inc., New York City
1907	863,401	Kacer	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene dye and process of making	National Aniline & Chemical Co., Inc., New York City
1907	868,399	Bohn	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene dye and process of making	National Aniline & Chemical Co., Inc., New York City
1908	885,577	Boner	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Process of making alizarin	National Aniline & Chemical Co., Inc., New York City
1908	893,412	Wolff	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene dye and process of making	National Aniline & Chemical Co., Inc., New York City
1908	893,507	Isler	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Omega-halogen-methyl-anthraquinone compound	National Aniline & Chemical Co., Inc., New York City
1908	893,508	Isler	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene dye and process of making same	National Aniline & Chemical Co., Inc., New York City
1909	909,800	Isler	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene dye and process of making same	National Aniline & Chemical Co., Inc., New York City
1909	929,443	Isler, Wolff and Kacer	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene dye and process of making same	National Aniline & Chemical Co., Inc., New York City
1909	931,618	Kacer	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene dye and process of making same	National Aniline & Chemical Co., Inc., New York City
1909	932,290	Kacer	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Compound of the anthracene series and process of making	National Aniline & Chemical Co., Inc., New York City
1909	941,320	Isler, Luttringhaus and von Diesbach	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Halogenated naphthanthraquinone and process	National Aniline & Chemical Co., Inc., New York City
1910	968,376	Luttringhaus	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Pigment	National Aniline & Chemical Co., Inc., New York City
1910	970,340	Kacer	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene compound and process of making	National Aniline & Chemical Co., Inc., New York City
1911	992,567	Kunz	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene dye	National Aniline & Chemical Co., Inc., New York City
1911	995,936	Wolff	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Green anthracene dye and process of making	National Aniline & Chemical Co., Inc., New York City
1911	1,001,408	Isler	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene compound and making same	National Aniline & Chemical Co., Inc., New York City
1911	1,002,066	Luttringhaus	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Vat dye	National Aniline & Chemical Co., Inc., New York City
1911	1,004,433	Isler	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Dianthraquinonyldialdehydes and process	National Aniline & Chemical Co., Inc., New York City
1911	1,010,930	Luttringhaus	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Vat dyes	National Aniline & Chemical Co., Inc., New York City
1911	1,011,068	Luttringhaus	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Vat dyes	National Aniline & Chemical Co., Inc., New York City
1912	1,016,604	Bally	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene dye and process of making same	National Aniline & Chemical Co., Inc., New York City
1912	1,018,836	Luttringhaus and von Diesbach	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Orange-red vat dye	National Aniline & Chemical Co., Inc., New York City
1912	1,018,837	Luttringhaus and von Diesbach	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Yellow vat dye	National Aniline & Chemical Co., Inc., New York City

LIST OF APPLICATIONS MADE TO THE FEDERAL TRADE COMMISSION FOR LICENSES UNDER ENEMY-CONTROLLED PATENTS PURSUANT TO THE "TRADING WITH THE ENEMY" ACT. (Concluded)					
YEAR	PAT. NO.	PATENTEE	ASSIGNEE	PATENT	APPLICANT
1912	1,026,557	Boner and Bally	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene compounds and process of making same	National Aniline & Chemical Co., Inc., New York City
1912	1,026,288	Isler	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene compounds and process of making same	National Aniline & Chemical Co., Inc., New York City
1912	1,026,621	Bally	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Halogenated vat dyes and process of making	National Aniline & Chemical Co., Inc., New York City
1912	1,032,215	Isler	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthraquinone vat dyes and process of making	National Aniline & Chemical Co., Inc., New York City
1912	1,032,216	Isler	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthraquinone vat dyes and process of making	National Aniline & Chemical Co., Inc., New York City
1912	1,035,023	Luttringhaus and Braren	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Vat dyes and making the same	National Aniline & Chemical Co., Inc., New York City
1912	1,037,410	Bally	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene dye and process of making same	National Aniline & Chemical Co., Inc., New York City
1912	1,044,673	Luttringhaus and von Diesbach	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Orange-yellow vat dye	National Aniline & Chemical Co., Inc., New York City
1912	1,044,674	Luttringhaus and Schwarz	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Yellow vat dye	National Aniline & Chemical Co., Inc., New York City
1912	1,044,675	Luttringhaus and Schwarz	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Yellow vat dye	National Aniline & Chemical Co., Inc., New York City
1912	1,047,812	Isler	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene dyes and process of making same	National Aniline & Chemical Co., Inc., New York City
1912	1,047,813	Isler	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	1,1'-Dianthraquinonyl-2,2'-dialdehyde bodies and process of making such compound	National Aniline & Chemical Co., Inc., New York City
1913	1,052,507	Neresheimer	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Vat dyes of the anthraquinone series	National Aniline & Chemical Co., Inc., New York City
1913	1,054,888	Wolff	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Blue-green vat coloring matter	National Aniline & Chemical Co., Inc., New York City
1913	1,057,243	Isler and Nawiasky	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene coloring matter and process	National Aniline & Chemical Co., Inc., New York City
1913	1,058,604	Kunz	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene compounds and process of making	National Aniline & Chemical Co., Inc., New York City
1913	1,061,714	Wolff	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Dyes containing sulfur and process	National Aniline & Chemical Co., Inc., New York City
1913	1,062,990	Nawiasky	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthraquinone dyes and process of making same	National Aniline & Chemical Co., Inc., New York City
1913	1,063,000	Wolff	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene dyes and making the same	National Aniline & Chemical Co., Inc., New York City
1913	1,065,102	Bally	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene compounds and coloring matters and process	National Aniline & Chemical Co., Inc., New York City
1914	1,086,123	Bally	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene dyes and process of making same	National Aniline & Chemical Co., Inc., New York City
1914	1,090,621	Isler	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthraquinone vat dyes	National Aniline & Chemical Co., Inc., New York City
1914	1,093,427	Isler and Bally	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthraquinone dyes and process of making them	National Aniline & Chemical Co., Inc., New York City
1914	1,095,731	Kacer	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Producing anthraquinone-thiazoles	National Aniline & Chemical Co., Inc., New York City
1915	1,126,475	Isler	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Yellow-to-brown vat dyes	National Aniline & Chemical Co., Inc., New York City
1915	1,128,836	Bally	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Vat dyes	National Aniline & Chemical Co., Inc., New York City
1915	1,133,081	Wolff	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Production of coloring matters of the anthraquinone series	National Aniline & Chemical Co., Inc., New York City
1916	1,169,404	Isler	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Blue-gray to green-gray vat dyes	National Aniline & Chemical Co., Inc., New York City
1916	1,196,127	Luttringhaus	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Vat dyes and process of making them	National Aniline & Chemical Co., Inc., New York City
1916	1,201,968	Isler	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Vat coloring-matters and process of making them	National Aniline & Chemical Co., Inc., New York City
1916	1,202,260	Bally	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Vat dyes and process of making them	National Aniline & Chemical Co., Inc., New York City
1916	1,204,639	Bally and Metzger	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Producing vat dyes	National Aniline & Chemical Co., Inc., New York City
1916	1,207,762	Isler	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthraquinone dyes and process of making	National Aniline & Chemical Co., Inc., New York City

The Committee of the American Institute of Chemical Engineers, which is coöperating with the Government in the disposition of chemical plants and surplus stock of chemicals and apparatus, announces that the Chemical Warfare Service desires to dispose of the following material: 3,000,000 lbs. of bleach, 2,000 tons of sulfur chloride, 100 tons of titanium tetrachloride, 300 tons of stannic chloride, 600 tons of phosgene, 600 tons of liquid chlorine, and considerable stocks of mineral acids. This material is difficult to store and therefore should be sold at once.

The United States Supreme Court has granted a writ of certiorari to the Brown Company, of Portland, Me., in the so-called "hydrogenated oil case." This litigation, which is to determine the scope or validity of the Burchenal patent, owned by Procter & Gamble, has so far resulted in a decision for the defendant in the district court and a reversal in the appellate division. The Supreme Court will now pass upon the question, which is said to be the first patent case of the kind to come before them.

The Anglo-American Aniline Dye Company has purchased the plant of the U. S. Aircraft Corporation at Redwood City, Cal., and will spend \$50,000 in making improvements. Aniline dyes and kindred products will be manufactured.

The Texas Cottonseed Crushers' Association says in a bulletin recently issued: "Unless a tariff is fixed on peanut and palm oils imported from the Orient, domestic products of a similar character will suffer and cottonseed will be worth \$10 per ton. More than 30,000,000 gal. of peanut and palm oils, more than 45,000,000 gal. of soy bean oil, and more than 55,000,000 gal. of coconut oil, or more than 130,000,000 gal. in all, were imported in 1918 from the Orient."

The National Cannerymen's Association has about 125 canneries that are now members of their inspection system, and during this first season they propose to send out about twenty inspectors who will inspect salmon canneries from the standpoints of sanitation, fire risk, and safeguarding employees. They are planning to establish a chemical and bacteriological laboratory as soon as possible in Seattle, but that they think will probably not be until the end of the present salmon packing season. According to E. D. Clark, director of investigations of the National Cannerymen's Association, the action of the salmon packers in installing this inspection system marks another great step in advance in the matter of insuring that the large-scale preparation of foods shall be upon the proper sanitary basis.

United States Alkali Export Association, Inc., has been organized under the laws of the state of Delaware. At a meeting held recently the following directors were elected: Eli Winkler, Eugene M. Taylor, Charles M. Butterworth, H. M. Hooker, and H. G. Carrell. Included among the stockholders are Hooker Electrochemical Company, Michigan Alkali Company, Pennsylvania Salt Manufacturing Company, Solvay Process Company, Columbia Chemical Company, Republic Chemical Company, with other interests soon to enter. The address of the Association is 171 Madison Ave., New York City. Immediate steps are to be taken by the Association to place ocean rates on a more competitive basis, and other plans will be announced as soon as they are completed.

Whether the Diamond Match Company will continue to operate its muriate of potash plant is in doubt, according to the president, Mr. W. A. Fairburn, who says that the company's Burmeister potash works, located on Great Salt Lake, must be considered a war plant, and unless the American potash chemical industry is given government protection it is probable that the plant will cease to operate when trade with Europe is resumed.

According to recent advices from Washington, the Japanese government is expecting to adopt a licensing system for the importation of dyes into that country. This measure, it is stated, will not only regulate the supply of foreign goods, but will stop the incoming of those goods which stand in rivalry with the goods turned out in Japan.

The dyestuff and intermediate department of the Marden, Orth and Hastings Corporation, New York City, has been moved to Bound Brook, N. J.

Plans for the marketing of the stock of the Chemical Foundation, Inc., which recently purchased upwards of 4,500 enemy-owned patents from the Alien Property Custodian, are rapidly maturing. The directors and counsel have opened offices in the Market and Fulton Bank Bldg., 81 Fulton St., New York City.

The International Agricultural Corporation has authorized the erection of a new big plant at Boston. Building of this plant and extension of phosphate activities in preparation for expected export business will involve the expenditure of about \$750,000. It is probable that another plant, at Norfolk, Va., will be erected in the not distant future.

Establishment of a million dollar plant for the manufacture of sulfuric acid fertilizer, located at Great Falls, near Rockville, Md., is being negotiated by a group of New York and Philadelphia capitalists.

The Bureau of Mines, Department of the Interior, has now returned to its interrupted peace program, and during the week of September 29 will formally dedicate to the best interests of humanity, its new million dollar laboratories and workshops in Pittsburgh, Pa., with ceremonies which will be national in scope.

Plans for a cement mill to be located in an undisturbed section of Mexico are under way in California. The materials to be used consist of limestone and natural pozzuolana. The preliminary burnings and engineering tests have shown a sound, cheaply-produced Portland cement. It is understood that capital is being furnished jointly by American and Mexican financiers.

The U. S. Civil Service Commission announces an open competitive examination for laboratory assistant, qualified as paper fiber microscopist, to fill vacancies in the Bureau of Standards. Competitors will not be assembled for examination, but sworn statements, on Form 1312, must be filed with the Commission before June 17, 1919.

An examination for food and drug inspector, for men only, to fill vacancies in the Bureau of Chemistry, is announced by the U. S. Civil Service Commission to be held on June 18, 1919. Application should be made on Form 1312.

Cold-pressed virgin peanut oil with a delicious flavor is being made in increasingly large quantities in this country, say the oil specialists of the Bureau of Chemistry, United States Department of Agriculture, who have made a study of the production and conservation of American edible oils. This product has a characteristic flavor pronounced by many consumers here and abroad to be superior to the oils which are hot-pressed and subjected to a necessary refining process, leaving them practically tasteless. Furthermore, many consumers consider that virgin peanut oil compares favorably with virgin olive oil. Until recently very little virgin peanut oil was made in this country.

The Texas Producing & Refining Company, which was recently incorporated at Fort Worth with a capital stock of \$2,000,000, has adopted plans for the construction of two refineries. One will be located at Fort Worth and will have a capacity of 4000 barrels a day, and the other will be located at Henrietta and will be of 2000 barrels daily capacity.

Funds have been provided for a scholarship in the department of chemistry of the University of Chicago, to be called "The Joseph Triner Scholarship in Chemistry." It is to be assigned to a Czechoslovak graduate of the Harrison Technical School, Chicago.

Production of a tanning extract known as gametto and having as its base the liquid found in palmetto roots, will be undertaken at Miami, Fla., by the Paltanic Tanning Extract Company which expects to begin shortly the manufacture of the extract on a large scale.

Damage estimated at more than \$25,000 was done to the plant of the California Ink Company at Third and Camilla Streets, Berkeley, Cal., when an explosion of chemicals wrecked a 2-ton aniline dye-making machine.

The Mineral Refining and Chemical Corp., St. Louis, will build an addition to its plant at a cost of \$2,500,000 for the manufacture of a paint pigment.

Three new chemical companies were organized recently under Massachusetts laws. They are the Chester Chemical Company at West Springfield, with capital of \$400,000; the New England Nitrogen Company, Boston and New York, capital \$700,000; and the Devoe & Reynolds Company, Inc., of Massachusetts, paints, chemicals and drugs.

The investment in new chemical, drug, and dye companies organized during March amounted to \$5,115,000, distributed among 16 concerns with authorized capital of \$50,000 and over. The aggregate was much below that for February when the authorized capitalization of such companies was \$15,680,000. For the first quarter of 1919, the aggregate capitalization of companies was \$23,475,000, against \$46,010,000 in the corresponding period of last year.

The American Shale and Petroleum Co., San Francisco, Cal., has purchased 1600 acres of high-grade shale land on Green River, Wyo., and plans the erection of a 500-ton reduction plant and refinery designed to be enlarged later to have a capacity of 2000 tons a day.

At the annual meeting of the Barrett Company stockholders, held at Jersey City last week, the retiring directors were re-elected.

What is possibly the largest body of cannel coal in the United States, if not in the world, lies on the Rio Grande, about 25 miles from Laredo, Tex. This coal is of geologic interest because, although it lies in rocks which elsewhere in Texas contain only lignite, it is a bituminous coal. It has the qualities of a cannel coal, it contains a large amount of volatile matter or gas, and it yields oil by distillation—about 50 gal. of oil per ton of coal. It contains more nitrogen than any other coal in the United States. The coal of this field is described in a bulletin entitled "The Santo Tomas Cannel Coal, Webb County, Texas," by George H. Ashley, issued by the U. S. Geological Survey, Department of the Interior, as Bulletin 691-I. This bulletin can be obtained free on application to the Director, U. S. Geological Survey, Washington, D. C.

The World Trade Club, 681 Market Street, San Francisco, has sent out a pamphlet advocating the adoption of the meter-liter-gram as the standards of weight and measure.

PERSONAL NOTES

Mr. Louis E. Wise, who recently resigned his position as biochemist in the Bureau of Chemistry, has accepted a position as organic research chemist with E. I. du Pont de Nemours & Co., Wilmington, Del.

Mr. C. D. Ball, Jr., formerly in the Chemical Warfare Service, has resumed his duties as instructor in chemistry at the Michigan Agricultural College, East Lansing, Mich.

Mr. Robert E. Wilson has been discharged from the Research Division, Chemical Warfare Service, and has accepted a position as assistant director of the research laboratory of applied chemistry and assistant professor of chemical engineering in the Massachusetts Institute of Technology, Cambridge, Mass.

Mr. S. G. Weir recently left the Wright-Martin Aircraft Corp., where he had charge of all nonferrous work, to take charge of the new research laboratory of Willys-Overland Company, Toledo, Ohio.

Dr. B. G. Feinberg, formerly of the department of chemistry at the College of the City of New York, was recently discharged from the Army where he served as First Lieutenant in the Ordnance Division, having been engaged in correlating research conducted in various laboratories and arsenals on high explosives and chemicals.

Dr. William L. Gomory has severed his connection with the Wabash Refining Company as their general manager in Robinson, Ill., and is now connected with the Leonard Engineering Company of Chicago, New York, Mexico, Santo Domingo, and Canada, as head of their Refinery Engineering Department, with headquarters in Chicago, Ill., 855 McCormick Building.

Sir James Dewar was recently elevated to the rank of baron by the British Government, in recognition of his public services during the war.

Dr. Paul Poetschke, who for the past five years has been located at the plant of L. D. Caulk Company, Milford, Del., and who is still their consulting and research chemist, is now vice president and director of the department of chemistry of the Pease Laboratories, successors to the Lederle Laboratories, of which Dr. H. D. Pease is president.

Professor W. Lee Lewis, of Northwestern University, has been elected chairman of the department of chemistry to succeed Professor A. Van Eps Young, who has recently retired with the title of professor emeritus. Professor Lewis was in service in charge of Organic Research Unit No. 3, of the Offense Research Section, C. W. S., during 1918, and is at present assisting Col. W. D. Bancroft in editing the researches of the American University Experiment Station.

Mr. Bernard T. Ellis has been discharged from the Chemical Warfare Service, U. S. A., Edgewood Arsenal, Md., and is now chemical engineer with the Intercean Oil Co., at East Brooklyn, Baltimore, Md.

Mr. John S. Bates, for five years superintendent of the Forest Products Laboratories of Canada, Montreal, and during the war chemical representative of the Imperial Munitions Board, is now chemical engineer with Price Brothers & Co., Ltd., Kenogami, Quebec, Canada.

Mr. E. H. Loeb, who was engaged during the war in toxic gas manufacture at Edgewood Arsenal, has resumed work on a fellowship at the Mellon Institute, Pittsburgh, Pa.

Lt. Douglas G. Stewart has been released from the Navy, and is now with the G. Gordon Urquhart Co., Chemical Engineers, Philadelphia, Pa.

It is announced by the Universal Gypsum Corporation at Alamogordo and Buffalo, N. Y., that that company has adopted plans for the construction of the largest gypsum manufacturing plant in the world. It will be located either at Alamogordo or Valmont, N. M. They have the largest deposit of white sand in the world in the Tularosa Basin. In the white sands which they control, there are more than 10,000,000 tons of the gypsum. The articles to be manufactured from the sand are terra-cotta, plaster boards, plaster of Paris, fireproof tile, building blocks, and other building materials.

According to M. L. Requa, general director of the oil division of the Fuel Administration, "Germany will require approximately 500,000 tons of lubricating oil within the next 12 months. She will also require approximately 3,000 tons of paraffin wax and 600,000 tons of other petroleum products." He also said that this oil would begin to move as soon as the blockade was lifted.

Dr. Carl P. Sherwin, formerly assistant professor of organic and biochemistry in the Fordham University Medical School, has been promoted to professor of chemistry and head of that department.

Mr. E. C. Merrill, formerly chemist with the Drug Division of the Bureau of Chemistry, Washington, D. C., and at one time chief of the Porto Rico Laboratory of that Bureau, is now associated with the United Drug Company (Liggett-Rexall), Boston, Mass., in the capacity of chief chemist.

Mr. Leo E. Kesselman, who was honorably discharged from the Research Division, Chemical Warfare Service, January 1919, is now connected with the National Drug Co., Philadelphia, Pa., as analytical research chemist.

Major Clarence J. West, of the Editorial Section of the Chemical Warfare Service, has been engaged to direct the Information Department, an extension of the present library of Arthur D. Little, Inc., Cambridge, Mass.

Lt. James E. Heckel, formerly of the Chemical Warfare Service, has entered the employ of James B. Sipe & Co., Pittsburgh, Pa., as research chemist.

Mr. Frank J. Tone, past president of the American Electrochemical Society, has been elected president of the Carborundum Co., Niagara Falls, N. Y., and Mr. George R. Rayner, vice president and secretary.

Mr. C. O. Ewing, who during the war was in charge of the pharmacognosy laboratory, Bureau of Chemistry, Washington, D. C., has recently resigned to accept a position as assistant chief chemist with the United Drug Company (Liggett-Rexall), Boston, Mass.

The chemistry department of University of Virginia announces the following appointments: Dr. Graham Edgar, of the National Research Council, as professor, and Mr. J. H. Yoe, of the Chemical Warfare Service, as adjunct professor.

Mr. Charles E. Sholes has resigned from the Grasselli Chemical Company to become vice president of the Edison Storage Battery Co., Orange, New Jersey.

Dr. F. W. Zons has accepted the position of chief research chemist in Thomas A. Edison's central laboratory, Newark, N. J.

Dr. Robert P. Fischelis has resigned from the H. K. Mulford Company to become director of the newly organized technical department of the Matos Advertising Company, with especial direction of advertising which involves chemicals, pharmaceuticals, or engineering, and the management of advertising service along those lines. Dr. Fischelis, who had experience in trade journalism prior to taking up chemistry as a profession, is professor of commercial pharmacy at the Philadelphia College of Pharmacy, a post he will retain in connection with his new position.

Mr. F. W. Dearborn, of the Ordnance Department, has joined the staff of the Bureau of Standards and will be engaged in research on the chemistry of cellulose.

Mr. B. E. Sive, formerly of the chemical reagent testing laboratory of the Bureau of Standards, is now with the American Colortype Company of Chicago, Ill.

Mr. L. E. Smith, formerly with the Mont Calm Chemical Works of Indianapolis, and lately discharged from the Chemical Warfare Service, is now attached to the chemical staff of the General Electric Lamp Works, Cleveland, Ohio.

Mr. H. E. Howe, formerly manager of the commercial department of Arthur D. Little, Inc., of Cambridge, Mass., and who was attached to the Nitrate Division of the Ordnance Department, U. S. A., during the latter part of the war, will hereafter devote his efforts to the interests of the National Research Council and particularly to the work of its Division of Industrial Research.

Mr. Arthur Lachman has resigned his position as vice president and general manager of the Great Western Electro-Chemical Company and the California Alkali Company, his connections with these firms having been established in the interest of war production of needed chemicals, a necessity which no longer exists, and has opened offices in the Holbrook Building, San Francisco.

Mr. A. J. Seltzer, former chemist for the Bartlesville Zinc Co., Blackwell, Okla., has opened an assay office in Picher, Okla.

Mr. Pierre S. du Pont has resigned from the presidency of E. I. du Pont de Nemours & Company, and Irene S. du Pont, chairman of the executive committee, succeeds him as president, Pierre S. du Pont becoming president of the board of directors.

Professor J. Watson Bain, who has done such valuable work for the Canadian War Mission, Washington, D. C., has returned to his duties at Toronto University.

Dr. W. N. Berg, formerly captain in the Sanitary Corps, and stationed at Camp Lee, received his honorable discharge from the Army in March and has returned to the Bureau of Animal Industry.

Dr. A. O. Leuschner, who has been with the National Research Council since November 1918, returned to the University of California in the latter part of March.

Dr. W. B. Meldrum, professor of chemistry at Haverford College, and until lately a member of the Chemical Warfare Service and of the price section of the War Trade Board, has received a temporary appointment as assistant physical chemist at the Geophysical Laboratory, Carnegie Institution of Washington.

Dr. H. C. Taylor, head of the department of agricultural economics in the College of Agriculture, University of Wisconsin, has been appointed Chief of the Office of Farm Management, Department of Agriculture.

Prof. William A. Noyes, head of the department of chemistry of the University of Illinois, will be a member of the faculty of the summer session at the University of California, giving courses in chemistry.

Capt. James Riddick Partington has been appointed to the newly established university chair of chemistry, at East London College.

Prof. Vaughn Harley has resigned the chair of pathological chemistry, which he has held for twenty-three years at the University of London.

Concluding a study of the various phases of the food problem in Army aviation camps, Guy R. Stewart has resumed his duties as assistant professor of agricultural chemistry at the University of California.

The following appointments have been made in the department of chemistry of the Massachusetts Institute of Technology: William H. McAdams, to be assistant professor of chemical engineering; Dr. Charles S. Venable and Dr. William G. Horsch, to be research associates in applied chemistry; and Thomas M. Knowland, to be research assistant in the same department.

Mr. Neal Tuttle, A.M., has been appointed Austin teaching fellow in chemistry at Harvard University.

The Montyon prize (\$500) has been awarded by the Paris Academy of Sciences to Drs. Henri Guillemand and André Labat, of Paris, for their researches on asphyxiating gases.

The Ramsay Memorial Committee has offered to the University of London a sum of not less than \$125,000 towards the foundation of a laboratory of chemical engineering at University College.

Mr. Hubb Bell, who was given leave of absence February 1918, from the Pittsburgh Testing Laboratory to enter the service for the duration of the war, has resigned from the Bureau of Mines, Central Control Laboratory, at Pittsburgh, Pa., and returned to the Sales Department, Pittsburgh Testing Laboratory, Pittsburgh, Pa.

Mr. Edward F. Kohman, formerly organic and physiological chemist in the Bureau of Chemistry, has recently been discharged from the Base Hospital of Camp Jackson, Columbia, S. C., where he was in charge of the bacteriological work, and has accepted a position with the Research Laboratory of the National Canners' Association, Washington, D. C.

Mr. A. J. Turner, who has accepted the appointment of professor of textile technology in the College of Technology, Manchester, England, has been in charge of the Fabrics Laboratory of the Royal Aircraft Establishment, conducting investigations on textile fabrics mainly from the physicochemical standpoint.

Mr. H. M. Gaylord has succeeded B. C. Keith as deputy commissioner of internal revenue, in charge of the unit which includes the miscellaneous, distilled spirits, tobacco, and chemistry divisions.

Capt. A. U. Wetherbee, who recently received his discharge from the Chemical Warfare Service and who was formerly chief engineer and assistant works manager of the Niagara Alkali Company, has accepted a position as chief engineer with the Powdered Coal Engineering & Equipment Company of Chicago.

Mr. W. J. Cotton, formerly chemical examiner for the United States Civil Service Commission, has joined the staff of the Color Investigation Laboratory of the Bureau of Chemistry, Washington, D. C.

Lt. Russel C. Gebert, recently released from the Ordnance Department of the Army, has been made chief metallurgist and superintendent of heat-treating at the Hammond Steel Co., Syracuse, N. Y.

Mr. B. S. Knabenshue has been discharged from the Quartermaster's Corps, Oil Branch, and has accepted the position of chief chemist with the Warren Oil Company of Pennsylvania, Warren, Pa.

President William H. Nichols, of the AMERICAN CHEMICAL SOCIETY, is making a trip through the West with an itinerary which included addresses before the Southern California, San Francisco, and Seattle Sections of the SOCIETY, on May 15, 19, and 24, respectively.

Mr. G. E. Behr, Jr., formerly superintendent of the sandpaper and emery cloth, etc., factories of Herman Behr & Co., Inc., 61 Broadway, New York City, has been discharged from the Army, and is with Baeder, Adamson & Co., Philadelphia, Pa.

Mr. Benjamin F. Ruby, who was formerly chief chemist of the Star Rubber Company, Akron, Ohio, is now assistant chief chemist of the Howe Rubber Company, Inc., New Brunswick, N. J.

Major W. L. Evans, after fourteen months' service in the Chemical Warfare Service, has resumed his professional duties in the department of chemistry at Ohio State University.

Professor D. J. Demorest, of the department of metallurgy, Ohio State University, has received his discharge from the Chemical Warfare Service and is again in Lord Hall.

Dr. J. R. Withrow, formerly chemical engineer and unit chief of the manufacture of cyanogen compounds on the small scale basis, and also identified with the Research Division of the Chemical Warfare Service, is again devoting his entire time to his professional work in the department of chemistry, at Ohio State University.

Dr. C. E. Boord, who was chief of the Ohio State University Field Station, of the Research Division, has been released from the Chemical Warfare Service and is once more giving all of his time to the department of chemistry.

Major O. R. Sweeney, in charge of the manufacture of chlorpicrin while in the Chemical Warfare Service at Edgewood Arsenal, is now professor of industrial chemistry at the University of Cincinnati.

Mr. C. S. Adams, who was commissioned Second Lieutenant in the Chemical Warfare Service last October, has been released and is now connected with the Central Dyestuff and Chemical Company, Columbus, Ohio, as research chemist.

Mr. W. W. Bauer has been released from the Ohio State University Field Station of the Research Division, Chemical Warfare Service, and has accepted a position with the Jackson Laboratories of the du Pont Chemical Company.

Mr. Francis E. Daniels, formerly captain in the Sanitary Corps, and Camp Sanitary Engineer of Camp Lee, Va., has received his discharge from the Army and has returned to the engineering division of the Pennsylvania State Department of Health, Harrisburg, Pa.

Mr. E. D. Clark has resigned from the Bureau of Chemistry to become Director of the Fisheries Investigations and Inspection Service for salmon canneries on the Pacific Coast, under the auspices of the National Canners' Association, Seattle, Wash.

Mr. Walter Arthur, formerly with the Garford Motor Truck Co., at Lima, Ohio, is now chief chemist and metallurgist of the Haynes Automobile Company, Kokomo, Indiana, where he has charge of all laboratory work, heat treatment of steel, furnace construction and operation.

GOVERNMENT PUBLICATIONS

By R. S. McBRIDE, Bureau of Standards, Washington

NOTICE—Publications for which price is indicated can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. Other publications can usually be supplied from the Bureau or Department from which they originate. Commerce Reports are received by all large libraries and may be consulted there, or single numbers can be secured by application to the Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington. The regular subscription rate for these Commerce Reports mailed daily is \$2.50 per year, payable in advance, to the Superintendent of Documents.

PUBLIC HEALTH SERVICE

The New Science of Industrial Physiology. F. S. LEE. Public Health Reports, 34, 723-728. Issued April 11, 1919.

Studies on the Treatment and Disposal of Industrial Wastes. (Made under the supervision of E. B. Phelps.) 1—The Treatment and Disposal of Strawboard Waste. H. B. HOMMON. 2—The Determination of Biochemical Oxygen Demand of Industrial Wastes and Sewage. F. J. THERIAULT and H. B. HOMMON. Public Health Bulletin No. 97. 86 pp. Paper, 15 cents. Issued October 1918. The present studies were undertaken to develop, if possible, a method of purification and sludge disposal which would more satisfactorily meet the requirements of the various state boards of health and fish and game commissioners, and at the same time be practical and within the economic resources of the strawboard companies. After conference with the officials of the Indiana State Board of Health the matter of location was taken up with the officers of the American Strawboard Co. It was decided to build a testing station at that company's plant at Noblesville, Ind. This was done and the station was operated from January 1, 1915, to July 1, 1916. During the progress of these tests it was found that sedimentation of the waste in tanks for a period of two to three hours, followed by filtration through cinders, would produce a final effluent suitable for discharge into a stream without danger of creating a nuisance or killing fish. It was also learned that the sludge accumulating in the tanks could be dried over beds of cinders within a period of 30 days, and that the dried material could be hauled away in wagons and dumped either on land as a fertilizer or on lowland as a fill. Fertilizing tests carried out on the strawboard farm on a large scale proved that this material has valuable fertilizing ingredients which are worth, to the land, about as much as ordinary barnyard manure.

It was demonstrated that fish could live in the effluent from the filters and that the sanitary quality was such that samples were not putrescible when stored in stoppered bottles at room temperature for a period of about four days.

The plant as operated during the latter part of the tests appeared practical to the officials of the American Strawboard Company, and at the close of the tests the Public Health Service was requested to design a permanent unit, for installation by the company, for the purpose of demonstrating on a large scale the possibility of duplicating the results obtained in the smaller plant.

As a result of these studies there has been developed and employed in the study of sewage and industrial wastes an improved procedure for the determination of the biochemical oxygen demand by the excess oxygen method. The procedure appears to overcome the more serious difficulties that have hitherto been experienced in the analytical details of this method and to give results that are concordant among themselves and sufficiently accurate for the purposes for which they are required. The details of this procedure will be given somewhat fully because of the

importance that has been found to attach to a close adherence to detail in every essential operation.

WAR DEPARTMENT, PURCHASE, STORAGE, AND TRAFFIC DIVISION

Chain. War Department Catalogue 5. 101 pp. Issued January 1919. Specifications.

Rope, Twines and Cordage. War Department Catalogue 3. 38 pp. Issued January 1, 1919. Specifications.

GEOLOGICAL SURVEY

Sand and Gravel in 1917. R. W. STONE. Mineral Resources of the United States, 1917, Part II. 16 pp. Issued February 21, 1919.

In 1917 the total quantity of sand and gravel produced was 76,419,325 short tons, valued at \$35,296,932, as compared with 89,091,732 tons in 1916, valued at \$29,809,995.

Although the quantity of glass sand produced in the United States passed the 2,000,000-ton mark in 1916, it fell below that mark in 1917. The production was greater, however, than in any year previous to 1916. The value of the total output, on the other hand, increased largely, exceeding \$2,500,000, although in no previous year had it reached \$2,000,000. The average price per ton in the last seven years has ranged from \$0.85 to \$1.06, but in 1917 it rose to \$1.38, owing to the increased cost of labor, machinery, and fuel.

The total production of grinding, polishing, and blast sand in 1917 was 1,179,190 tons, or only a little less than in 1916. There was, however, a very considerable increase in value, the total amount being \$1,220,708, as compared with \$889,651 in 1916. The average price per ton for all sands under this head was 65 cents in 1916 and \$1.04 in 1917. Pennsylvania, Illinois, New Jersey, and New York were the leading producers in the order named.

The total production of fire or furnace sand in 1917 was 604,035 tons, valued at \$695,455, as compared with 426,654 tons, valued at \$384,738, in 1916. Pennsylvania, Ohio, New Jersey, and Illinois were the largest producers. The average price per ton was 34 cents in 1915, 90 cents in 1916, and \$1.15 in 1917.

Filter sand, reported separately for the first time in 1916, fell off in 1917, the production being 62,170 tons, valued at \$47,351, as compared with 76,033 tons, valued at \$68,340, in 1916.

Sand valued at \$142,586 was imported into the United States in 1917, as compared with imports valued at \$87,144 in 1916. This is largely building sand brought to the United States from Canada as a near source of supply or brought as ballast from overseas. The imports usually include a small quantity of French molding sand used for making fine bronze castings, refractory sand from England for lining certain iron furnaces, and sands adapted to special uses and brought in small quantity. This importation of sand from abroad is for the most part nonessential but is done because molders, foundrymen, or others of foreign birth learned their trade with a foreign sand and are averse to using other sands than those with which they are familiar.

Gold, Silver, Copper, Lead, and Zinc in Montana in 1917. V. C. HEIKES. Mines Report, Mineral Resources of the United States, 1917, Part I. 36 pp. Issued February 21, 1919.

Gold, Silver, Copper, Lead, and Zinc in Nevada in 1917. V. C. HEIKES. Mines Report, Mineral Resources of the United States, 1917, Part I. 46 pp. Issued February 18, 1919.

Ground Water in the Animas, Playas, Hachita, and San Luis Basins, New Mexico. A. T. SCHWENNESEN. With Analyses of Water and Soil. R. F. HARE. Water-Supply Paper 422. 149 pp. Paper, 20 cents.

Bibliography and Index of the Publications of the United States Geological Survey Relating to Ground Water. O. E. MEINZER. Water-Supply Paper 427. 169 pp.

Coal South of Mancos, Montezuma County, Colorado. A. J. COLLIER. Bulletin 691-K. Contributions to Economic Geology, 1918, Part II. 18 pp. Issued February 24, 1919.

Gold, Silver, Copper, Lead and Zinc in Arizona in 1917. V. C. HEIKES. Mines Report. Separate from Mineral Resources of the United States, 1917, Part I. 40 pp. Issued April 1, 1919.

Gold, Silver, Copper, Lead and Zinc in Idaho and Washington in 1917. C. N. GERRY. Mines Report. Separate from Mineral Resources of the United States, 1917, Part I. 50 pp. Issued April 3, 1919.

Oil and Gas Geology of the Birch Creek-Sun River Area, Northwestern Montana. E. STEBINGER. Bulletin 691-E. Contributions to Economic Geology, 1918, Part II. 36 pp. Issued August 13, 1918.

Structure and Oil Resources of the Simi Valley, Southern California. W. S. W. KEW. Bulletin 691-M. Contributions to Economic Geology, 1918, Part II. 25 pp. Issued April 9, 1919.

Anticlines in a Part of the Musselshell Valley, Musselshell, Meagher, and Sweetgrass Counties, Montana. C. F. BOWEN. Contributions to Economic Geology, 1918, Part II. 25 pp. Issued November 22, 1918. Previous investigations had shown that the Musselshell Valley, Montana, is an area in which the rocks have undergone considerable folding. On the basis of this information work was begun in June 1916 to determine the nature and extent of the folds and to make examination as to the possible occurrence of accumulations of oil and gas in them. The work has demonstrated the existence within the area studied of several well-developed anticlines and domes, which seem to offer structurally favorable places for the accumulation of oil and gas. The demonstration of the presence or absence of commercial accumulations of these fluids in the folds has been less conclusive, owing largely to the undeveloped condition of the area.

Quicksilver. F. L. RANSOME. Bulletin 666-FF. Separate from "Our Mineral Supplies." 9 pp. The world's production of quicksilver in 1917 is estimated at 122,592 flasks, of which the United States produced 36,159 flasks, Italy 29,300 flasks, Spain 25,133 flasks, and Austria-Hungary probably about 27,500 flasks.

The Alaskan Mining Industry in 1917. G. C. MARTIN. Bulletin 692-A. Separate from Mineral Resources of Alaska, 1917-A. 42 pp.

The statistics for the mineral production of Alaska for the last three years are given in the following table. The output of marble, gypsum, petroleum, and certain other substances is given as a single item, because a separate listing might reveal the production of individual properties.

The Nelchina-Susitna Region, Alaska. T. CHAPIN. Bulletin 668. 67 pp.

Iron Ore, Pig Iron and Steel in 1917. E. F. BURCHARD. Separate from Mineral Resources of the United States, 1917, Part I. 47 pp. Issued April 28, 1919.

The iron ore mined in the United States in 1917, exclusive of that containing 5 per cent or more of manganese, amounted to 75,288,851 gross tons, as compared with 75,167,672 gross tons mined in 1916, an increase of 121,179 gross tons, or 0.16 per cent. Beneficiated ore, instead of crude ore mined, is included in these figures, if the ore is treated in any way. The quantity of iron ore shipped from the mines in the United States in 1917 amounted to 75,573,207 gross tons, valued at \$238,260,444, as compared with 77,870,553 gross tons, valued at \$181,902,277, shipped in 1916. This represents a decrease in quantity of 2,297,346 gross tons, or 2.95 per cent, and an increase in value of \$56,358,167, or 30.98 per cent, as compared with shipments in 1916. The average price of ore per ton at the mines for all grades of ore for the whole country in 1917 was \$3.15, as compared with \$2.34 in 1916. These quantities of ore, both mined and shipped, include the iron ore used for fluxing other metallic ores at smelters in the western states, but the shipments do not include the iron ore sold for the manufacture of paint. The quantity of iron ore sold for the manufacture of paint in 1917 amounted to 18,486 tons, valued at \$56,559, or \$3.06 per ton, compared with 16,968 gross tons, valued at \$45,256, or \$2.67 per ton in 1916.

The ore reported as sold for fluxing other than in the manufacture of pig iron amounted to 107,793 gross tons, valued at \$374,441, in 1917, as compared with 88,601 gross tons, valued at \$288,089, in 1916. The domestic iron ore actually sold for the manufacture of pig iron amounted in 1917 to 75,465,414 gross tons, valued at \$237,886,003, as compared with 77,781,952 gross tons, valued at \$181,614,188, in 1916.

The average prices per gross ton (the whole United States considered) in 1917 were: Hematite, \$3.12; brown ore, \$2.95; and magnetite, \$4.29; as compared with prices, respectively, of \$2.32, \$2.03, and \$3.11, in 1916. These figures are taken directly from statements of the producers and probably represent only approximately the actual selling prices. The element of inaccuracy lies in the fact that by far the greater bulk of the iron ore produced in the United States is mined by iron and steel producers for their own furnaces and that the value placed on such ore is therefore largely a matter of accounting. Some of the reports made to the Survey evidently include merely actual mining costs; others contain, in addition, the cost of selling and insuring the ore; in others an allowance for sinking fund is included; and in still others the figures given are the prices used in charging costs against the blast furnaces. At any rate, they include no freight costs.

The general average price per gross ton of all kinds of iron ore in the United States was \$3.15 in 1917, compared with \$2.34 in 1916, an increase of 81 cents a ton, or nearly 35 per cent.

The quantity of iron ore imported into the United States in 1917 was 971,663 gross tons, valued at \$3,655,392, or \$3.76 a ton. This represents a decrease in quantity of 354,073 tons, or nearly 27 per cent, and in value of \$911,122, or nearly 20 per cent, as compared with the imports during 1916, which were 1,325,736

MINERAL OUTPUT OF ALASKA, 1915, 1916 AND 1917

	1915		1916		1917	
	Quantity	Value	Quantity	Value	Quantity	Value
Gold, fine ounces.....	807,966	\$16,702,144	834,068	\$17,241,713	709,050	\$14,657,353
Silver, fine ounces.....	1,071,782	543,393	1,379,171	907,554	1,239,150	1,021,060
Copper, pounds.....	86,509,312	15,139,129	119,602,028	29,484,291	88,795,400	24,240,598
Tin, metallic, tons.....	102	78,846	139	121,000	100	113,390
Antimony, crude ore, tons.....	833	74,000	1,458	134,000	165	28,000
Lead, short tons.....	437	41,118	820	109,120	852	146,584
Coal, short tons.....	1,400	3,300	12,200	55,000	53,955	265,317
Marble, gypsum, petroleum, platinum, tungsten, chromium, and graphite.....		272,299 ¹		579,500 ²		218,000
		32,854,229		48,632,178		40,700,212

¹ No platinum, chromium, or tungsten included.

² No chromium included.

gross tons, valued at \$4,566,514, or \$3.44 a ton. As to the source of the imports in 1917, Cuba produced more than 56 per cent of the ore, Canada 20 per cent, Spain 16 per cent, Sweden 6 per cent, and minor quantities came from French Africa and the United Kingdom. Supplies from Canada have increased since 1914, largely from the Canadian ranges in the Lake Superior region. Fig. 1 indicates the source and destination of the iron ore imported into the United States.

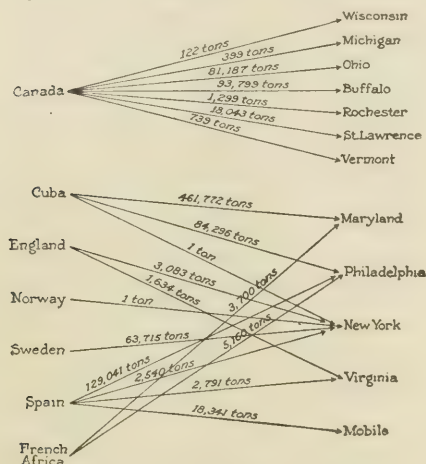


FIG. 1.—SOURCE AND DESTINATION OF IRON ORE IMPORTED INTO THE UNITED STATES IN 1917

The total beneficiated ore reported as shipped from mines in the United States in 1917 amounted to 8,166,564 gross tons, valued at \$27,733,036, compared with 8,105,011 tons, valued at \$21,037,364, in 1916. This represents an increase in quantity of 61,553 tons, or about 0.76 per cent. From such figures as are available, showing the relation between crude ore treated and beneficiated ore recovered, it is apparent that in washing brown ore the ratios, by weight, of crude ore washed to resultant concentrates range from 7 : 1 to 1.24 : 1; in concentrating red hematite, the ratios range from 1.69 : 1 to 1.05 : 1; and in magnetite they range from 3.89 : 1 to 1.041 : 1.

According to reports to the United States Geological Survey by the manufacturers, the shipments of pig iron, exclusive of ferro-alloys, in 1917 amounted to 38,612,546 gross tons, valued f. o. b. at the furnaces at \$1,053,785,975, as compared with 39,126,324 tons, valued at \$663,478,118, in 1916, a decrease in quantity of 513,778 tons, or 1.3 per cent, and an increase in gross value of \$390,307,857, or nearly 59 per cent. These values represent the approximate amounts received for the iron f. o. b. at the furnaces, and eliminate freight costs, selling commissions, and other items which are included in some of the market prices of pig iron as published in the trade journals.

The pig iron shipped includes the metal produced from foreign as well as from domestic ore. The quantity and value of pig iron derived from ore imported from Africa, Canada, Cuba, Spain and Sweden, although it constitutes a very small percentage of the total production, is considerable, as it is calculated that the shipments derived from foreign ore in 1917 amounted to 505,216 gross tons, valued at \$14,381,196.

The general average prices for 1916 and 1917 appear low for such active years in the iron industry. At the close of 1916 market prices of pig iron were between 45 and 68 per cent higher than at the beginning of the year, but this increase was confined almost entirely to the last two or three months of the year, so that the average increase in price was only 28 per cent as com-

pared with 1915. In 1917, however, the course of prices was very different, for at the beginning and end of the year prices were more nearly the same with the high levels at the middle of the year. The curve of market prices of basic iron at Valley furnaces reflects this unusual condition. The general average price for all grades of pig iron at the furnaces, exclusive of ferro-alloys, for the year 1917 was \$27.29, as compared with \$16.96 in 1916, an increase of \$10.33 a ton, or nearly 61 per cent. The states in which the average selling price of pig iron was more than \$30 a ton were Connecticut, Georgia, Massachusetts, Missouri, New Jersey and Washington.

The statistics of production of the principal grades of pig iron have been published by the American Iron and Steel Institute for 1917, as follows:

GRADE	1917 Gross Tons
Bessemer and low phosphorus.....	13,714,732
Basic (mineral fuel).....	17,671,662
Pure pig iron.....	345,707
Foundry and ferro-silicon.....	5,328,258
Malleable.....	1,015,579
Spiegel-eisen.....	192,985
Ferromanganese.....	260,125
White, mottled, direct castings, etc.....	92,168
	38,621,216

STEEL PRODUCTION IN THE UNITED STATES GROSS TONS

YEAR	Bessemer	Open-hearth	Crucible	Other Steel	Total
1915.....	8,287,213	23,679,102	113,782	70,939	32,151,036
1916.....	11,039,039	31,415,427	129,692	169,522	42,773,680
1917.....	10,479,960	34,148,893	126,716	305,038	45,060,607

The following table gives an incomplete outline of the sales of ferro-alloys in the United States in 1916 and 1917:

FERRO-ALLOYS OF DOMESTIC MANUFACTURE SHIPPED IN 1916 AND 1917

VARIETY OF ALLOY	1916		1917	
	Quantity Gross Tons	Value Dollars	Quantity Gross Tons	Value Dollars
Ferromanganese.....	224,103	30,123,493	260,225	53,930,771
Spiegel-eisen.....	182,837	6,158,202	189,241	9,736,236
Ferrosilicon.....	{ 166,308 12,966 }	5,273,088	175,079	8,562,182
Ferrotungsten (50 per cent or more tungsten).....	1	1	1,258	4,225,070
Other varieties.....	3,524	8,726,909	8,218	7,257,465
	589,738	50,281,692	634,021	83,731,724

¹ Included with "Other varieties."

² 1916: Ferromanganese, ferromolybdenum, ferrotungsten and ferro-vanadium; 1917: Ferrocerium, ferrochrome, ferromolybdenum, ferro-carbonyl, ferro-uranium and ferro-vanadium.

FERRO-ALLOYS IMPORTED FOR CONSUMPTION IN THE UNITED STATES IN 1917

VARIETY OF ALLOY	1917	
	Quantity Gross Tons	Value Dollars
Chrome or chromium and ferrochrome.....	...	5,458
Ferrophosphorus.....	9,740	691,684
Ferrosilicon.....	...	...
Molybdenum and ferromolybdenum.....	...	...
Titanium and ferrotitanium.....	...	...
Tungsten and ferrotungsten.....	1	3,606
Ferromanganese.....	41,969	5,710,988
Spiegel-eisen.....	3,968	291,594
	55,763	6,703,330

The production of steel by the electric process in 1917 amounted to 304,543 gross tons, as compared with 168,918 tons in 1916, an increase of 135,625 tons, or more than 80 per cent. In 1908 there were 55 tons of electric steel produced, but this quantity was included with open-hearth steel for that year.

The extraordinary development of the export trade in steel in the United States since the beginning of the war in Europe is indicated in the table of exports which shows, by classes, the exports of manufactured iron and steel from this country in 1915, 1916, and 1917. For comparison the imports are tabulated also. The figures were compiled from records of the Bureau of Foreign and Domestic Commerce.

In 1915, 1916, and 1917 the quantity of iron and steel exports (so far as recorded) increased 149 per cent, 66 per cent and 5 per cent, respectively, but the total values increased 133 per cent, 136 per cent, and 57 per cent, respectively.

BUREAU OF CENSUS

Cotton. A report of cotton ginned, crops of 1918, 1917 and 1916. Issued March 20, 1919. This publication is in postal card form.

BUREAU OF MINES

Illinois Mining Statutes Annotated. J. W. THOMPSON. Bulletin 169. 594 pp. Paper, 35 cents. Issued October 1918. This includes all Illinois mining laws.

Combustion Experiments with North Dakota Lignite. H. KREISINGER, C. E. AUGUSTINE AND W. C. HARPSTER. Technical Paper 207. 41 pp. Paper, 10 cents. Issued January 1919. This paper gives the results of combustion tests of North Dakota lignite burned in two forms—natural lignite as it comes from the mine and the carbonized residue from gas retorts. The tests were made by burning the fuels at various rates in experimental furnaces and by studying the processes of combustion. The information thus obtained was used in determining some of the general principles on which a successful furnace can be developed for use under power-plant boilers and for house-heating apparatus. A small furnace of this character was designed and tested with promising results. The experiments indicate that the lignite and its carbonized residue might be burned successfully on an inclined plate grate with an arch extending from the bridge-wall over almost the entire length of the grate. The arch turns the flames and the hot gases back over the incoming fuel, thus aiding ignition. It also directs air admitted at the bridge wall against the fuel bed and increases the rate of combustion.

Traps for Saving Gas at Oil Wells. W. R. HAMILTON. Technical Paper 209. 34 pp. Paper, 10 cents. Issued February 1919.

Combustion and Flue Gas Analysis. Technical Paper 219. Reprint of Engineering Bulletin No. 4. Prepared by the United States Fuel Administration in collaboration with the Bureau of Mines. 12 pp. Paper, 5 cents.

BUREAU OF STANDARDS

Electrical Characteristics and Testing of Dry Cells. Circular No. 79. 44 pp. Paper, 10 cents. Issued April 25, 1919. The object of this circular is to describe briefly the various kinds of cells that are obtainable, to indicate the kinds of service for which they are adapted, and to describe the methods of testing them. In the appendix are given tentative specifications for dry cells which have been drawn by this Bureau in consultation with the principal manufacturers of dry cells. These specifications are designed primarily for government uses, but may be used by anyone. In the preparation of this circular the literature of the subject has been reviewed and studied and liberal use made of material contained in a number of books. The Bureau has also benefited by the information and experience obtained from the leading manufacturing companies.

Optical Conditions Accompanying the Striae which Appear as Imperfections in Optical Glass. A. A. MICHELSON. Scientific Paper No. 333. 5 pp. Issued November 1918.

Publications of the Bureau of Standards. Descriptive List. Circular No. 24. 5th Edition. 149 pp. Paper, 25 cents. Issued April 14, 1919.

DEPARTMENT OF AGRICULTURE

Growing Sugar Cane for Sirup. P. A. YODER. Farmers' Bulletin 1034. Contribution from the Bureau of Plant Industry. 35 pp.

The Use of Wood for Fuel. Department Bulletin 753. Contribution from the Forest Service. 40 pp. Paper, 10 cents. Issued March 10, 1919.

Farm Practice in Growing Sugar Beets in Three California Districts. T. H. SUMMERS, L. A. MOOREHOUSE, R. S. WASHBURN, AND C. O. TOWNSEND. Department Bulletin 760. 48 pp. Paper, 10 cents. Issued March 14, 1919.

The Field Testing of Copper-Spray Coatings. J. R. WINSTON AND H. R. FULTON. 9 pp. Contribution from the Bureau of Plant Industry.

Articles from the Journal of Agricultural Research

Cyanogenesis in Andropogon Sorghum. C. T. DOWELL. 16, 175-183 (February 17).

Effect of Certain Compounds of Barium and Strontium on the Growth of Plants. J. S. MCHARGUE. 16, 183-194 (February 17).

Solubility of the Lime, Magnesia, and Potash in Such Minerals as Epidote, Chrysolite, and Muscovite, Especially in Regard to Soil Relationships. R. F. GARDINER. 16, 259-263 (March 10).

A Field Study of the Influence of Organic Matter upon the Water-Holding Capacity of a Silt-Loam Soil. F. J. ALWAY AND J. R. NELLER. 16, 263-278 (March 10).

Ammonification of Manure in Soil. H. J. CONN AND J. W. BRIGHT. 16, 313-350 (March 24).

BUREAU OF FOREIGN AND DOMESTIC COMMERCE

Industrial Standards Series. The text as adopted by the American Society for Testing Materials in Spanish-English editions has been prepared under supervision of the Bureau of Standards. The series covers industrial standards for materials, which includes standards prepared by government and by technical societies and other organizations.

Standard Specifications for Wrought Solid Carbon-Steel Wheels for Steam Railway Service. Industrial Standards Series No. 15. Revised 1916. 21 pp.

Standard Specifications for Steel Tires. Industrial Standards Series. No. 16. Revised 1916. 15 pp.

Standard Specifications for Boiler and Fire-Box Steel for Locomotives. Industrial Standards Series No. 21. Revised 1918. 19 pp.

Standard Specifications for Steel Castings. Industrial Standards Series No. 17. Revised 1916. 21 pp.

Standard Specifications for Boiler Rivet Steel. Industrial Standards Series No. 22. Revised 1914.

Standard Specifications for Engine-Bolt Iron. Industrial Standards Series No. 25. Revised 1918. 15 pp.

COMMERCE REPORTS—APRIL 1919

The discovery is reported from Celebes, Dutch East Indies, of extensive deposits of high-grade iron ore, as well as chrome iron, nickel and manganese ores. The iron ore deposits are shallow and easily accessible. The average iron content is about 50 per cent. Both coal and hydraulic power are available. (P. 63)

Efforts are being made to recover vanadium from blast furnace slags at Taberg, Sweden, where vanadiferous slag has accumulated for centuries. (P. 163)

The paper industry of Japan is described in detail. Much of the paper is porous, being adapted for a brush and ink, but not for a pen. Other products are papier-mâché, crêpe, leather, paper, paper fabric, and oiled and waterproof paper. (Pp. 164-77)

A great variety of artificial fertilizers are used in Japan, including bone meal, blood, silkworms, fish, ammonium sulfate, cyanamide, potash, superphosphates, and oil cake of all kinds. (Pp. 179-82)

The war-time production of cyanide in Scotland was sufficient to meet the most of the requirements of England and the Allies. (P. 191)

The Japanese dye market has slumped badly, owing to expected American competition, not so much in the Japanese domestic market as in China and the South Seas. (P. 203)

In a review of the Swedish wood-pulp industry, it is shown that the sulfite industry has been very favorable with less demand for sulfite pulp. (P. 216)

Blast furnace slag is but slightly used in Great Britain for road making; but considerable amounts of slag cement are made and used for foundations, etc. (P. 227)

The quarterly allotment of camphor from Taiwan to the United States has been slightly decreased, owing to decreased production. (P. 227)

Export of tungsten ore from Hongkong has practically ceased, owing to the reduction in price and uncertainty as to demand. Large fields have been developed, so that with increased demand shipments can be renewed, even at present prices. (P. 248)

The price of iron in Germany has been increased 100 marks (\$23.80) per metric ton, causing much anxiety. (P. 249)

A review of the Belgian glass industry shows that most of the plants are intact, and but few of the laborers were killed. (P. 274)

Industries suggested for post-war development in Australia are eucalyptus distillation (for medicinal oils); gold mining (which has decreased steadily since 1903); and beet-sugar production (which has prospered during the war). (Pp. 326-8)

Plans are being made for the erection in Cuba of 10 alcohol plants, to use the molasses residue from sugar manufacture. For each ton of sugar 40 gallons of molasses are produced, which yield 16 gallons of alcohol. (P. 347)

In an extensive report to the British Minister of Munitions of the committee on the post-war position of the sulfuric acid industry it is shown that the annual pre-war consumption was about 1,000,000 tons of 100 per cent sulfuric acid, of which 60 per cent was used in the production of ammonium sulfate and superphosphate. The present excess production capacity is about 650,000 tons per annum. Consideration of various possibilities shows that the only outlet for any considerable quantity is the superphosphate manufacture. The situation is further complicated by the importation of Australian zinc concentrates,

which will yield much acid, but cannot in every case be roasted in existing pyrite burners. It is recommended that the use of artificial fertilizer be encouraged by demonstration and experiment, by decreased freight rates, and by securing adequate supplies of phosphate rock. Also that a high rate of depreciation on acid plants be allowed in income tax calculation; and that public compensation be given for plants that are ordered scrapped. It is also recommended that steps be taken to improve the status of technical chemists; and that data on costs of production, etc., obtained during the war be given wide circulation. (Pp. 370-7)

Efforts to aid the Japanese iron industry may take the form of an import duty, or of government subsidy. In either case the object is chiefly that of national defense. (P. 384)

By a new Swedish process invented by a Dr. E. L. Rinman, flax and various straws may be used to produce in addition to the fiber, acetone, benzole, methyl alcohol, and lubricating oils. The process consists essentially in boiling with caustic soda, producing fiber (or ultimately pulp) and a black liquor. Two plants are in operation in Germany. (P. 461)

SPECIAL SUPPLEMENTS ISSUED IN APRIL

CANARY ISLANDS—15c	VENEZUELA—48c
JAMAICA—22c	STRAITS SETTLEMENTS—56c
MEXICO—32c	AUSTRALIA—60c
BRAZIL—40c	BRITISH SOUTH AFRICA—66c
DUTCH GUIANA—44c	EGYPT—68c
PERU—46c	

STATISTICS OF EXPORTS TO THE UNITED STATES

CANARY ISLANDS—15c	RUSSIA—P. 45	VENEZUELA—Sup. 48c
Sup. 15c	Bristles	Bones
Cochineal	Hides	Copaiba
Hides	Licorice	Divi-divi
Pumice	Potassium carbonate	Hides
	Sugar-beet seed	Sugar
	Platinum	Balaista
MEXICO—Sup. 32c	PERU—Sup. 46c	Chicle
Antimony ore	Aluminum	Gold
Bones	Copper } Bullion	STRAITS SETTLEMENTS
Copper	Copper ore } Lead and	—Sup. 56c
Copper ore	Dyewood } Silver	Coccolat oil
Dyewood	Cochineal	Copra
Gold	Hides	Gambier
Guanó	Molybdenum ores	Gamboge
Graphite	Mercury	Gum benjamin
Hides	Rubber	Camphor
Lead ore	Sugar	Copal
Manganese ore	Tungsten ore	Cutch
Silver	Vanadium ore	Damar
Silver ore	Zinc ore	Gutta-percha
Sugar	Peruvian bark	Hides
Tungsten ore	Naphtha	Rubber
Zinc ore	Lubricating oil	Tin
Zinc chloride	Potassium sulfate	
Grayule rubber		

BOOK REVIEWS

The Preparation of Substances Important in Agriculture: A Laboratory Manual of Synthetic Agricultural Chemistry. By CHARLES A. PETERS. vi + 81 pp. John Wiley & Sons, Inc., New York, 1919. Price, \$0.80 net.

The teacher of agricultural chemistry has heretofore had to depend largely upon his individual notes in presenting to the student the phases of the subject covered by this text, and often the work has been imperfectly done by reason of the absence of such a manual as this.

In this book laboratory exercises are given in the preparation of a number of important substances employed as fertilizers, insecticides, fungicides, etc., and detailed working directions are supplied for carrying out the various steps of the processes employed, the leading chemical changes involved being represented by equations.

A number of questions, to be answered in the student's notebook, are given under each topic, and in writing out his notes the student should accordingly be led to give thought and study to the most essential features of the subject under consideration. A considerable amount of stoichiometrical work is also included in the scope of the questions propounded in connection with the various preparations.

Among the facts and phenomena brought to the attention of the student in carrying out this work may be mentioned oxidation, neutralization, distillation, crystallization, saturation, metathesis, mass action, double salts, colloids, etc., so that the short course presented should afford training of value in pure, as well as in applied chemistry.

As the author states, the matter embraced in this book was originally placed at the disposal of his students in the form of mimeographed notes, and in its present form becomes available for the wider use it should attain in courses in agricultural chemistry in other institutions.

B. B. ROSS

The Production and Treatment of Vegetable Oils. By T. W. CHALMERS. iv + 152 pp., 9 folding plates and 95 illustrations. D. Van Nostrand Co., New York City, 1918. Price, \$7.50.

This beautifully printed and illustrated volume, as stated in the preface, is an "attempt to deal with the production and treatment of vegetable oils primarily from the engineer's viewpoint, an aspect of the industry which has hitherto received in

print scanty consideration as compared with the attention paid to the chemist's side of the matter."

The book is largely arranged from a series of articles by the author appearing between February 9 and June 29, 1917, in the *Engineer*.

The fact that machinery catalogues appear to have been largely drawn upon for illustrations enhances rather than detracts from its value as a very useful reference book of up-to-date oil milling machinery and methods in use in England.

In the description of the various oil-milling machines measurements and detailed drawings are furnished which make the book of especial practical value to the oil-mill engineer.

There is a very good chapter on solvent extraction, while the chapter on oil refining gives a good idea of English practice.

Of course no modern book on the subject of fats and oils would be complete without a chapter on hydrogenation. The chapter on this subject gives a very complete exposition of a plant in operation, together with detailed operating cost estimate, which, however, looks rather optimistic.

No attempt is made to show other methods of bringing about the same results.

The manufacture of hydrogen by the iron contact method as practiced by Lane is very fully illustrated and described.

The chapters on soap and glycerin will give the reader a good idea of some of the standard English machinery and practice of the present day.

Taken all in all, the book is to be heartily commended to chemical engineers and others interested in keeping posted on modern oil-mill engineering.

DAVID WESSON

Gas and Flame in Modern Warfare. By LT. COL. S. J. M. AULD, Royal Berkshire Regiment, Member of the British Military Mission to the United States. 8vo. ix + 201 pp. George H. Doran Co., New York, 1918. Price, \$1.35.

Now that the war is over (unless it starts up again) one has time to take an occasional evening off and pore over the books that have accumulated during the strenuous days that have passed and have been carefully put aside for reading in more peaceful times. It is safe to say that for the many chemists who have been actively engaged in the Chemical Warfare Service there is no book that will be read with greater pleasure and interest than this one. The book will have an additional interest for the large number of chemists who have had the privilege of an intimate acquaintance with the author during his extended stay in the United States. Colonel Auld was Chief Gas Officer to Sir Julian Byng's army. As his publisher expresses it, he is "a chemist, veteran of two wars, wearer of the Military Cross, wounded in No Man's Land while crawling into the enemy trenches to observe the effect of a British gas attack * * *". His book, therefore, is the result of his experience with gas warfare—wise in its counsels and personal observations * * *."

After the entry of the United States into the war, upon the request of our Government Colonel Auld came to the United States, bringing with him a rich experience in all matters pertaining to gas warfare. With the exception of a short interval he remained until after the signing of the armistice, rendering marked assistance in the development of gas warfare. This assistance was acknowledged recently on the part of our Government by the award of the Distinguished Service Medal.

Beginning back with the experiences of the first gas attack on April 22, 1915, the story of the efforts of the boche to overcome the British by his varied assortment of gases together with the counter efforts of the British not only to neutralize the boche's attacks but to take a little hand in the "gassing" business themselves, is told in a fascinating way. The book can be read through in a few hours; indeed, one is apt to find it so captivating as to read it through in a single sitting. While the story is told in a

popular way and seasoned with the introduction of many humorous incidents, nevertheless it contains much information of interest to the expert on chemical warfare matters. Since the book was written before the signing of the armistice, it is necessarily silent on many matters that one would like to know about. It is hoped that after peace is assured and there is no longer any necessity for secrecy, the author may tell us more of the methods of gas warfare used by the British.

Authoritative books on gas warfare such as the above are greatly to be desired. There is perhaps no subject connected with the war concerning which so much misinformation has been handed out to the public as that of gas warfare. The articles that have appeared on this subject belong largely to the field of fiction. They nevertheless have had a very serious influence and nearly led to the abolishment of the Chemical Warfare Service—a step, which, in the minds of many at least, would have been a most serious mistake. As a matter of fact, from the standpoint of the principles of humanity, gas warfare has much more in its favor than those methods of warfare based on the use of high explosives. The statistics show that the percentage of fatalities among gas casualties is only about one-seventh that among the high explosive casualties; moreover, it is asserted upon the best of authority that so far as is known, there is not a single instance of permanent disability among our troops resulting from the effects of gas. In fact, it would seem that for certain purposes, gas warfare is not only the most humane but the most effective yet devised. However, any agent may be used as an instrument of torture when employed by an unscrupulous nation.

But to come back to the book—every chemist should take an evening off and read it, if he has not done so already.

WM. MCPHERSON

Chlorination of Water. By JOSEPH RACE. John Wiley & Sons, Inc., New York City, 1918. Price, \$1.50 net.

So far as the reviewer knows, this is the first publication by an unprejudiced brother devoted exclusively to the process of water purification which is generally known as chlorination or sterilization of water.

His bibliography seems complete and accurate. Too much space is devoted to the use of the hypochlorite of lime as that process has been almost completely superseded since an adequate supply of liquid chlorine and reliable controlling apparatus have been available.

His figures as to costs are conservative and check with other published results, till he comes to a discussion of the "chloramine" process. Here the author seems to have a personal bias because of his own experiments and short period of operation at Ottawa. The city of Ottawa has since abandoned the process and is now using liquid chlorine.

A report on the Esopus Creek plant made at the March meeting of the New York Section of the American Water Works Association indicates through the subsequent discussion that this process is not suitable for the ordinary plant and can be made to work only when in charge of a high-grade chemist, and where costs are not carefully checked.

His final chapter on results obtained is a valuable compilation of data which hitherto has been widely scattered through the literature.

We think the book ought to be in the hands of all interested in the vital subject of water purification.

D. K. BARTLETT

Mill and Cyanide Handbook. By A. W. ALLEN. 128 pp. J. B. Lippincott Co., Philadelphia, 1918. Price, \$2.00 net.

In general this book will be quite useful to mill operators, since it contains a great deal of data for which the mill operator constantly has use. The book is not a treatise in any sense of

the word, but is a collection of tables, formulas, and data pertaining to the operation of cyanide mills. The field covered includes both the chemical factors and the mechanical ones, there being some quite important data concerning crushing and mining machinery. If there is any fault to be found with the book, it must be that the data are rather older than one might wish to see published at this time.

Mr. Allen, however, calls attention in his preface to the fact that the compilation and arrangement were made in 1914, publication being postponed on account of the war. Most of the matter this lapse of time does not impair. In the case of some of it, however, there is available later data which might somewhat change the figures. This is particularly true with the tables pertaining to ball-mill capacity, speeds, horse power, and charges. One may also object to the selection of the published data of a particular manufacturer of crushers, since the product marketed by various firms is by no means equal, and some manufacturers may perhaps find difficulty in fulfilling promises as to capacities. It might have been better to provide a review from actual practice in order to provide some reliable data on the features of crushing machines.

The ore treatment charts shown in the latter part of the book are quite valuable, and the report forms will prove of assistance to those having forms for the recording of their own mill data. Finally, the glossary is good, and will prove helpful to many operators.

It may be said without fear of contradiction that any mill man would be very glad to have a copy of this book at hand to provide him with facts and figures useful in his daily work.

H. A. MEGRAW

Asphalts and Allied Substances. By HERBERT ABRAHAM, B.S. xxv + 606 pp. D. Van Nostrand Co., New York, 1918. Price, \$5.00 net.

This book is a treatise on bituminous materials in general and, as stated by the author, "It embraces (1) methods serving as a guide for the works chemist engaged in testing and analyzing raw and manufactured products; (2) data for assisting the refinery or factory superintendent in blending and compounding mixtures; (3) information enabling the ambitious salesman to enlarge his knowledge concerning the scope and limitations of the articles he vends; and (4) the principles underlying the practical application of bituminous products for structural purposes, of interest to the engineer, contractor, and architect." There are 33 chapters grouped in five parts under the following headings: I—General Considerations; II—Semi-Solid and Solid Native Bituminous Substances; III—Tars and Pitches; IV—Manufactured Products and Their Uses; and V—Methods of Testing.

Part I opens with a most interesting and instructive historical review of the discovery and use of bituminous materials. The second chapter is devoted to terminology and classification of bituminous substances, in which the author exhibits considerable ingenuity in constructing a system of nomenclature containing certain more or less original definitions. A number of the basic definitions are quite contrary to common usage and do not agree with standards adopted by the American Society for Testing Materials. It is extremely doubtful if the author's terminology and classification will ever be generally accepted. The remainder of Part I is taken up with chapters on the chemistry, geology and origin, and the production of bituminous substances.

Part II deals with the occurrences, physical and chemical properties of, and the general methods of refining semi-solid and solid native products. Most of the characteristics given are referred to tests which are described in detail in Part V.

Part III treats of tars and pitches in a similar manner and takes up in considerable detail methods of production or manufacture. As the refining of petroleum and the properties of

liquid petroleum products are considered in this section, Part III should properly be entitled Tars, Petroleum, and Pitches.

Part IV consists of five chapters on manufactured products and their uses and, with the exception of a chapter on bituminous paving materials, constitutes a most valuable addition to the literature of bituminous materials. It opens with a chapter on methods of blending which should prove of considerable use to manufacturers as a guide to intelligent selection and combination of materials in order to secure products possessing desirable characteristics. The chapter on bituminous paving materials, while broad in scope, is greatly limited in important details. As the author states, however, in his introduction, "Topics which have been ably presented in other reference books, as for example, the technology of pavements, etc., have purposely been subordinated to those concerning which little data has hitherto been available."

The subjects covered by the last three chapters of Part IV are well presented and a great deal of new and useful data is made available. A chapter on bituminized fabrics deals with sheet roofings of various types; bituminized floor coverings; waterproofing membranes; insulating and sheathing papers; electrical insulating tape; and bituminized wall board. A chapter on semi-liquid, semi-solid, and solid bituminous compositions includes adhesive compounds for built-up roofing and waterproofing work; pipe dips and pipe sealing compounds; electrical insulating compounds; bituminous rubber substitutes; moulding compositions; bituminous fuels; etc. The last chapter of Part IV is devoted to bituminous paints, cements, varnishes, enamels, and japans.

In Part V various methods of testing crude, refined, and blended bituminous substances are described under chapters with the following headings: Physical Characteristics; Heat Tests; Solubility Tests; Chemical Tests. Methods of testing various manufactured products, such as bituminized mineral aggregates, bituminized fabrics, bituminous emulsions, and bituminous paints, cements, varnishes, and japans are covered in a separate chapter. The last chapter of the book is devoted to weathering tests. Certain of the tests described and constantly referred to in other parts of the book, in connection with the characteristics of various materials, have originated with the author and, as they have not as yet been widely adopted, their significance is apt to be somewhat vague to chemists who have become accustomed to other methods.

The book is well illustrated and indexed and the general arrangement of subject matter is excellent. It contains a brief but useful bibliography and numerous references throughout the text to patents and current technical literature. It should constitute a valuable addition to the library of every chemist, engineer and manufacturer interested in the technology of bituminous materials.

PREVOST HUBBARD

Tables of Refractive Indices: Vol. 1, Essential Oils. Compiled by R. KAMTHACK. Edited by N. G. GOLDSMITH. 148 pp. Adam Hilger, London, 1918. Sold in this country by Arthur H. Thomas Company, Philadelphia. Price, \$6.00.

This little volume is the first of a series in which the refractive indices of technical substances are tabulated. The editor does not unduly emphasize the importance of refractive indices considered by themselves. In view of the facility with which these values are determined by means of the Abbé refractometer it would seem to the reviewer that such instruments might be used to advantage more generally than is the case. Literature references are given for all data. A useful compilation such as the present volume is welcome, particularly on account of the practice of certain essential oil producers of insisting that the physical constants of their own particular oils are to be taken as standard.

B. T. BROOKS

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RECENT JOURNAL ARTICLES

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Atomic Structure and Chemical Affinity. F. H. LORING. *The Chemical News*, Vol. 118 (1919), No. 3076, pp. 145-149.

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China Clays: A Comparison of American China Clays as Porcelain Ingredients. A. S. WATTS. *Journal of the American Ceramic Society*, Vol. 2 (1919), No. 2, pp. 131-133.

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Colloid State from the Electrical Standpoint. W. C. MCC. LEWIS. *Engineering and Mining Journal*, Vol. 107 (1919), No. 16, pp. 696-698.

Cyanogen Compounds: Manufacture of Cyanogen Compounds in Concentrated Ammonia Liquor. P. E. SPIELMANN and HENRY WOOD. *The Chemical News*, Vol. 118 (1919), No. 3077, pp. 157-159.

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Silica Brick: How to Make the Best Silica Brick. H. LE CHATELIER and B. BOGITCH. *Brick and Clay Record*, Vol. 54 (1919), No. 8, pp. 686-690.

Steel: Flaky Fractures and Their Possible Elimination; A Critical Review of the Literature Bearing upon Oxides and Other Inclusions in Steel. HAAKON SYVIL. *Chemical and Metallurgical Engineering*, Vol. 20 (1919), No. 9, pp. 478-483.

MARKET REPORT—MAY, 1919

WHOLESALE PRICES PREVAILING IN THE NEW YORK MARKET ON MAY 15, 1919

INORGANIC CHEMICALS

Acetate of Lime, Basis 80%.....	100 Lbs.	2.00	@	2.05
Alum, ammonia, lump, U. S. P.....	100 Lbs.	4.25	@	4.50
Aluminum Sulfate, (iron free).....	Lb.	3	@	3 1/4
Ammonium Carbonate, domestic.....	Lb.	13	@	13 1/2
Ammonium Chloride, white.....	Lb.	19	@	20
Aqua Ammonia, 26°, drums.....	Lb.	6 1/2	@	7
Arsenic, white.....	Lb.	9	@	11
Barium Chloride.....	Ton	65.00	@	85.00
Barium Nitrate.....	Lb.	12	@	14
Barytes, prime white, foreign.....	Ton	30.00	@	35.00
Bleaching Powder, 35 per cent.....	100 Lbs.	1.40	@	1.80
Blue Vitriol.....	Lb.	7	@	8
Borax, crystals, in bags.....	Lb.	7 1/4	@	10 1/4
Boric Acid, powdered crystals.....	Lb.	13 1/4	@	14
Bromine, crude, domestic.....	Long Ton	28.00	@	35.00
Bromine, technical, bulk.....	Lb.	75	@	
Calcium Chloride, lump, 70 to 75% fused.....	Ton	18.00	@	22.00
Caustic Soda, 76 per cent.....	100 Lbs.	2.55	@	3.00
Chalk, light precipitated.....	Lb.	4 1/4	@	5
China Clay, imported.....	Ton	20.00	@	30.00
Feldspar.....	Ton	8.00	@	15.00
Fuller's Earth, foreign, powdered.....	Ton	nominal		
Fuller's Earth, domestic.....	Ton	20.00	@	30.00
Glauber's Salt, in bbls.....	100 Lbs.	2.10	@	3.00
Green Vitriol, bulk.....	100 Lbs.	2.00	@	2.25
Hydrochloric Acid, commercial, C. P.....	Lb.	8	@	8 1/4
Iodine, resublimed.....	Lb.	4.25	@	4.30
Lead Acetate, white crystals.....	Lb.	14	@	15
Lead Nitrate, C. P.....	Lb.	85	@	
Litharge, American.....	Lb.	9 1/2	@	10 1/2
Lithium Carbonate.....	Lb.	1.50	@	
Magnesium Carbonate, U. S. P.....	Lb.	21	@	22
Magnesite, "Calcined".....	Ton	60.00	@	65.00
Nitric Acid, 40°.....	Lb.	7.50	@	7.75
Nitric Acid, 42°.....	Lb.	8.00	@	8.50
Phosphoric Acid, 48/50%.....	Lb.	26	@	30
Phosphorus, yellow.....	Lb.	35	@	40
Plaster of Paris.....	100 Lbs.	2.00	@	2.50
Potassium Bichromate.....	Lb.	32	@	34
Potassium Bromide, granular.....	Lb.	1.25	@	1.30
Potassium Carbonate, calcined, 80 @ 85%.....	Lb.	15	@	17
Potassium Chlorate, crystals, spot.....	Lb.	28	@	30
Potassium Cyanide, bulk, 98-99 per cent.....	Lb.	nominal		
Potassium Hydroxide, 88 @ 92%.....	Lb.	60	@	70
Potassium Iodide, bulk.....	Lb.	3.30	@	3.50
Potassium Nitrate.....	Lb.	27	@	30
Potassium Permanganate, bulk, U. S. P.....	Lb.	58	@	65
Quicksilver, flask.....	75 Lbs.	80.00	@	
Red Lead, American, dry.....	100 Lbs.	10.25	@	10.75
Salt Cake glass makers'.....	Ton	17.50	@	22.00
Silver Nitrate.....	Oz.	65	@	67
Soapstone, in bags.....	Ton	10.00	@	12.50
Soda Ash, 58%, in bags.....	100 Lbs.	1.60	@	1.65
Sodium Acetate, broken lump.....	Lb.	8 1/4	@	10 1/4
Sodium Bicarbonate, domestic.....	100 Lbs.	9	@	2.50
Sodium Bichromate.....	Lb.	16	@	18
Sodium Chlorate.....	Lb.	29	@	30
Sodium Cyanide.....	Lb.	14	@	15
Sodium Fluoride, commercial.....	100 Lbs.	2.60	@	3.60
Sodium Hyposulfite.....	Lb.	4.07 1/2	@	
Sodium Nitrate, 95 per cent, spot.....	100 Lbs.	1 1/4	@	2
Sodium Silicate, 60% fused, in bbls.....	Lb.	3 1/2	@	3 1/4
Sodium Sulfide, powdered.....	Lb.	5	@	7
Strontium Nitrate.....	Lb.	25	@	30
Sulfur.....	100 Lbs.	2.25	@	4.60
Sulfuric Acid, chamber 66° Bé.....	Ton	17.50	@	18.50
Sulfuric Acid, oleum (fuming).....	Ton	23.00	@	
Talc, American, white.....	Ton	15.00	@	
Terra Alba, American, No. 1.....	100 Lbs.	1.17 1/2	@	
Tin Bichloride, 50°.....	Lb.	26	@	28
Tin Oxide.....	Lb.	65	@	70
White Lead, American, dry.....	Lb.	9	@	9 1/4
Zinc Carbonate.....	Lb.	18	@	20
Zinc Chloride, commercial.....	Lb.	14	@	14 1/2

ORGANIC CHEMICALS

Acetanilid, C. P., in bbls.....	Lb.	38	@	40
Acetic Acid, 56 per cent, in bbls.....	100 Lbs.	5.75	@	6.00
Acetic Acid, glacial, 99 1/2%.....	100 Lbs.	12.75	@	13.00
Acetone, drums.....	Lb.	15 1/4	@	16
Alcohol, denatured, 180 proof.....	Gal.	4.00	@	4.3

Alcohol, Ethyl, non-beverage, 190 proof.....	Gal.	4.70	@	4.95
Alcohol, wood, 95 per cent, refined.....	Gal.	1.22	@	1.24
Amyl Acetate.....	Gal.	3.75	@	3.85
Aniline Oil, drums extra.....	Lb.	23	@	24
Benzoin Acid, ex-toluol.....	Lb.	1.00	@	1.10
Benzene, pure.....	Gal.	22	@	22 1/2
Camphor, refined in bulk, bbls.....	Lb.	1.24 1/2	@	1.25
Carbolic Acid, U. S. P., crystals, drums.....	Lb.	10	@	15
Carbon Bisulfide.....	Lb.	9	@	10
Carbon Tetrachloride, drums, 100 gals.....	Lb.	14 1/4	@	15 1/4
Chloroform, U. S. P.....	Lb.	33	@	35
Citric Acid, domestic, crystals.....	Lb.	1.00	@	1.06
Cresote, beechwood.....	Lb.	2.00	@	2.10
Cresol, U. S. P.....	Lb.	17	@	17 1/2
Dextrine, corn (carloads, bags).....	Lb.	7	@	8
Dextrine, imported potato.....	Lb.	nominal		
Ether, U. S. P. 1900.....	Lb.	23	@	24
Formaldehyde, 40 per cent.....	Lb.	21 1/2	@	22
Glycerin, dynamite, drums extra.....	Lb.	20	@	21
Oxalic Acid, in cauls.....	Lb.	33	@	35
Pyrogallie Acid, resublimed, bulk.....	Lb.	2.60	@	2.75
Salicylic Acid, U. S. P.....	Lb.	25	@	35
Starch, corn (carloads, bags) pearl.....	100 Lbs.	5.12	@	5.27
Starch, potato, Japanese.....	Lb.	8 1/2	@	9
Starch, rice.....	Lb.	19	@	19 1/4
Starch, sago flour.....	Lb.	7	@	8
Starch, wheat.....	Lb.	nominal		
Tannic Acid, commercial.....	Lb.	65	@	80
Tartaric Acid, crystals.....	Lb.	86 1/2	@	87

OILS, WAXES, ETC.

Beeswax, pure, white.....	Lb.	55	@	60
Black Mineral Oil, 29 gravity.....	Gal.	24	@	25
Castor Oil, No. 3.....	Lb.	20	@	21
Ceresin, yellow.....	Lb.	16	@	17
Corn Oil, crude.....	100 Lbs.	nominal		
Cottonseed Oil, crude, f. o. b. mill.....	Lb.	17 1/2	@	—
Cottonseed Oil, p. s. y. Oct. option.....	100 Lbs.	23.60	@	24.00
Menhaden Oil, crude (southern).....	Gal.	62	@	65
Neat's-foot Oil, 20°.....	Gal.	1.80	@	2.00
Paraffin, crude, 118 to 120 m. p.....	Lb.	8 1/2	@	9
Paraffin Oil, high viscosity.....	Gal.	40	@	41
Rosin, "R" Grade, 280 lbs.....	Bbl.	12.15	@	12.25
Rosin Oil, first run.....	Lb.	75	@	76
Shellac, T. N.....	Lb.	nominal		
Spermaceti, cake.....	Lb.	31	@	33
Sperm Oil, bleached winter, 38°.....	Gal.	1.98	@	2.00
Spindle Oil, No. 200.....	Gal.	38	@	40
Stearic Acid, double-pressed.....	Lb.	18	@	18 1/2
Tallow, acidless.....	Gal.	1.15	@	1.20
Tar Oil, distilled.....	Gal.	36	@	38
Turpentine, spirits of.....	Gal.	79	@	80

METALS

Aluminum, No. 1, ingots.....	Lb.	33	@	—
Antimony, ordinary.....	Lb.	7	@	—
Bismuth, N. Y.....	Lb.	nominal		
Copper, electrolytic.....	Lb.	16	@	—
Copper, lake.....	Lb.	15 1/2	@	16
Lead, N. Y.....	Lb.	55	@	5.10
Nickel, electrolytic.....	Lb.	55	@	56
Platinum, refined, soft.....	Lb.	nominal		
Silver.....	Lb.	1.11	@	—
Tin, Straits.....	Lb.	nominal		
Tungsten (Wol).....	Lb.	6.50	@	10.00
Zinc, N. Y.....	Lb.	9.40	@	9.60

FERTILIZER MATERIALS

Ammonium Sulfate.....	100 Lbs.	4.90	@	—
Blood, dried, f. o. b. New York.....	Ton	5.25	@	5.50
Bone, 3 and 50, ground, raw.....	Ton	35.00	@	37.00
Calcium Cyanamide.....	Unit of Ammonia	nominal		
Calcium Nitrate, Norwegian.....	100 Lbs.	—	@	—
Castor Meal.....	Unit	—	@	—
Fish Scrap, domestic, dried, f. o. b. works.....	Unit	nominal		
Phosphate, acid, 16 per cent.....	Ton	15.50	@	16.00
Phosphate Rock, f. o. b. mine.....	Ton	nominal		
Florida land pebble, 68 per cent.....	Ton	5.00	@	6.00
Tennessee, 78-80 per cent.....	Ton	nominal		
Potassium "muriate," basis 80 per cent.....	Ton	120.00	@	130.00
Pyrites, furnace size, imported.....	Unit	nominal		
Tankage, high-grade, f. o. b. Chicago.....	Unit	4.50	@	4.75

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EDITORIALS

WAYS AND MEANS COMMITTEE HEARINGS

The chemical industries developed during the war period will be safeguarded by the present Congress. That is our prediction based upon the hearings which have taken place before the Ways and Means Committee of the House of Representatives in Washington during the past two weeks. The final details of this protection may vary from the forms in which originally presented to the Congress, but it is evident that regardless of party politics Congress will stand united in its determination that these American industries shall not suffer from after-war German competition or from the invasion of this market by the industries of Japan, where, according to the testimony submitted, the cost of labor is from one-tenth to one-fifteenth of that paid in American establishments.

At the outset of the hearings full opportunity was given for the presentation of the claims of chemical glassware, chemical porcelain, and scientific instrument manufacturers. The hearings on potash held during the same week leave an impression of doubt as to the final outcome regarding this industry.

During the second week of the hearings the claims of the dyestuff industry were fully presented to the Committee. Representatives of the Army and Navy testified to the value of this industry in chemical warfare. Mr. Joseph H. Choate, Jr., representing the Chemical Foundation, Inc., presented a brilliant argument in support of the measures proposed. Important consumers, representing the great bulk of the consuming industry of the country, urged the importance of the industry as a means of economic independence, while dyestuff manufacturers presented, through the comprehensive brief of Dr. J. Merritt Matthews, representing the American Dyes Institute, a complete survey of the situation from the producers' standpoint. Opportunity was afforded to present to the Committee, with the official sanction of the War Trade Board, statistics showing the tremendous increase in the requests for import licenses for dyes from Switzerland, at a rate so far above the normal capacity of the Swiss factories as to suggest a contemplated leakage of German dyes or intermediates through a neutral country.

The discussion was based upon the Longworth bill, which embodies the recommendations of the U. S. Tariff Commission, and increases materially both the ad valorem and the specific duties on intermediates and on finished products. To this bill was proposed an amendment, put forward by the Chemical Foundation, Inc., providing for a license system which would permit the exclusion of dyes already produced in sufficient quantity in this country and the restricted importation of dyes not yet produced, pending the rounding out of the American industry.

It was evident that there was at the outset opposition to the license plan in the Committee, but as the hearings proceeded and opportunity was afforded to answer the objections raised by the various members

of the Committee this opposition gradually diminished, and completely disappeared when, in the last few minutes of the hearings, Chairman Fordney clearly indicated his conversion to the necessity of a temporary license system supplementary to the protective duties.

The most dramatic feature of the hearings, and perhaps the most convincing argument, came from an entirely unexpected source. During the course of his extensive statement Mr. Choate introduced a translation of a report sent by Ambassador von Bernstorff to Berlin. This report was prepared by Dr. Hugo Schweitzer, the then head of the Bayer Company in this country, and one of the leading spirits in the German spy system in America. In January 1917, a copy of the report together with other papers was seized by agents of the Department of Justice in the office of Dr. Albert in New York City.

The importance of Dr. Schweitzer's report justifies its preservation in the chemical literature of the war period. Under date of New York, January 26, 1917, I. von Igel wrote to Ambassador von Bernstorff as follows:

I am respectfully transmitting to your Excellency an expert opinion on the effect of the new duties on the dyestuffs handed over to me from an expert source [Dr. Hugo Schweitzer, Badische Anilin Fabrik (Baden Aniline Factory)]. As the matter is still in a fluid state and possibly still other changes in the legislation, of which I enclose a copy, will have to be reckoned with, I refrain from more detailed explanations until further notice. I suggest, however, that the expert judgment be passed on to Berlin.

I. VON IGEL

The letter was addressed to "His Excellency, the Imperial Ambassador, Count von Bernstorff, Washington, D. C."

SCHWEITZER REPORT IN FULL

Following is the full text of the Schweitzer report:

The influence of the new customs tariff and its prospective effect on German importation and on the development of the American industry into an export industry, and on the chances of the American dyestuff industry in the world market must be considered from two points of view:

1 During a Long War

Should the war still continue for years, then, of course, the industry here would be very much furthered and would have a great boom. The United States does not lack raw materials for the manufacture of dyestuffs of any kind whatsoever. The only product necessary for manufacture that must be imported is saltpeter. The question of price does not play any part in this either, for as long as dyestuffs cannot be imported and must be produced here, the question whether the price of manufacture is higher or lower makes no difference. A longer war will bring the further danger that the plants can be amortized from the great earnings which can be made and that the factories after the peace can carry on competition with the German dyestuffs more easily.

The difficulties in manufacture, which are incomparably greater in the manufacture of intermediate products than in the manufacture of dyestuffs from imported intermediates, will be gradually overcome. The greatest lack is that of technically trained chemists. It seems that American industry is trying to emancipate itself in this respect by importing chemists from

Switzerland. One of the largest of the newly founded factories is said to have engaged, together with thirty chemists, Maurice Ceresole, who was lately professor of technical chemistry at the University of Zurich and formerly manager of the French branch of the Baden Aniline and Soda Factory, and had worked still earlier, together with myself, in the Badische Anilin und Soda Fabrik in Ludwigshafen, in order to help build up the American dyestuff industry here. I have not yet succeeded in finding out which factory has employed these chemists.

INQUIRY FOR AMERICAN GOODS

How difficult the production of intermediates is, is apparent from a letter which was sent to an American manufacturer by the French branch of the Badische Anilin und Soda Fabrik on September 13, 1915, over a year after the outbreak of the war, and which in the translation runs as follows:

We are purchasers of beta-naphthol, beta-naphthylamine, diphenylamine, dimethylaniline.

Will you please tell me whether you sell these products, and in case you do, please inform us of your conditions and the quantities you can offer us.

At the same time we beg you to inform us of other raw materials of interest for the manufacture of dyestuffs which you may have to offer us, aside from those mentioned above.

In case your answer should be negative, we should be obliged to you if you would kindly indicate to us the addresses of firms to whom we could address ourselves with prospect of success.

The content of this letter proves that the branch of the Badische Anilin und Soda Fabrik which has existed since the year 1873 and in which dyestuffs have been manufactured since that time, to be sure from intermediates which were delivered by the manufactory in Ludwigshafen, could not itself manufacture such simple intermediate products as beta-naphthol, beta-naphthylamine, diphenylamine, and dimethylaniline. This branch has besides the advantage that chemists stood at its disposal who had been trained in the German factory and had been sent by the same to France in order to produce as serviceable dyestuffs as those manufactured in Germany.

NEW INDUSTRY'S DRAWBACKS

The manufacture of the intermediates offers much greater difficulties for an industry still in the process of development for the reason that such an incredibly large variety of products is necessary. In a well developed industry like that of the Germans a technical use is found in the end for all these products. In a less well developed industry and in an industry which is only in the process of development, great hindrances stand in the way of the utilization of these derivatives. Many cannot be used at all and thus become troublesome waste products. The price of those derivatives which can be utilized is thereby increased to an incredible degree. In order to make the manufacture and utilization of these derivatives more graphic I subjoin the enclosed table¹ which shows how many derivatives of a single coal-tar raw product, namely naphthalene, are combined with a single basic substance, benzidine, in order to form dyestuffs. In a well developed industry all these products are manufactured, and ultimately find utilization. Those whose names appear in squares are used directly for the manufacture of colors; those which are enclosed in ovals, are at the present time not yet utilized, but are subjects of scientific investigation, and will ultimately find suitable utilization.

The manufacture of intermediates stands in Germany on such an incredibly high plane that the prices for the manufactured articles are very low. It would take American industry many years, even if it will ever be possible at all, before it could produce these intermediates as cheaply as German industry has done. In order to show these differences of price, the examples in the following table may be cited.

¹ This table was not submitted by Mr. Choate. We venture the guess, however, that the table referred to is the one which appeared in *THIS JOURNAL*, 6 (1914), 1024.—[Editor.]

	It cost in 1908 in Germany per lb., in cents	Imported to America under the tariff at that time
Aniline oil.....	9.28	11.60
Paranitraniline.....	16.00	24.00
H acid.....	23.29	34.80
Alpha-naphthylamine.....	6.20	7.75
R salt.....	9.68	14.50
Amido G salt.....	17.60	26.75
Freun acid.....	11.60	17.25
Cleve acid.....	11.60	17.25
Gamma.....	29.36	44.00
Salicylic acid.....	12.06	26.01
Tollidine.....	26.40	33.00
Benzidine.....	24.20	30.26

These are figures which American industry will never attain. It can be assumed with certainty that the most of these products cannot be manufactured here at three to four times the price.

ADVANTAGE FOR GERMANY

The wonderfully developed technique of intermediates will, therefore, for many years to come, give German industry a preponderance over all other lands in which the derivative industry has first to be built up.

2—After the Peace

The question, what prospective effect the customs duties will have on German importation, on the development of American industry into an exporting industry and upon its chances in the world market can be answered by a single argument:

The new tariff divides the products used and manufactured in the dyestuff industry into three groups—raw products, half-products (intermediates), and dyes. While the raw products are imported free of duty, on the half-products and the dyes, in addition to an ad valorem duty, a specific duty of 2½ cents per pound and 5 cents per pound is levied.

Happily, the following dyes are excluded from this specific duty:

Except natural and synthetic alizarin, and dyes obtained from alizarin, anthracene, and carbazol; natural and synthetic indigo and all indigoids, whether or not obtained from indigo; and medicinals and flavors.

This exception may well become the sheet-anchor of the German industry. The dyestuffs which are excepted from this specific duty are the so-called vat dyes, and these vat dyes are a comparatively modern achievement of the German dye technique, and are in general regarded as the most genuine dyes.

The preëminent coloring qualities of these products have already brought it about, and will do it even more so in the future, that the older coal-tar dyes, which in many respects are inferior to these vat dyes, will be driven from the market. The manufacture of these vat dyes is very complicated and can be undertaken only in a very highly developed industry. It is wholly out of the question that a new industry like the American can take up the manufacture of these vat dyestuffs, and it may well take a very long time before the dyestuff industry outside of Germany can concern itself with the manufacture of these complicated products.

Here the very greatest exertions will not make it possible to cope with the competition of Germany. In our considerations it is of still further importance that these vat dyes are much dearer than the ordinary coal-tar dyestuffs, which is readily explicable in view of the difficulties of manufacture. But in spite of this higher price, the vat dyestuffs, on account of their superior tinctorial qualities, are finding a more and more widely extended sphere of application in all fields of the textile, leather, paper, etc., industries.

AD VALOREM TARIFF DISCUSSED

The history of American tariff legislation has shown that in general a protective tariff of 30 per cent ad valorem does not afford sufficient protection to create an American industry. If this were the case with the old coal-tar dyestuffs, of which only a few staple kinds were ever manufactured here, and these, for the most part, from intermediates which were im-

ported from Germany, a protective tariff of 30 per cent is, of course, absolutely insufficient for the complicated vat dyestuffs.

In recognition of this fact the new tariff provides the specific duties in order to provide a far greater protection for the American industry.

But the new tariff now specifies the following in regard to the specific duties:

But if, at the expiration of five years from date of the passage of this Act, the President finds that there is not being manufactured or produced within the United States as much as 60 per centum in value of the domestic consumption of the articles mentioned in Groups II and III of Section 500, he shall by proclamation so declare, whereupon the special duties imposed by this section on such articles shall no longer be assessed, levied, or collected.

Here is where the German industry must apply the lever. It must, in any case, of these vat dyes, which must be regarded as the "highest quality" goods of the industry, dispose of in the American market more than 40 per cent of the total consumption in intermediates and dyestuffs, in order that the President will be in the position to abolish the specific duties. If this is actually made possible, and the President must abolish these specific duties, then the German industry will be in the same position as before the war, and has only to deal with the duty of 30 per cent ad valorem, which, as has already been elucidated above, was insufficient in the past to create an American industry.

EASY FOR GERMAN INDUSTRY

That it should be as easy as child's play for German industry to sell so much vat dyestuffs in the United States that the value of the same will amount to 60 per cent in value of the domestic consumption of the articles mentioned in Groups II and III of Section 500, is apparent from the following considerations:

1—The vat dyestuffs have in the past and will even more so in the future supplant the old coal-tar dyestuffs.

2—The money value of the vat dyestuffs is uncommonly higher than the money value of the old coal-tar dyestuffs.

3—The importation from Germany of these vat dyes amounts to-day already to 27.63 per cent of the money value of the total dyestuffs importation.

From the statements of the *Chemical Journal* [*Chemiker-Zeitung*] of the year 1914 we gather for the year 1913 the following figures for imports into the United States:

	Value	Per cent of the Whole
Indigo.....	\$1,316,913	13.08
Alizarin.....	178,587	1.77
Anthracene dyestuffs.....	1,287,037	12.78
Aniline dyestuffs.....	7,288,471	72.40
Total.....	\$10,071,008	100.03

In this connection, however, we must pay regard to the fact that Germany in the year 1913 imported to the United States intermediates to the value of \$1,086,300. The foregoing percentage of 27.63 is somewhat lowered thereby. On the other hand, the production of the old aniline dyestuffs out of intermediates which have been imported from Germany would naturally decrease from the increased exportation of vat dyes, so that in our reckoning the value of the intermediates can, in fact, be entirely neglected.

The high price of vat dyes, which is, on the average, four or five times as much as that of the old aniline dyestuffs, is especially well calculated quickly to make possible the 14–15 per cent still lacking in the total value of the dyestuff consumption. From a recently published list it turns out that 511 dyes to the value of \$7,500,000 have been imported into America, that is, the average import value of a dye amounts to \$14,000. In this list four vat dyes are given, which altogether were worth \$214,000, so that the average price of \$14,000 for dyestuffs in the case of all dyestuffs rises to about \$50,000 for the vat dyes, *i. e.*, amounts to about four times the average value.

When the time shall have come that the German industry will

import more than 40 per cent of the vat dyes, and in America less than 60 per cent of the value of the domestic consumption will be manufactured, then great difficulties in the calculation of these figures will emerge, and it will depend on the party politics of the President at that time, whether he will make an honest effort to abolish the specific duty or not. How is this "value of the domestic consumption" to be reckoned? How will the customs prices be taken into consideration in connection with the freight rates, and with the expenses of insurance and of business? In the case of the domestic industry how will the expenditures for amortization, for general business expenses, trade-mark, and patent ownership be counted in the calculation?

From these arguments it is clear that the salvation of the German dyestuff industry is to be sought in the development of vat dyestuff chemistry. The tendency to develop this field to the highest degree possible existed already before the outbreak of the war. The new tariff brings then no change in this line. For the industry after the war also no change would arise in this regard, since in any case Germany will be compelled to manufacture and to export high-grade goods in the entire industrial field in contrast to articles demanded in large quantities, which can little by little be produced in all countries.

In the competition in the field of goods demanded in quantities German industry will in the end not fare much worse under the new tariff since, by the manufacture of intermediates forced upon American industry, the dyestuff manufacturer thereof will stand them at a much dearer price so that the old tariff rate of 30 per cent ad valorem will mean a still smaller protection for the American industry. This will not, of course, come completely to light until the specific duties have been abolished. But even if these specific duties are not abolished the higher prices of intermediates will tend more and more to eliminate the difference between the protection which the old percentage of 30 ad valorem and the protection which the new percentages of 30 plus specific duties afford.

An interesting document, strongly suggestive of many articles published in *THIS JOURNAL*, and characterized by the usual error of underestimation of the ability of Americans. Indigo and alizarin are already here. American vat dyes are standing on the threshold.

In a presidential address before the AMERICAN CHEMICAL SOCIETY at Seattle in September 1915, we said:

Are the people of this country ready to cooperate with the chemists by authorizing the prompt enactment of such legislation? If so, there need be no fear that active capital will be longer withheld, and thus we can feel confident of a synthetic dyestuff industry commensurate with our needs.

As I think of the possibility of such an industry, I recall the words of the Swiss professor, Gnehm, who, in 1900, after one of his lectures on coal-tar dyes, said to me: "The natural home of the dyestuff industry is in your country and some day it will flourish there."

The creation of such a self-contained industry, however, has far deeper meaning for our national welfare than the supplying of needed dyestuffs, for such plants would constitute an easily convertible reserve for the manufacture of coal-tar explosives in times of war.

Through its stimulative effect on research, on technique, and on supply of material the dyestuff industry has furthered the development of both the explosives and the medicinal industries. Its firm establishment here would foretell the complete development of each of this great trio of industries, which, as a whole, furnish the rational and economic utilization of that great mass of coal tar which now wastes itself in useless flames above the coke ovens throughout the land.

Coöperation—it is a good word, and carries with it a wonderful power of accomplishment.

We have had coöperation. A flourishing industry is almost here. With the help of the present Congress the day of its full arrival will be assured.

CONTRIBUTIONS FROM THE CHEMICAL WARFARE SERVICE, U. S. A.

THE FIRST GAS REGIMENT

By JAMES C. WEBSTER, 1st Lt., First Gas Regiment

Received April 25, 1919

The First Gas Regiment, Chemical Warfare Service, was organized at Camp American University, Washington, D. C., in September 1917 as the 30th Engineers, Gas and Flame, under the command of Major (later Colonel) Earl J. Atkisson of the Corps of Engineers. Two companies were quickly recruited and trained, and sailed for France on December 26, 1917. At this time little was known here of offensive gas warfare on the western front, and the technical training of the two companies had to be deferred until they reached France. The enlisted personnel of these and succeeding companies was of very high caliber, and consisted of chemists, engineers, and mechanics from all parts of the country.

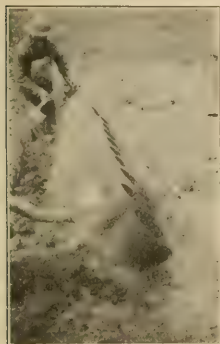


FIG. 1—PLACING A BATTERY OF PROJECTORS IN POSITION

While the first two companies were being trained with the Special Brigade, Royal Engineers (the British gas troops) at Helfaut, France, two more companies were being organized at Fort Myer, Va., and sailed on February 27, 1918. This gave us four companies, of 250 men each, trained for offensive work at the beginning of June 1918. A and B companies not only had seen service with the British, but had been working on the American front at this time, and, with the addition of companies C and D, we had gas troops operating during June and July in the Château-Thierry sector and on the

Lorraine and Vosges fronts. The last two companies, E and F, which were also organized at Fort Myer, arrived in France in July.

The plan of a projector operation upon a stabilized front consisted, in brief, of a preliminary reconnaissance to determine the emplacements, number of guns, camouflage, the type and approximate time of the work, and the carry. The target was furnished by intelligence. To the emplacement, which was selected as close as possible to the enemy's line, were later brought the necessary guns, base plates, gas bombs, charge boxes, and tools for digging in. Twenty guns constitute a battery and the charges are fired simultaneously by means of an electric exploder. The gas bomb is projected into the enemy line a distance depending upon the weight of charge used, and explodes after reaching the ground. Ranges as high as 1700 meters were possible with the 4 ft. Livens projector. Frequently the 4 in. Stokes mortars were used in connection with the larger projector operations. Gas and thermite were fired from the mortar upon machine gun emplacements and concentrations of enemy troops. The following data may be of interest to show the amount of material which was transported for one of the larger "shows."

Frequently, the bombs instead of containing gas were filled with T. N. T. and their use produced a demoralizing effect upon the enemy troops as each bomb was equivalent in explosive force to an 8 in. shell.

Location of "show".....	Merviller, near Baccarat
Company operating.....	C, 1st Gas Regt.
Time (zero).....	Midnight, August 17, 1918
Number of guns.....	800
Weight of projectors (2 ft. 9 in.).....	40 tons
Weight of gas bombs.....	24 tons
Weight of base plates.....	12 tons
Weight of charges, exploders, tools, etc.....	4 tons

Total weight of material.....	80 tons
Weight of gas projected.....	12 tons
Kinds of gas used.....	Phosgene and Chlorpicrin

With the formation of the American First Army, the Regiment ceased to operate with independent French and American units. It became a part of the First Army and the battalions (two companies each) were assigned to army corps and the companies to divisions holding the line. With this organization, the Regiment operated throughout the St. Mihiel and Argonne-Meuse drives and was on the line at the time of the signing of the armistice.

On the liquid or moving front the Stokes mortar was used almost exclusively in connection with the advance of the infantry. The ammunition fired included smoke, for concealment and deception; gas, against machine guns and enemy strong points; and thermite, which was used for its demoralizing effect. Occasionally projectors were installed and fired upon short notice against enemy strong points, but where the front was changing rapidly the projectors could not be used.

The Regiment returned to the United States under the command of Maj. J. B. Carlock, of San Francisco, and was demobilized at Camp Kendrick, N. J., in February 1919. Individual decorations awarded to members of the Regiment totaled 61, including 1 D. S. M., 15 D. S. C., and 45 Croix de Guerre. The casualties suffered by the Regiment were approximately 50 per cent.



FIG. 2—PROJECTORS BEING DISCHARGED

The following letter from Brig. Gen. Fries, Chief of the Chemical Warfare Service, A. E. F., was published to the Regiment as General Order No. 5:

At this time, I desire personally, and on behalf of the Chemical Warfare Service as a whole, to express to you and the officers and men of the First Gas Regiment under you, our pride in and profound admiration of the work you have done. To take a new regiment and in a few short months teach it an entirely new method of warfare, known to few but the enemy, and so handle that work that the Chemical Warfare Service, as well as the Regiment, became favorably known throughout an army of nearly 2,000,000 men, is an achievement of which any body of men may well be proud.



Fig. 3-4 IN. STOKES MORTAR IN POSITION

Not only is the First Gas Regiment well known, but its work has been so excellent that demands for more gas troops were constantly increasing in numbers and insistence. Everywhere the work has been spoken of as that of brave and able men, who feared no enemy and no hardships, and who stopped only when complete exhaustion overpowered them.

Whether the Chemical Warfare Service will be continued in peace remains to be seen. That your work will always be remembered and that it will be the guiding star for such work in any future war, should, unfortunately, our country ever again have to enter upon one, is absolutely certain.

At the time of the signing of the armistice other gas troops were being organized in the United States to supplement the six companies in France.

CLEVELAND, OHIO

PROTECTION AFFORDED BY ARMY GAS MASKS AGAINST VARIOUS INDUSTRIAL GASES¹

By A. C. FIELDNER, M. C. TEAGUE AND J. H. YOE

Received May 26, 1919

In considering the use of gas masks for protection against various gases it must be emphasized that they should never be used in atmospheres containing less than 12 per cent oxygen by volume. In such atmospheres an air helmet or a self-contained breathing apparatus containing an oxygen supply must be used. Neither does the army gas mask afford complete protection against very high concentration of toxic or irritating gases such as may be found in closed tanks or towers containing volatile liquids or in small closed rooms where a considerable quantity of gas has been suddenly released. In general, the gas mask is limited to concentrations not exceeding 1 to 5 per cent, depending on the kind of gas, the absorbent used, and the size of the canister.

The chemical filling of the standard army canister, Type H, consists of 42 cu. in. of an intimate mixture of 60 per cent charcoal and 40 per cent "purple" soda lime (by volume). The size of granules is between 8 and 14 mesh. This mixture combines maximum protection as nearly as possible against both acid gases and those removed by physical absorption only. For special gases the filling may be all charcoal, all soda lime, or some other specific absorbent. When protection against irritating or toxic smokes is also required two cotton wadding pads are placed in the

canister at $\frac{1}{3}$ and $\frac{2}{3}$ distance from the bottom, respectively.

In the following table of protection against various gases "standard army filling" shall refer to 42 cu. in. of the 60 to 40 per cent mixture of charcoal and soda lime.

These tests were made by the methods described in a previous paper¹ on "Methods of Testing Gas Masks and Absorbents."

AVERAGE RESULTS OF TESTS AGAINST VARIOUS GASES

GAS	ABSORBENT FILLING	CONCENTRATION P. p. m.	Kind of Test ¹	LIFE Min.
Aniline	Charcoal	300	Machine	1410
Ammonia	Standard	40,000	Machine	3
Ammonia	Standard	5,000	Machine	3
Ammonia	Standard	2,500	Machine	5
Ammonia	CoCl ₂ ·6H ₂ O on pumice	20,000	Machine	22
Ammonia	CoCl ₂ ·6H ₂ O on pumice	20,000	Machine	84
Ammonia	CoCl ₂ ·6H ₂ O on pumice	50,000	Machine	18
Ammonia	CoCl ₂ ·6H ₂ O on pumice	50,000	Man	192
Ammonia	CuSO ₄ ·5H ₂ O on pumice	50,000	Man	175
Ammonia	CuSO ₄ ·5H ₂ O on pumice	50,000	Machine	20
Ammonia	CuSO ₄ ·5H ₂ O on pumice	20,000	Machine	46
Arsenic trichloride	Standard	500	Machine	119
Arsenic trichloride	Standard	2,000	Machine	64
Benzol	Standard	40,000	Machine	3
Benzol	Standard	10,000	Machine	14
Benzol	Charcoal	10,000	Machine	14
Benzol	Charcoal	40,000	Machine	57
Benzyl bromide	Standard	100	Machine	470
Bromobenzyl cyanide	Standard	28	Machine	+5100
Bromobenzyl cyanide	Purple soda lime	28	Machine	0
Carbon bisulfide	Standard	10,000	Machine	17
Carbon bisulfide	Charcoal	10,000	Machine	68
Carbon bisulfide	Charcoal	30,000	Machine	20
Carbon bisulfide	Charcoal	50,000	Machine	8
Chloroacetone	Standard	2,000	Machine	226
Chloroacetone	Standard	8,000	Machine	41
Chloroacetophenone	Standard	15	Machine	+1800
Chloroacetophenone	Purple soda lime	15	Machine	0
Chloroacetyl chloride	Standard	1,000	Machine	408
Chloroacetyl chloride	Standard	10,000	Machine	17
Chloroacetyl chloride	Purple soda lime	10,000	Machine	39
Chloroacetyl chloride	Charcoal	10,000	Machine	21
Chlorine	Standard	5,000	Machine	47
Chlorine	Standard	10,000	Man	125
Chlorpicrin	Standard	17,500	Machine	7
Chlorpicrin	Standard	10,000	Machine	12
Chlorpicrin	Standard	4,000	Machine	30
Chlorpicrin	Standard	500	Machine	263
Chlorpicrin	Standard	4,000	Man	150
Cyanogen bromide	Standard	50,000	Machine	38
Cyanogen bromide	Standard	100	Machine	295
Cyanogen bromide	Standard	1,250	Man	+40
Cyanogen chloride	Standard	500	Machine	21
Cyanogen chloride	Standard	1,000	Machine	143
Cyanogen chloride	Charcoal	500	Machine	77
Cyanogen chloride	Charcoal	750	Machine	58
Cyanogen chloride	Charcoal	5,000	Machine	25
Cyanogen chloride	Purple soda lime	1,000	Machine	0
2,4 - Dichlorobenzyl bromide	Standard	40	Machine	+3600
Dichloroethyl sulfide	Standard	100	Machine	1980
Dichlorodiethyl sulfide	Soda lime	100	Machine	0
Dimethyl sulfate	Standard	700	Machine	262
Diphenylcyanarsine	Standard	15	Machine	150
Ethyl chloride	Charcoal	15,000	Machine	21
Ethyl chloride	Charcoal	10,000	Machine	33
Ethyl chloride	Charcoal	5,000	Machine	64
Formaldehyde	"J Type"	10,000	Man	40
Hydrocyanic acid	Standard	250	Machine	217
Hydrocyanic acid	Standard	1,000	Machine	64
Hydrocyanic acid	Standard	2,500	Machine	30
Hydrocyanic acid	Standard	5,000	Machine	17
Hydrocyanic acid	Purple soda lime	5,000	Machine	31
Hydrocyanic acid	Green soda lime	5,000	Machine	67
Hydrogen chloride	Standard	50,000	Machine	74
Hydrogen chloride	Standard	50,000	Machine	9
Hydrogen sulfide	Standard	10,000	Machine	97
Hydrogen sulfide	Charcoal	10,000	Machine	37
Hydrogen sulfide	Purple soda lime	10,000	Machine	170
Methylchlorarsine	Standard	2,500	Machine	118
Methylchlorarsine	Standard	5,000	Machine	46
Methylchlorarsine	Standard	500	Man	+510
Methylchlorarsine	Charcoal	2,500	Machine	106
Methylchlorarsine	Purple soda lime	2,500	Machine	94
Nitrogen peroxide	Standard	1,500	Man	+70
Perechloromethylchloroformate	Standard	2,000	Machine	56
Perechloromethylchloroformate	Standard	3,000	Machine	39
Perechloromethylmercaptan	Standard	1,500	Machine	40
Perechloromethylmercaptan	Purple soda lime	.....	Machine	3
Perechloromethylmercaptan	Charcoal	.....	Machine	20

¹ A. C. Fieldner, G. G. Oberfell, M. C. Teague and J. N. Lawrence, THIS JOURNAL, 11 (1919), 519.

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AVERAGE RESULTS OF TESTS AGAINST VARIOUS GASES (Concluded)

GAS	ABSORBENT FILLING	CONCENTRATION		LIFE Min.
		P. p. m. by Vol.	Kind of Test ¹	
Phenylamido phosgene	Standard	250	Machine	754
Phenylamido phosgene	Purple soda lime	250	Machine	6
Phosgene	Standard	5,000	Machine	47
Phosgene	Standard	5,000	Man	297
Phosgene	Charcoal	5,000	Man	160
Phosgene	Charcoal	10,000	Man	66
Phosgene	Purple soda lime	10,000	Man	15
Phosgene	Purple soda lime	5,000	Man	17
Silicon tetrachloride ²	Standard	500	Man	185
Sulfur dioxide	Standard	2,500	Machine	60
Sulfur dioxide	Standard	5,000	Machine	32
Sulfur dioxide	Standard	50,000	Man	29
Sulfur dioxide	Charcoal	5,000	Machine	7
Sulfur dioxide	Purple soda lime	5,000	Machine	54
Sulfur dichloride	Charcoal	5,000	Machine	16
Sulfur monochloride	Standard	2,500	Machine	70
Sulfur monochloride	Charcoal	3,000	Machine	33
Thiophosgene	Standard	5,000	Machine	42
Thiophosgene	Purple soda lime	5,000	Machine	6
Tin tetrachloride	Standard	500	Man	+60
Titanium tetrachloride ²	Standard	500	Man	+84
Xylyl bromide	Standard	250	Machine	470

¹ Machine test is at 32 l. per min. flow and corresponds to a man doing moderate work. Man test is made with the man at rest and approximates 8 l. per min.

² Attention is called to the fact that for protection against gases which fume on exposure to moist air, it is necessary that cotton pads be employed. The standard canister has two 3-layer pads placed $\frac{1}{2}$ and $\frac{2}{3}$ the distance from the bottom to the top.

From the above table it is seen that the standard army filling containing a mixture of charcoal and soda lime combines protection against almost all toxic gases; the chief conceptions among the common toxic gases are ammonia and carbon monoxide.

It is of course obvious that the standard mixture does not furnish the maximum protection against such gases as are absorbed by one component only, as for example, carbon tetrachloride or benzol which is absorbed by the charcoal only or sulfur dioxide which is taken up principally by the soda lime. Hence, when masks are required for specific gases or when high concentrations of a gas absorbable by one component only is to be encountered, it becomes advisable to fill the entire canister with either charcoal or soda lime.

The standard 60 to 40 per cent mixture filling is recommended for:

Chlorine
Phosgene
Tetrachlorides of tin, silicon and titanium¹
Arsenic tin chloride¹
Xylyl and benzyl bromides
Chlor- and brom-acetone
Chlorpicrin
Dimethyl sulfate
Perchloromethylchloroformate
Nitrogen peroxide

The all-charcoal filling is recommended for:

Gasoline vapor
Benzol
Carbon bisulfide
Carbon tetrachloride
Cyanogen bromide
Similar vapors which are not acted on by soda lime

The all-soda lime filling is recommended for:

Sulfur dioxide
Carbon dioxide
Hydrocyanic acid gas
Hydrogen sulfide
Hydrogen chloride
Other acid gases

When smoke particles, such as the hydrolysis products of stannic chloride, or solid particles as

¹ Cotton filter pads are also required to remove the hydrated oxides.

arsenic trioxide, are encountered, the canister should contain at least two cotton wadding pads or other filter material.

Ammonia is not completely absorbed by the standard filling. For this purpose copper sulfate on pumice is recommended.

Carbon monoxide, natural gas, artificial illuminating gas, coke oven gas, blast furnace gas, and the difficultly condensable gases, such as oxygen, hydrogen, nitrogen, methane, etc., are not removed by the canister.

The standard canister containing filter pads gives good protection against smoke from wood, rags, tar, sulfur, and other combustibles. Tests have been made in which men wearing standard army masks remained in dense smoke from burning wood and wet straw for a period of 20 minutes without discomfort. Care, however, must be observed that such combustion smoke contains no appreciable quantities of carbon monoxide, for which the mask provides no protection, and which would not be detected by the wearer before being overcome. For this reason the standard army gas mask with charcoal and soda lime canister containing filter pads should be used with some caution by firemen in entering burning buildings; in exceptional cases, dangerous quantities of carbon monoxide may be present.

The army mask, however, has been used successfully in fighting forest fires. It can probably be used safely in similar smoke occurring in the open air, or for a very short period of time in buildings where the smoke is diluted by circulation of air.

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GAS FLOW METERS FOR SMALL RATES OF FLOW¹

By A. F. BENTON
Received May 23, 1919

INTRODUCTION

In the experimental work connected with the various phases of chemical warfare research, the measurement of the rate of flow of gas was a very important factor, and probably entered into more problems than any other single variable. Owing to the nature of the experiments, unusual difficulties were encountered in metering the gas. For example, the rates of flow were many times smaller than those ordinarily met with in industrial work, the gases to be handled were highly corrosive, and the urgency of the work was such that the meters had to be easy to construct, or readily available in quantity.

THE USUAL TYPES OF METER

Each of the customary methods of measuring gas flow possesses one or more features which render it unsuitable for work of this nature. The displacement type of meter, represented by the "dry" meter, or the comparatively accurate "wet" meter, could not conveniently be employed since these do not give instantaneous readings of rate of flow, but require the operator to observe the time interval during which a

¹ Published by permission of the Director of Chemical Warfare Service.

definite volume is passed. Anemometers and float meters are delicate and insufficiently accurate, especially at small rates of flow. The method of measuring the change of temperature of the gas due to the continuous addition to it of a known quantity of heat has the disadvantage of not giving direct reading of flow without complicated apparatus.

Orifice meters seemed more promising. However, since glass is probably the most satisfactory material for use with corrosive gases, the construction according to specifications offers considerable difficulty. Small orifices made by punching a hole in the hot glass with a platinum wire of suitable diameter have been used almost exclusively by one unit of the Research Division, who have found them suitable for rates as small as 1 or 2 l. per min. Experience has shown, however, that it is very difficult to duplicate dimensions, so that the performance of the finished meters cannot be predicted with any great exactness. For smaller rates this difficulty renders them totally unsatisfactory. Both Pitot tubes and Venturi meters, while excellent in principle because of the comparatively small resistance they introduce into the line are unsuited to the measurement of gas at rates of the order of 50 l. per min. or less, and the difficulty of constructing them of glass is very great.

RESISTANCE-TUBE METERS

Another principle, distinct from any of the above, which takes advantage of frictional resistance to flow, has occasionally been employed, particularly in water works, for the approximate measurement of fluids.

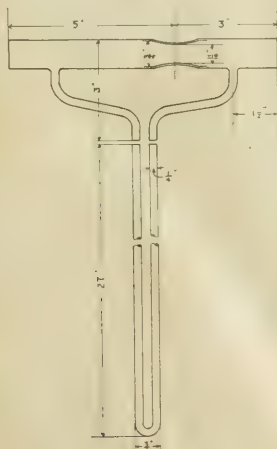


FIG. 1

The method consists simply in determining the pressure in the line at two widely separated points, the quantity passed being obtained from a previous calibration in which the volume has usually been measured by one of the methods described above, or by pumping into a receiver of known capacity. In

spite of its obvious simplicity, this method has met with little favor in engineering practice, chiefly because of the uncertainty introduced by the continually changing surface of the pipe walls, and also for the reason that the points where the pressure was measured had ordinarily to be a mile or more apart to give a sufficiently large pressure drop. The principle is well adapted, however, to the measurement of low rates of flow. A meter for this purpose, in which the pressure difference is measured across a length of capillary tubing, has been described by Muster,¹ and more recently by Guye and Schneider.² Several years ago, a similar meter was developed in the Bureau of Mines Experiment Station at Pittsburgh, Pa., in connection with work on the chlorination of natural gas. These flow meters proved so simple and convenient, as regards both construction and operation, that they have been adopted almost universally throughout the Chemical Warfare Service.

To satisfy all the varied requirements, three general types of meter were evolved. Type A, shown in Fig. 1, can be used conveniently for rates of flow from 1 or 2 l. per min. up to 200 or more. In the constriction is placed a 1-hole rubber stopper, through which passes a short glass tube of suitable size, to serve as the resistance. The manometer, containing water or other convenient liquid, may be sealed to the head of the meter, or may be connected to it with good rubber tubing. Table I contains suitable specifications for the indicated rates of flow for air. These values are not to be relied upon, however, except as a guide in constructing meters; calibration³ is essential for the best results. Dimensions for rates of flow of gases other than air will be considered later.

TABLE I¹
LENGTH OF TUBE = 30 MM.
RATE OF FLOW OF AIR (LITERS PER MINUTE)
AT HEAD INDICATED

DIAMETER MM.	500 MM. Water	250 MM. Water	84 MM. Water	50 MM. Water
6.2	120	84	37	
5.4	90	64	28	
4.7	70	50	22	
3.9	50	35	16	
3.5	40	28	12	
3.2	35	23	10	
2.8	24	17	7.5	
2.3	18	11	5	
1.8	10	7	3	
1.5	6	4.5	2	
0.9	2	1.5	0.5	

¹ The values given are for tubes with sharp ends.

The Type B meter, shown in Fig. 2, is suitable for rates between 500 cc. and 5 l. per min. Because of the wide choice of dimensions for these low rates and the many factors affecting the selection of desirable sizes, no attempt will be made at this point to tabulate specifications. This question will be taken up later in the discussion of the experimental data given below. The Type C meter is particularly adapted to the measurement of exceedingly small rates of flow, although it will handle as much as 5 l. per min. quite satisfactorily. The construction is similar to that of Type B, with the exception that the capillary tube

¹ Thesis, Geneva, 1907.

² *Helv. Chim. Acta*, 1 (1918), 35.

³ The method of calibration is described in the experimental part of the paper.

¹ The principle is illustrated by a frequent application to the determination of the viscosity of gases and liquids.

is made a replaceable part, and is connected in with rubber tubing instead of being sealed to the rest of the meter. Since it is impracticable to duplicate dimensions for these small rates by actual measurement, this type allows of different tubes being connected in temporarily, until by means of a rough calibration the desired size is found. A flow meter of this type may be provided with a set of replaceable tubes of suitable dimensions so that any particular rate, over a considerable range, may be quickly and easily obtained.

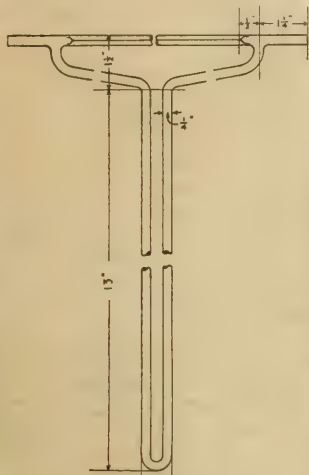


FIG. 2

Various modifications and conveniences may be added to any of these types of meter, as circumstances may require or permit. For example, the refilling of the manometer is greatly facilitated by means of a third tube, sealed at its lower end to the bend of the U-tube, and closed at its upper end with a rubber tube carrying a short length of glass rod. To prevent the liquid "sucking over," a bulb larger than the total volume of liquid in the manometer may advantageously be blown in the upper portion of the low-pressure arm. If desired, the manometer may be made to read on one side only by employing at the lower end of the high-pressure arm a bulb of such size that the level of liquid in it is not materially altered by changes in the height of the column in the other arm. This modification is of no advantage, however, if the liquid has a considerable volatility. A much more dependable method of reading the pressure drop is obtained by the use of a sliding scale, which may be made to move up and down between the arms of the manometer. In this way errors of observation are reduced to a minimum since, if the zero point of the scale is adjusted opposite the lower level, the pressure drop may be read off the scale directly. If it be desired to reduce to a minimum the head lost in metering the gas, or only very small heads are available, some more sensitive type of gauge than the U-manometer may

be employed, such as an inclined gauge or a differential manometer.¹ Such an instrument will give satisfactory results, however, only when the pressure in the gas line is almost entirely free from fluctuations. In those numerous cases in which the function of the meter is to pass a known, constant rate of flow, the automatic device² of Oberfell and Mase for maintaining a constant head is said to give excellent results.

THEORETICAL DISCUSSION

The theory of the flow of gas through tubes of small diameter has a very important bearing on their use as flow meters. The development of the theory for gases is due originally to O. E. Meyer,³ whose formula may be expressed as follows:

$$p_1 v_1 = p_2 v_2 = \frac{\pi r^4 (p_1^2 - p_2^2)}{8 \eta l} \dots \dots (1)$$

where p_1 and p_2 represent the pressures at the inlet and outlet ends of the tube, respectively, v_1 and v_2 are the corresponding volumes, t is the time, η is the coefficient of viscosity, and r is the radius, and l the length of the tube. If, however, we consider that the volume is measured under the mean pressure, i. e., $\frac{1}{2} (p_1 + p_2)$, this equation reduces to the well-known formula of Poiseuille for the flow of liquids:

$$v = \frac{\pi r^4 (p_1 - p_2)}{8 \eta l} = \frac{\pi r^4 h}{8 \eta l} \dots \dots (2)$$

when h is the pressure difference, or head. Obviously the volume is not actually measured under the mean pressure, but if the head is small in comparison with the pressures at the ends of the tube, only a small error will result from substituting the measured volume in Equation 2. For example, if p_1 is atmospheric pressure and h is 20 cm. of water, the error is roughly 1 per cent. In what follows, therefore, Poiseuille's formula will be taken to be sufficiently exact for the purpose.

These equations are obtained on the supposition that the motion of the gas is streamline, that is, that the lines of flow in the tube are parallel to its axis. When this is the case the resistance to flow is due simply to molecular friction, i. e., viscosity, as the above equations indicate. Above a certain rate of flow, which depends on the diameter, the motion loses its streamline character and breaks up into turbulent, or eddy, flow. When this occurs, motion is transferred from one layer of gas to another by actual cross currents and eddies much more than by molecular friction, so that here the resistance depends chiefly on the density of the gas. Osbourne Reynolds⁴ studied this so-called "critical" phenomenon, and found for the case of water that the change in the character of the flow occurs when $\frac{dS\rho}{\eta} = 1900$ to 2000, where d represents

d diameter, S linear velocity of flow, and ρ the density of the water. In 1908, W. Ruckes⁵ found that gases exhibit the same phenomenon, and that, for glass tubes, it occurs at about the same value of

¹ See, e. g., L. S. Marks, "Mechanical Engineers' Handbook," p. 284.

² THIS JOURNAL, 11 (1919), 294.

³ PAGE ANN. 127 (1866), 253.

⁴ Phil. Trans. 174 (1883), 935.

⁵ Ann. Physik. [4] 25 (1908), 983.

$d\delta\rho$ as given by Reynolds' criterion.¹ For the turbid flow above this critical region, Lees² has obtained an empirical expression, which may be put in the following form:

$$\frac{h}{l} = \frac{\rho R^2}{r^3} \left[0.00018 + 0.0182 \left(\frac{\eta r}{\rho R} \right)^{0.35} \right],$$

where R is πr , the rate of flow.

When applied to flow meters, these results show that when the flow is streamline, the head is proportional to the first power of the rate of flow, whereas above the critical region, it varies as R^n , where n lies usually between 1.86 and 2. If a meter is constructed of such dimensions that the available range of rates is entirely above or entirely below the critical region, the head will vary with the rate in a regular manner, and smooth curves will be obtained when these are plotted as variables. If, however, the critical region lies within the range through which the meter is to be used, the curves plotted in this way will show a sudden change in direction where the motion becomes turbulent. Under these circumstances an inconveniently large number of "points" would have to be determined on the meter to make the calibration at all certain.

The theoretical development outlined above takes no account of a distributing influence which is almost always present when these tubes are used as flow meters. This is due to the fact that some static pressure is converted into kinetic pressure as the gas enters the capillary. This will be evident if a tube be considered to become shorter and shorter, until finally only the ends remain, and the middle has shrunk to nothing. According to the formulas given above, the resistance h should now be zero. Actually this is not the case, since it is the resistance offered by an orifice of the same diameter as the tube. This so-called "end effect" has frequently been considered³ in determining gas viscosity by the capillary tube method, but investigators have generally found it convenient to employ such long tubes that the effect was negligible. For flow meter purposes, however, it is essential to have data giving the relation between dimensions and capacity in this intermediate range, if the construction of meters is not to be simply a "cut-and-try" process.

EXPERIMENTAL METHOD

The majority of the resistance-tube flow meters, with their calibration data, that have been used in the Chemical Warfare Service, do not supply the necessary material, since the dimensions of the tubes were seldom determined by any but the roughest methods. However, 40 meters were made and calibrated especially for this purpose, covering the range most frequently required. Five diameters of resistance tube were tested (from 0.7 to 4 mm.) and 8 lengths of each were employed (from 1 to 100 cm.). The construction was as follows: Glass tubes of each desired diameter

and about a meter long were examined for irregularities of bore by observing the length of a short thread of clean mercury at different positions along the whole length of each tube. The tubes finally selected were those found free from any abrupt change, and which showed the least gradual variation in bore from end to end. Each of these was then made up into a flow meter by connecting a T tube to each end with rubber tubing, and attaching a water manometer to the vertical branches of these T's. Care was taken to have the cross sectional area of these end vessels at least twenty times the internal area of the resistance tube. The construction was similar to the Type C flow meter above described. The ends of the resistance tubes were in all cases sharp edged. The average diameter for each length of tube tested was determined from the weight of mercury required to fill it at a known temperature.

The calibration of the meters was made with air. The volume passed was measured¹ by means of a meter of the displacement type; a wet meter was used for rates up to 6 l. per min., a dry meter² for higher rates. At the beginning of these experiments the wet meter was standardized against a water aspirator, and the dry meter standardized against this wet meter. The time required to pass any suitable volume was obtained by means of an accurate stop-watch. The apparatus for calibration was set up according to the following scheme: atmosphere \rightarrow flow meter \rightarrow mercury manometer \rightarrow standard wet or dry meter \rightarrow suction. The relative positions of the flow meter and standard meter may be reversed, so that the latter indicated the volume entering the flow meter rather than the volume discharged from it, but this procedure has the disadvantage, when a wet meter is used, that the air entering the flow meter is practically saturated with water vapor, which may condense in the capillary, thus altering its resistance. For this reason the arrangement shown was adopted, and the mercury manometer was added to render it possible to calculate the observed volumes to any other conditions of temperature and pressure, or to convert them to weight if desired. In the results which are given below, the volumes have been calculated by this means to 25° C. and 760 mm. pressure, the conditions adopted as standard. For each meter the rate of flow was obtained at four different heads, between 50 and 500 mm. of water, the value at each head being the average of 3 or 4 trials. The rate of flow is plotted against the head, preferably on logarithmic paper, and the head corresponding to the rate desired is then read off the resulting curve directly.

RESULTS

Space does not permit of presenting all the results in this form. In Fig. 3, however, the logarithmic curves are shown for one tube, which is typical of the rest. It will be noted that many of the curves show a sharp

¹ For metal (iron, copper, brass) capillaries, Ruckes found $d\delta\rho = 400$ to 500.

² Proc. Roy. Soc. (London), [A] 91 (1914), 46.

³ See especially M. Brillouin, "Leçons sur la Viscosité des Liquides et des Gases," 2, 37; W. J. Fisher, Phys. Rev., 33 (1911), 216; I. M. Rapp, Ibid., [2] 2 (1913), 363.

¹ Very small rates are most conveniently measured by drawing the gas through the flow meter with some sort of aspirator, e. g., a gas buret in which the volume may be read off directly.

² No hesitation need be felt in using a dry meter for this purpose. Although it is quite true that its limit of accuracy is only several per cent. plus or minus, its precision has been found entirely satisfactory.

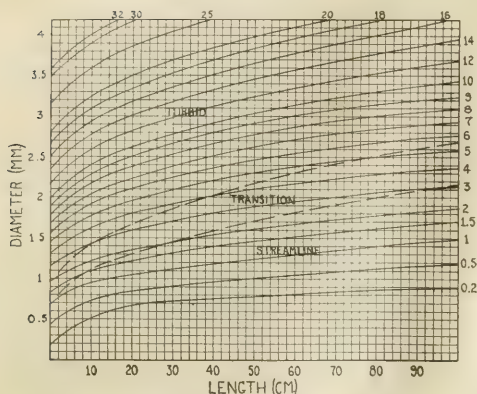


FIG. 5—CURVES SHOWING RATE OF FLOW, IN LITERS PER MINUTE, AT A HEAD OF 250 MM. OF WATER, FOR DIFFERENT LENGTHS AND DIAMETERS OF RESISTANCE TUBES

where d is the diameter. Similarly the orifice formula may be put in the form:¹

$$h_o = \frac{k_2 \rho R^2}{d^4}$$

Combining these

$$h = h_1 + h_o = \frac{k_1 \eta R l}{d^4} + \frac{k_2 \rho R^2}{d^4}$$

or

$$h d^4 = k_1 \eta R l + k_2 \rho R^2$$

If, as a first approximation, it is assumed that the pressure and temperature remain constant, η and ρ become constants. An application of the method of least squares to the forty-nine observed "points" which lay below the critical region gave the following equation:

$$1.263 R l + 67.9 R^2 = h d^4 \dots \dots (3)$$

where l and d are expressed in mm., h in mm. of water, and R in liters per min. at 25° C. and 760 mm. pressure. On testing the equation in this form, it was found that the rate of flow, calculated in this way, agreed with the observed rate within 2 per cent on the average. Hence the equation is adequate for the purpose of supplying suitable dimensions for a given rate of flow, for air at atmospheric pressure and room temperature.

OTHER GASES THAN AIR

Specifications for flow meters have been experimentally determined only for air, or for mixtures of other gases with air in such low concentration that the viscosity and density of the air remained substantially unaltered. However, with the help of the equation given above, it is possible to choose suitable dimensions for use with other gases, with considerable confidence. It will be observed that resistance tubes act in two quite different ways, according as the flow is below or above the critical region. Below this point the tube will usually be of such length that the end effect can be disregarded in choosing specifications.

¹ Since the pressure differences employed are small in comparison with the actual pressures. See R. J. Darley, *Trans. A. S. M. E.*, 27 (1906), 193.

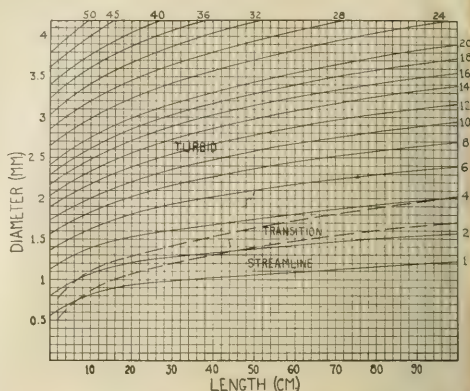


FIG. 6—CURVES SHOWING RATE OF FLOW, IN LITERS PER MINUTE, AT A HEAD OF 500 MM. OF WATER, FOR DIFFERENT LENGTHS AND DIAMETERS OF RESISTANCE TUBES

In this case Poiseuille's law indicates that the volume passing through the meter is inversely proportional to the viscosity of the gas, while the weight (or the actual volume, calculated to standard temperature and pressure) is proportional directly to the density and inversely to the viscosity. Above the critical region, on the other hand, viscosity contributes very little to the resistance. Here whether the tube be long or short, the volume varies inversely and the weight directly as approximately the square root of the density. Hence if other gases than air, or even liquids, are to be measured, it is only necessary to calculate, by means of these relations, the rate of flow of air which corresponds to the desired rate of gas, and then select the necessary dimensions from Figs. 4, 5 and 6, or from Equation 3.

INFLUENCE OF TEMPERATURE AND PRESSURE

The relations considered in the preceding section show also the effect on the flow of changes in temperature and pressure.¹ Since the viscosity of gases is independent of the pressure, it is evident that ordinary changes in barometric pressure will have only a very slight influence on the flow below the critical region. In this range, however, the influence of temperature is very marked. In the neighborhood of room temperature, a rise of 10° C. will decrease the volume about 3 per cent and the weight nearly 7 per cent. Obviously no great accuracy will be obtained in these long tubes where the flow of gas is below the critical region, unless the temperature be maintained fairly constant. If, however, the flow be above the critical region or if the tube be sufficiently short, the rate depends principally on the density, but the relative change in rate is only half the relative change in density. Thus in the vicinity of room conditions, a decrease in pressure of 15 mm. of mercury, or an increase in temperature of about 6° C. would be required to increase the volume or decrease the weight by 1 per cent.

¹ The effect of temperature and pressure on the dimensions of the capillary and on the density of the manometric fluid is negligible in comparison with the other influences mentioned.

SUMMARY

The inapplicability of the usual forms of gas-metering device to the measurement of small rates of flow is discussed, and the resistance-tube flow meter, developed for this purpose in the Bureau of Mines, is described. The nature of the flow of gas through these resistance tubes is considered from the point of view of flow meter design. Specifications for construction, calibration, and operation are included, and the in-

fluence of temperature and pressure changes discussed.

This work was carried out under the direction of the Bureau of Mines. The writer wishes further to express his deep appreciation of the valuable suggestions of Dr. E. Buckingham, of the U. S. Bureau of Standards.

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ORIGINAL PAPERS

EQUILIBRIUM IN THE SYSTEM $\text{Na}_2\text{SO}_4\text{--CuSO}_4\text{--H}_2\text{SO}_4\text{--H}_2\text{O}^1$

By H. W. FOOTE

Received October 28, 1918

In considering proposals for the utilization of niter cake, Johnston² has stated that "the best mode of using a solution of niter cake for any particular purpose could be ascertained from the appropriate solubility data; this involves the investigation * * * of four-component systems such as $\text{Na}_2\text{SO}_4\text{--H}_2\text{SO}_4\text{--FeSO}_4\text{--H}_2\text{O}$." It is hoped that the present investigation may serve as an aid in that direction.

The problem has been limited to determining the solubility relations, at two temperatures, of the following systems:

- (1) $\text{Na}_2\text{SO}_4\text{--H}_2\text{SO}_4\text{--H}_2\text{O}$
- (2) $\text{CuSO}_4\text{--H}_2\text{SO}_4\text{--H}_2\text{O}$
- (3) $\text{Na}_2\text{SO}_4\text{--CuSO}_4\text{--H}_2\text{O}$
- (4) $\text{Na}_2\text{SO}_4\text{--CuSO}_4\text{--H}_2\text{SO}_4\text{--H}_2\text{O}$

A knowledge of (1), (2), and (3) is obviously necessary in considering (4). Stated in a different way, the problem has consisted in determining the changes which take place when sulfuric acid, in increasing amounts, is added to the system $\text{Na}_2\text{SO}_4\text{--CuSO}_4\text{--H}_2\text{O}$. Systems containing more than approximately 60 per cent of sulfuric acid in solution were not investigated.

In general, only the solubility of univariant systems was determined and in plotting the results the points which represent them are connected by straight lines to show the composition of the corresponding divariant systems. Actually, these curves are usually somewhat concave. At a given temperature, the univariant systems of three components have two solid phases in equilibrium with a solution of fixed composition and vapor pressure. With four components, there are three solid phases at such points.

METHOD

To determine the univariant points in the three-component systems, a series of crystallization experiments at the given temperature showed approximately the conditions necessary. The solution which deposited one compound near the point where another formed was then treated with an excess of the latter, or in some cases with both, and the solubility of the mixture determined. In all cases, a second result

was obtained by adding further quantities of one or both solids and again shaking, the constancy of the results showing that the univariant point had been reached. When the univariant points in the ternary systems had been fixed, it was usually a simple matter to obtain the corresponding points in the quaternary system by merely adding an excess of the third solid necessary. Here also a duplicate result was obtained after adding further quantities of the solids in equilibrium.

Solubilities were determined at 12° and 25°. For 12° a low temperature thermostat¹ gave excellent service. At 25° the ordinary form of thermostat, heated by gas, was used. The various mixtures were shaken in glass-stoppered bottles, kept tight by dipping the tops in paraffin. Solutions for analysis were removed through small filters of glass wool directly into weighed specimen tubes.

In analyzing solutions containing all four components, copper was determined either electrolytically or, as the amount was always small, by precipitating as sulfide, roasting, and weighing copper oxide. After removing copper, sodium was determined in the filtrate as the sulfate, the excess of sulfuric acid being removed by ignition with ammonium carbonate. Free sulfuric acid was determined directly by titrating with standard sodium hydroxide. Preliminary determinations showed that the small amount of copper sulfate present did not affect the end-point. In a few cases, total sulfate was determined (by precipitating as barium sulfate) instead of weighing sodium sulfate, but the method was abandoned as less accurate than the other. Where only three components were present, the method of analysis could be correspondingly simplified.

(1) SYSTEM, $\text{Na}_2\text{SO}_4\text{--H}_2\text{SO}_4\text{--H}_2\text{O}$

This system has been investigated previously by D'Ans³ at 25° and by Pascal⁴ through a considerable range of temperature, though the latter expresses his results only in the form of a diagram which contains some obvious inaccuracies. D'Ans gives the solubility conditions for the following salts: $\text{Na}_2\text{SO}_4\text{--}10\text{H}_2\text{O}$, Na_2SO_4 , $\text{Na}_3\text{H}(\text{SO}_4)_2\text{--H}_2\text{O}$, $\text{Na}_3\text{H}(\text{SO}_4)_2$, $\text{NaHSO}_4\text{--H}_2\text{O}$, NaHSO_4 .

The salt $\text{Na}_2\text{H}(\text{SO}_4)_2\text{--H}_2\text{O}$ forms spontaneously from solutions only very rarely and D'Ans speaks of ob-

¹ This investigation was undertaken at the request of the Division of Chemistry and Chemical Technology of the National Research Council.

² This JOURNAL, 10 (1918), 468.

³ Z. physik. Chem., 33 (1900), 749.

⁴ Ber., 39 (1906), 1534; Z. anorg. Chem., 49 (1906), 356; 61 (1909), 91.

⁵ Compl. rend., 164 (1917), 628.

taining it only by chance, though when it has formed, it can doubtless be obtained afterward by inoculating. In all our experience we have never observed this form. Its solubility relations, as shown by D'Ans, are very nearly those of the anhydrous form, so it affects the diagram but slightly and it is not considered here. It seems unlikely that this form would be met in practice. Our solubility results agree closely with those of D'Ans at 25°. One difference as to the solid phases in strongly acid solution is mentioned later.

The following results were obtained. Percentages here and in all tables following represent the parts in 100 parts of solution. The letters in the last column refer to the corresponding points in the diagrams which are described later.

TEMPERATURE = 12°			
SOLID PHASES	Per cent H ₂ SO ₄	Per cent Na ₂ SO ₄	Corresponding Point in Diagram
Na ₂ SO ₄ ·10H ₂ O.....	None	9.53	A
Na ₂ SO ₄ ·10H ₂ O and NaH(SO ₄) ₂	16.51	32.96	Q
NaH(SO ₄) ₂ and NaHSO ₄ ·H ₂ O.....	16.52	32.90	
NaH(SO ₄) ₂ and NaHSO ₄ ·H ₂ O.....	27.96	25.38	H
NaH(SO ₄) ₂ ·H ₂ O (Divariant) ¹	27.96	25.45	
	58.79	4.33	G
TEMPERATURE = 25°			
Na ₂ SO ₄ ·10H ₂ O.....	None	21.90 ¹	A
Na ₂ SO ₄ ·10H ₂ O and Na ₂ SO ₄	8.62	33.46	J
	8.62	33.50	
Na ₂ SO ₄ and NaH(SO ₄) ₂	16.25	35.20	I
	16.29	35.53	
NaH(SO ₄) ₂ and NaHSO ₄ ·H ₂ O.....	30.59	27.13	H
	30.57	26.91	
NaHSO ₄ ·H ₂ O (Divariant) ²	56.25	6.54	G

¹ Loewel, *Ann. chim. phys.*, [3] **49** (1857), 50.

² This was as far toward the sulfuric end of the diagram as we considered it necessary to go. D'Ans found a univariant point with the solids NaHSO₄·H₂O and NaHSO₄ at about the same concentration at 25°, but at neither 12° nor 25° did we get any indication of the second salt at the concentrations given. The means we had of judging as to the solid present here was that a series of crystallizations carried out in this region all showed the very characteristic crystalline form of the hydrated salt. The solutions contained so much free sulfuric acid that the crystals could not be freed from it properly and analysis could not decide which salt was present. A salt very different in appearance, which was probably NaHSO₄, was obtained in more concentrated solutions but its identity was not determined.

The solubility relations are somewhat simpler at 12° than at 25°, for at the former temperature the anhydrous salt is no longer stable under any conditions, as D'Ans showed originally, and the decahydrate exists in equilibrium with the salt Na₂H(SO₄)₂ at the univariant point.

(2) SYSTEM, CuSO₄-H₂SO₄-H₂O

In this system no acid salt forms, but the presence of sulfuric acid dehydrates the pentahydrate in stages, yielding the trihydrate, monohydrate, and ultimately the anhydrous salt in strong sulfuric acid. A discussion of this behavior will be found in a previous article¹ from which the solubility results at 25° have been taken. Bell and Taber² have also determined the solubility of this system at 25°. Following are the results:

TEMPERATURE = 12°			
SOLID PHASES	Per cent H ₂ SO ₄	Per cent CuSO ₄	Corresponding Point in Diagram
CuSO ₄ ·5H ₂ O.....	None	16.19	D
		16.11	
CuSO ₄ ·5H ₂ O and CuSO ₄ ·3H ₂ O.....	51.63	1.67	E
	51.38	1.61	
CuSO ₄ ·3H ₂ O and CuSO ₄ ·H ₂ O.....	61.56	0.87	F
	61.52	0.75	
TEMPERATURE = 25°			
CuSO ₄ ·5H ₂ O.....	None	18.47	D
CuSO ₄ ·5H ₂ O and CuSO ₄ ·3H ₂ O.....	49.20	2.83	E
CuSO ₄ ·3H ₂ O and CuSO ₄ ·H ₂ O.....	55.72	2.13	F

¹ *J. Am. Chem. Soc.*, **37** (1915), 288.

² *J. Phys. Chem.*, **12** (1908), 171.

(3) SYSTEM, Na₂SO₄-CuSO₄-H₂O

This system has been investigated in some detail by Koppel¹ and his data are given below for 25°. A transition temperature in this system exists at 16.7°, below which only the single salts crystallize, while above it the double salt Na₂SO₄·CuSO₄·2H₂O forms. At 12°, therefore, there is but one univariant system and the two solids present consist of the single salts. At 25° there are two such systems. In one the solid phases consist of double salt and CuSO₄·5H₂O, and in the other, double salt and Na₂SO₄·10H₂O.

TEMPERATURE = 12°			
SOLID PHASES	Per cent Na ₂ SO ₄	Per cent CuSO ₄	Corresponding Point in Diagram
Na ₂ SO ₄ ·10H ₂ O.....	9.53	None	A
	9.34		
Na ₂ SO ₄ ·10H ₂ O and CuSO ₄ ·5H ₂ O.....	10.43	14.69	R
	10.44	14.51	
CuSO ₄ ·5H ₂ O.....	None	16.19	D
		16.11	
TEMPERATURE = 25°			
Na ₂ SO ₄ ·10H ₂ O.....	21.90	None	A
Na ₂ SO ₄ ·10H ₂ O and Na ₂ SO ₄ ·CuSO ₄ ·2H ₂ O.....	21.20	6.28	B
CuSO ₄ ·5H ₂ O and Na ₂ SO ₄ ·CuSO ₄ ·2H ₂ O.....	10.95	16.85	C
CuSO ₄ ·5H ₂ O.....	None	18.47 ¹	D

¹ *J. Am. Chem. Soc.*, **37** (1915), 288.

(4) SYSTEM, Na₂SO₄-CuSO₄-H₂SO₄-H₂O

The general method of obtaining the univariant points in the four-component system has already been mentioned. In most cases there was no special difficulty when once the univariant points in the ternary systems were found. For each univariant point in the latter, there was a corresponding point in the quaternary system, in which the solution was saturated with one more solid phase. For instance, starting with the ternary univariant system containing the solid phases CuSO₄·5H₂O and CuSO₄·3H₂O, a univariant point in the quaternary system could be reached by adding sodium sulfate. As this salt, however, would be converted into the double salt Na₂SO₄·CuSO₄·2H₂O before equilibrium was established, the latter was actually used in the solubility determinations. This double salt was the only one found and exists under a very wide range of conditions. It forms one of the phases in every univariant system containing the four components.

The relations in the system at 12° are unusual in one respect. As already mentioned, the two salts in water do not form a double salt at this temperature, but crystallize separately. With more than 7.4 per cent of sulfuric acid, the double salt forms, and at this concentration of acid there is a univariant system with the three solid phases, CuSO₄·5H₂O, Na₂SO₄·10H₂O, and double salt. The presence of the sulfuric acid causes the double salt to be stable below its transition temperature. The case is comparable with the simpler one of sodium sulfate, in which the anhydrous form may exist in contact with sulfuric acid solutions below its transition temperature into the decahydrate, but I am not aware of any similar case which has been observed with four components.

The solubility data for the univariant systems are given in the following table. The one divariant system included at each temperature shows the limiting value obtained on the curve at the sulfuric acid end.

¹ *Z. phys. Chem.*, **42** (1902), 1.

TEMPERATURE = 12°

SOLID PHASES	Per cent H ₂ SO ₄	Per cent Na ₂ SO ₄	Per cent CuSO ₄	Corresponding Point in Diagram
Na ₂ SO ₄ ·10H ₂ O, Na ₂ H(SO ₄) ₂ , D.S. ¹	16.50	32.92	0.18	S
	16.54	32.89	0.13	
Na ₂ H(SO ₄) ₂ , NaHSO ₄ ·H ₂ O, D.S. ¹	27.97	25.47	0.08	M
	27.86	25.36	0.14	
NaHSO ₄ ·H ₂ O, D.S. (Divariant).....	58.20	4.65	0.77	N
	50.41	2.53	1.60	P
CuSO ₄ ·5H ₂ O, CuSO ₄ ·3H ₂ O, D.S. ¹	50.54	2.51	1.59	V
	59.96	2.59	0.73	
CuSO ₄ ·3H ₂ O, CuSO ₄ ·H ₂ O, D.S. ¹	59.86	2.80	0.73	
	7.40	13.62	8.65	T
Na ₂ SO ₄ ·10H ₂ O, CuSO ₄ ·5H ₂ O, D.S. ¹	7.42	13.69	8.82	

TEMPERATURE = 25°

Na ₂ SO ₄ ·10H ₂ O, Na ₂ SO ₄ , D.S. ¹	8.58	33.18	0.44	K
	8.59	33.43	0.44	
Na ₂ SO ₄ , Na ₂ H(SO ₄) ₂ , D.S. ¹	16.21	35.57	0.18	L
	16.18	36.16	0.19	
Na ₂ H(SO ₄) ₂ , NaHSO ₄ ·H ₂ O, D.S. ¹	30.41	26.98	0.16	M
	30.52	27.02	0.20	
NaHSO ₄ ·H ₂ O, D.S. (Divariant).....	55.58	6.62	0.69	N
	55.46	6.54	0.87	
CuSO ₄ ·5H ₂ O, CuSO ₄ ·3H ₂ O, D.S. ¹	47.04	2.98	2.75	P
	47.11	2.81	2.97	
CuSO ₄ ·3H ₂ O, CuSO ₄ ·H ₂ O, D.S. ¹	54.15	2.38	2.24	V
	53.80	2.63	2.10	

¹ Double salt.

Equilibrium in the system $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ - Na_2SO_4 - $10\text{H}_2\text{O}$, D. S. given in the above table at 12° was reached very slowly and it is possible for the two single salts to remain in contact with a solution containing considerably more than 7.4 per cent of sulfuric acid and show no sign of transforming into double salt even after a considerable time. The other systems offered no difficulty in reaching equilibrium.

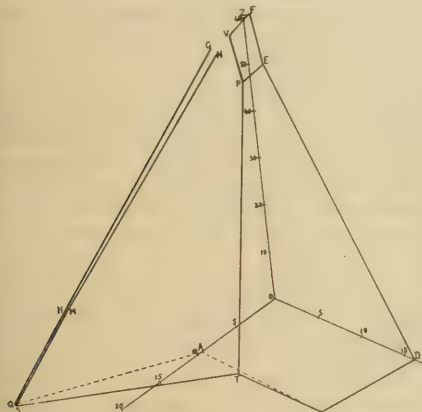


FIG. 1—TEMPERATURE = 12°

The relations of the different systems appear much clearer when the results which have been given are plotted. This has been done in Figs. 1 and 2. The percentages of sodium sulfate, copper sulfate, and sulfuric acid are plotted respectively on the three axes, OA, OD and OZ, which make an angle of 120° with each other. For clearness, the scale for sulfuric acid is one-half that for the two salts. Points where the same solids are present at both temperatures are lettered alike. AQHG at 12° (Fig. 1) and AJIHG at 25° (Fig. 2) represent the solubility of sodium sulfate in sulfuric acid solutions; DEF gives that of copper sulfate at both temperatures, and DRA at 12° and ABCD at 25° give the solubility of sodium and copper sulfates (or their double sulfate) in water in the presence of each other. The four-component

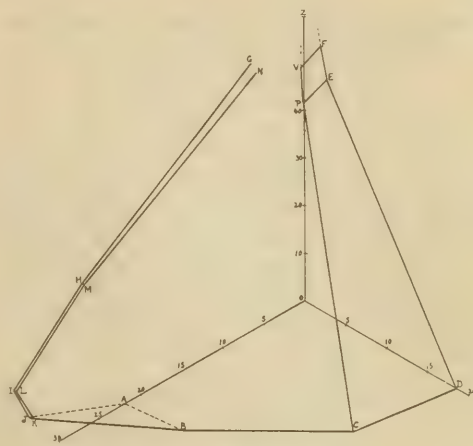


FIG. 2—TEMPERATURE = 25°

systems are, of course, limited by these three-component curves, the points inside, at the intersection of three curves, representing univariant systems with three solid phases; the lines, divariant systems with two solids; and the fields, trivariant, with one solid. The fields, and their corresponding solid phases, are as follows:

	12° (Fig. 1)	25° (Fig. 2)
Na ₂ SO ₄ ·CuSO ₄ ·2H ₂ O.....	N M S T P V ¹	N M L K B C P V ¹
Na ₂ SO ₄ ·10H ₂ O.....	A Q S T R	A J K B
Na ₂ SO ₄	Absent	J L K
Na ₂ H(SO ₄) ₂	Q H M S	I H M L
NaHSO ₄ ·H ₂ O.....	G H M N ¹	G H M N ¹
CuSO ₄ ·5H ₂ O.....	D E F T R	D E P C
CuSO ₄ ·3H ₂ O.....	E F V F	E F V F

¹ Field incomplete at sulfuric acid end.

The diagram shows the wide range of conditions under which the double salt forms and the extremely limited range of stability of the acid sulfates of sodium in the presence of dissolved copper sulfate, which converts them into the double salt.

The very slight solubility of copper sulfate on the sodium sulfate-sulfuric acid side of the diagram is of course shown quantitatively in the solubility tables. Some of the difficulties which have been met in using niter cake to replace sulfuric acid for pickling copper alloys are probably due to this slight solubility, which causes the double salt to precipitate. The slight solubility also points to an obvious way of preventing copper sulfate from accumulating in solution or of removing it from solution.

Sodium sulfate forms double salts with all the vitriols, which resemble each other markedly in general solubility relations and in the fact that they are formed from their components above the transition temperature and break down below, this being the reverse of the common behavior of double salts. The transition temperatures also all lie near each other. On account of these similarities, it is probable that the system which has been investigated is typical of systems containing other vitriols in place of copper sulfate.

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THE DETERMINATION OF VANADIUM IN STEELS BY
ELECTROMETRIC TITRATION. THE SELECTIVE
OXIDATION OF VANADYL SALTS BY
NITRIC ACID IN THE PRESENCE
OF CHROMIC SALTS

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The difficulties caused by chromium in the determination of vanadium in chrome-vanadium steels are well known. Inasmuch as nearly all vanadium steels contain chromium these difficulties arise wherever vanadium is determined in steel. In this paper we have described a method which permits of the direct determination of vanadium in the original solution of the sample accurately, rapidly, and without interference by chromium or any other element at present used as a constituent of steel.

Our method is based upon the selective oxidation of vanadium by nitric acid, followed by electrometric titration with ferrous sulfate. Attempts to find some reagent which, when added to a mixture of chromate and vanadate, would reduce one completely without reducing the other, or which would exercise a similar selective oxidizing action upon a mixture of chromic and vanadyl salts led us to test many substances. Among reducing agents tried without success, mention may be made of arsenious, phosphorous, hypophosphorous, nitrous, formic, and lactic acids, and mercurous salts. As oxidizing agents we tried manganese dioxide, lead dioxide, sodium bismuthate, potassium iodate, and potassium chlorate. Some of these, particularly manganese dioxide and potassium iodate used as oxidizing agents, and nitrous acid used as a reducing agent, lacked only a little of being satisfactory. The only substance which regularly gave satisfactory results, even in a limited way, was nitric acid. The conditions under which we found it possible to use nitric acid are described below.

It should be confessed that our success in the use of nitric acid here was suggested by a study of our failure to secure complete oxidation as described in an earlier paper by one of us.¹ There the largest oxidation found amounted to 97.7 per cent. Our failure in that case was due to the fact that those concentrations of nitric acid which would have given us complete oxidation gave a solution which could not be titrated on the apparatus then in use. On the apparatus used in these experiments (which has been described elsewhere)² we are able to titrate solutions containing much larger amounts of nitric acid. This is probably because the galvanometer now in use is much more sensitive than the one used in the earlier work, but it is not certain that this accounts for the degree of improvement noted. Even now, however, it is somewhat more difficult to determine the endpoint sharply in nitric than in sulfuric acid solution. In the earlier paper referred to above, we also observed that the titration of vanadium was favored by low concentrations of vanadic acid and ferric and chromic salts, and a low temperature. Fortunately it is possible

to observe these conditions conveniently and still deal with all percentages of vanadium found in commercial steels.

TABLE I—EFFECT OF CONCENTRATION OF NITRIC ACID, TIME OF BOILING, AND INITIAL AND FINAL VOLUMES

Expt. No.	Conc. HNO ₃ Cc.	H ₂ SO ₄ Sp. gr. 1.58 Cc.	Time Boiled Min.	Initial Volume Cc.	Final Volume Cc.	V Oxidized Per cent
1	5	..	30	130	100	92.5
2	15	..	30	130	100	96.6
3	25	..	30	130	100	98.1
4	35	..	30	130	100	99.1
5	35	..	30	130	100	99.3
6	45	..	30	130	100	99.5
7	45	..	60	130	100	99.7
8	60	..	30	130	100	99.6
9	60	..	60	130	100	99.7
10	50	..	60	130	75	99.9
11	50	..	60	130	50	100.0
12	30	25	60	130	100	99.7
13	45	25	60	130	100	99.7
14	60	25	60	130	100	99.7
15	30	25	60	200	100	98.7
16	30	25	60	300	200	98.7
17	30	25	60	400	300	98.4
18	45	25	60	200	100	99.4
19	45	25	60	300	200	99.4
20	45	25	60	400	300	98.1
21	60	25	60	200	100	99.7
22	60	25	60	300	200	99.7
23	60	25	60	400	300	98.8
24	35	25	15	130	100	98.3
25	35	25	30	130	100	98.7
26	35	25	30	130	100	99.3
27	35	25	60	130	100	99.5
28	35	25	120	130	100	99.8
29	35	25	240	130	100	99.8
30	35	25	360	130	100	99.8

Selective oxidation of vanadium in the presence of chromium and other constituents of alloy steels was brought about by boiling the solution of the sample in a rather high concentration of nitric acid under conditions to be defined later. Table I illustrates the effects produced by differences in the concentration of nitric acid, initial and final volumes of the solutions, and the time of boiling. In each case the vanadium present was 0.1021 g. This was reduced with a slight excess of ferrous sulfate and diluted with the stated amount of nitric acid with sufficient water to give the required volume. The solutions were titrated electrometrically with ferrous sulfate and potassium dichromate.

The accuracy of titrations of the character shown in Table I is not greater than one part in 300. Nevertheless the effect on the degree of oxidation of a large concentration of nitric acid in the final volume is clearly shown in Expts. 9, 10 and 11 as contrasted with Expts. 1, 2, 3, 17, 20 and 23. Unfortunately for the method a concentration of nitric acid greater than 45 cc. in a final volume of 100 cc. may result in the oxidation of chromium. Expts. 15 and 18 are somewhat low because it is not until the latter part of the period of boiling that the concentration of nitric acid reaches its most effective oxidizing value. Boiling for a period less than 1 hr. gives distinctly lower results as shown by Expts. 4, 24, 25 and 26.

TABLE II—THE EFFECT OF IRON AND SULFURIC ACID UPON THE OXIDATION OF VANADIUM

Expt. No.	H ₂ SO ₄ Cc.	HNO ₃ Cc.	Fe Grams	V Gram	Time Min.	Initial Volume Cc.	Final Volume Cc.	V Oxidized Per cent
31	..	40	1	0.0500	120	200	40	100.0
32	..	40	1	0.0500	30	150	100	98.1
33	25	40	1	0.0500	60	150	100	99.1
34	50	40	1	0.0500	60	150	100	98.7
35	25	40	2	0.0025	60	150	100	101.0
36	25	40	2	0.0050	60	150	100	100.0
37	..	40	1	0.0200	60	150	100	99.5

When large amounts of vanadium, iron, and sulfuric acid are present, the oxidation of the vanadium appears to be inhibited. Expt. 31 in Table II shows

¹ J. Am. Chem. Soc., 38 (1916), 349.

² THIS JOURNAL, 9 (1917), 780.

complete oxidation of the vanadium in the presence of 1 g. of iron when sulfuric acid is absent and the final volume is small. Expts. 32, 33 and 34 show a low oxidation of vanadium as compared with oxidation in Table I by similar concentrations of nitric acid in the absence of sulfuric acid and in the presence of only small amounts of iron. On the other hand, Expts. 35 and 36 show that very small amounts of vanadium may be completely oxidized in the presence of considerable amounts of both sulfuric acid and iron. The oxidation of chromium by nitric acid is variable. It occurs only in concentrations of nitric acid of almost constant boiling strength, and even then, only after boiling for a considerable length of time. Boiling 1-g. samples of steel containing 1.5 per cent of chromium with from 40 to 70 cc. of concentrated nitric acid from a volume of 200 cc. to volumes of 20, 40 and 60 cc. gave solutions which when titrated contained oxidized chromium.

As a result of a large number of experiments, part of which are shown in Tables I and II, we have observed that the degree of oxidation of the vanadium varies widely with the conditions of the oxidation. All practical purposes, however, are adequately served by assuming that the vanadium is 99 per cent oxidized when a 1-g. sample of steel is dissolved in 80 cc. of sulfuric acid (sp. gr. 1.20), oxidized with a few drops of nitric acid diluted to 100 or 125 cc., and further oxidized by boiling at least 1 hr. with 40 cc. of nitric acid, taking care that the volume of the solution does not fall below 100 cc. Under these conditions we have never noted any oxidation of chromium, and check determinations on a sample of steel containing 2 per cent of vanadium agreeing within 0.02 per cent. When 2-g. samples of steels containing 0.15 to 0.25 per cent of vanadium are used, the agreement is usually within 0.01 per cent.

When tungsten is present in the steel, the tungstic oxide formed during the solution of the sample always retains a small amount of vanadium. The amount of vanadium so retained appears to be dependent rather upon the amount of tungstic oxide than upon the amount of vanadium. An excess of a uranyl salt precipitated with ammonia carries down completely small amounts of vanadium which may be present. To test this point we have prepared a solution of uranium nitrate containing about 4 g. of the salt in 1 l. To different amounts of this solution we added a few drops of sulfuric acid, 20 cc. of ammonium vanadate solution containing 21.0 mg. of vanadium, carbon dioxide-free ammonia in excess, and boiled for a few minutes. The precipitate was then filtered out, washed, and dissolved in dilute sulfuric acid. The vanadium in this solution was oxidized with silver nitrate and ammonium persulfate and determined electrometrically. The precipitation of vanadium was complete when 30 cc. of the uranium solution were used. When various quantities of tungstic oxide were present in the original mixture of uranium nitrate, sulfuric acid, and ammonium vanadate, ammonia served to dissolve the tungstic oxide and at the same time to completely precipitate both the uranium and the vanadium. We added 20

cc. of the ammonium vanadate solution to seven 1-g. samples of a steel containing 11 per cent of tungsten, but free from chromium and vanadium. After solution of the steel and oxidation of the tungsten, the tungstic oxide was filtered out and dissolved in ammonia. The solution was made barely acid with sulfuric acid, 30 cc. of the uranium nitrate solution added, followed by a slight excess of ammonia. The vanadium in the seven precipitates averaged 0.14 mg. Seven similar precipitates combined in one solution gave a precipitate containing 0.77 mg. of vanadium. On a single precipitate the titration was only 0.14 cc., and since the latter required 0.77 cc., it is considered a more reliable figure. Seven other precipitates formed in the presence of 5 cc. of ammonium vanadate solution also contained 0.77 mg. of vanadium. It is thus evident that a fourfold increase in the amount of vanadium present makes no measurable difference in the amount of vanadium occluded by the tungstic oxide. With this 11 per cent tungsten steel, the vanadium occluded amounts to 0.01 mg. per per cent of tungsten. Under similar conditions, but with tungsten varying from 5 to 30 per cent, the occluded vanadium was found to be in about the same proportion. We carried out similar experiments with steels containing chromium. When the vanadium was oxidized with nitric acid, the vanadium found in the tungstic oxide was in the proportion of 0.01 mg. per per cent of tungsten, but when ammonium persulfate was used to oxidize the solution, the apparent vanadium corresponded to 0.012 mg. per per cent of tungsten. This is undoubtedly due to traces of chromium which could not be washed out of the precipitate. This quantity of chromium, corresponding to 0.09 mg. or 0.009 per cent in a 1-g. sample of ordinary high-speed steel, is so small as to be entirely negligible. Under the conditions of our experiments the amount of vanadium occluded was so regular that we have adopted the practice of adding to the vanadium found by titration 0.001 per cent for each per cent of tungsten present. Thus for a steel containing 15 per cent of tungsten we would add 0.015 to the value otherwise found. No correction is made for chromium.

METHOD FOR THE DETERMINATION OF VANADIUM IN STEEL

When the amount of vanadium is less than 0.5 per cent, dissolve a 2-g. sample in 100 cc. of sulfuric acid (sp. gr. 1.20). With higher percentages of vanadium use a 1-g. sample and dissolve in 80 cc. of sulfuric acid of sp. gr. 1.20. When solution is complete add nitric acid, drop by drop, to the amount of 2 cc. Boil until the oxides of nitrogen are removed and until the tungstic oxide is yellow if there is any present. Dilute the solutions with hot water to a volume of 100 to 125 cc. and add 40 cc. of concentrated nitric acid. Boil this solution during 1 hr. or more at such a rate that the volume does not fall below 100 cc. Cool, dilute to 300 cc., and titrate electrometrically at 20° C. or lower with ferrous sulfate and dichromate solution. For this purpose a solution of dichromate may be prepared by dissolving 0.9609 g. of potassium

dichromate in a liter of water. The ferrous sulfate solution may be made by dissolving 8 g. of ferrous ammonium sulfate and 50 cc. of sulfuric acid in 1 l. of water which is then diluted until it is of the same strength as the dichromate solution. These solutions need frequent renewal. The dichromate solution, which is the standard, must be kept in well-stoppered bottles and should be freshly prepared at least once a week. One cubic centimeter of this dichromate solution is equivalent to 0.1 per cent of vanadium in a 1-g. sample.

The titration of the nitric acid solution of the oxidized vanadium corresponds to 99 per cent of the vanadium present. Accordingly this may be calculated by dividing by 0.99 or approximated by adding 1 per cent of the amount found by titration. The vanadium retained by the tungsten is not ordinarily determined in most of the published methods. As indicated above, this corresponds in the case of 1-g. samples to 0.001 per cent of vanadium for each per cent of tungsten present. This may be calculated and added, or in the case of most tungsten vanadium steels, it may be closely enough approximated by adding 0.014 per cent since these usually contain 13 to 15 per cent of tungsten.

THE DETERMINATION OF CHROMIUM IN CHROME-VANADIUM STEELS

Dissolve 1 g. of samples containing less than 5 per cent of chromium in 70 cc. of sulfuric acid (sp. gr. 1.20). Use smaller samples when the percentage of chromium is higher. In chromium and chromium vanadium steels it is often necessary to evaporate until salts separate to decompose carbides. Dilute the solution cautiously to a volume of 75 cc. This evaporation does not appear to be necessary, nor is it desirable, in the case of tungsten steels. After dissolving the separated salts, or after solution of the tungsten steel, 2 cc. of nitric acid are added cautiously. The solution is then boiled about 5 min. It is next diluted with hot water to a volume of 250 to 300 cc. and heated to boiling. To the boiling solution are added 10 cc. of silver nitrate solution (2.5 g. per l.) and 20 cc. of ammonium persulfate solution (100 g. per l.). For higher percentages of chromium larger amounts of persulfate should be used. The amount to use can be determined by observing the color of the solution which should become permanently colored with permanganic acid after 2 or 3 min. The solution should be allowed to boil at least 8 min. after the last addition of persulfate to permit of the complete decomposition of the latter. While still boiling, add 5 cc. of dilute hydrochloric acid (1 : 3) and continue boiling at least 5 min. After cooling to 20° C. the solution is ready to titrate.

A solution of potassium dichromate is prepared by dissolving 2.829 g. of the salt in enough water to make a liter. The iron solution is prepared by dissolving 23 g. of ferrous ammonium sulfate and 100 cc. of sulfuric acid in enough water to make a liter. The iron solution is then diluted to correspond to the dichromate solution. One cubic centimeter of this solution is equivalent to 0.1 per cent of chromium in a 1-g. sample. The dichromate solution should be renewed at least

once a week and the ferrous sulfate solution should be compared with the former daily.

Both chromium and vanadium are titrated, and the end-point observed is the vanadium end-point which has been described by Conant and one of us.¹ Take the number of cubic centimeters of the dichromate solution used in titrating the vanadium, after correction for the fact that the vanadium is only 99 per cent oxidized, but without including that portion which is in the tungstic oxide, and multiply by 0.339. This factor expresses the relation between the dichromate solution used for titrating vanadium and that used for titrating chromium. The number of cubic centimeters so found are to be subtracted from the total titration of chromium and vanadium. This gives the amount used in titrating chromium alone.

To illustrate the results obtained by the application of the methods described above to the analysis of synthetic steels we give the following:

Two grams of bar iron, dissolved as required in the vanadium determination, were treated at the time of solution with chromate solution corresponding to 1.25 per cent chromium and vanadate solution corresponding to 0.272 per cent vanadium. In three such solutions we found 0.27(3), 0.27(1), and 0.27(9) per cent vanadium. To 1 g. of a tungsten steel which was especially prepared under circumstances which would insure the presence of less than 0.01 per cent of chromium or vanadium, we added, at the time of solution, chromate solution corresponding to 4.23(7) per cent chromium and vanadate corresponding to 2.20(8) per cent vanadium. Of course, both the vanadate and chromate were completely reduced in the process of solution. Vanadium determined in three such solutions was found to be 2.19(9), 2.20(2), and 2.19(9). Chromium was determined as 4.23(7), 4.22(0), and 4.21(7).

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A SIMPLIFIED WET COMBUSTION METHOD FOR THE DETERMINATION OF CARBON IN SOILS

By D. D. WAYNICK
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The determination of total carbon through oxidation with a mixture of chromic and sulfuric acids is a method given in nearly all treatises on quantitative analysis. As applied to the determination of total carbon in soils and soil extracts, the method has been modified by different investigators, both from the standpoint of increased accuracy in the determination itself and the simplification of the apparatus. Of the modifications recently proposed, that of Gortner² provides for the weighing of the carbon dioxide evolved after absorption in potassium hydroxide, while both Ames and Gaither,³ and, more recently, Schollenberger,⁴ have used barium hydroxide as an absorbent, titrating with a standard acid. The first of these modifications is objectionable in that the time

¹ *J. Am. Chem. Soc.*, **38** (1916), 343.

² *Soil Science*, **2** (1916), 401.

³ *THIS JOURNAL*, **7** (1915), 561.

⁴ *Ibid.*, **8** (1916), 1126.

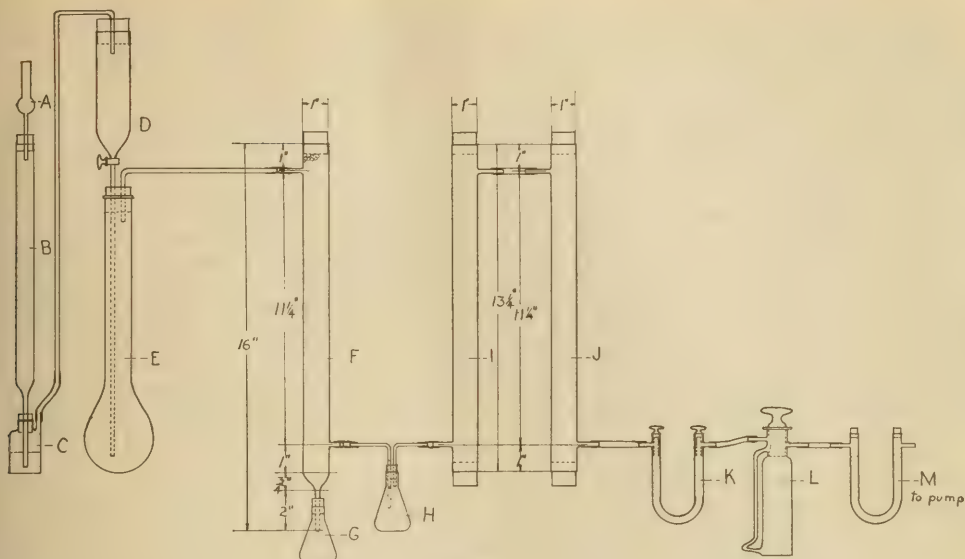


FIG. 1

required is about $2\frac{1}{2}$ hrs., while the chief objection to the two latter methods lies in the use of barium hydroxide as an absorbent, the inherent difficulties in its protection from the carbon dioxide of the air and in the titration of the excess barium hydroxide. The work in hand requiring the determination of total carbon in a large number of soil samples, the author undertook to modify the apparatus usually used in the wet combustion method to the end that the carbon dioxide evolved might be absorbed in soda lime and thus determined gravimetrically and that the time might be so reduced that the determination could be rapidly as well as accurately made. It is believed that both of these objectives have been attained and that the method outlined below will serve as a practical working scheme for the determination of total carbon in soils or similar substances.

REAGENTS

The reagents used are essentially those given by Ames and Gaither,¹ except that the chromic acid solution contained 3.3 g. in 5 cc. of water. This amount of chromic acid, together with 50 cc. of sulfuric acid, were used for each combustion. It was found necessary to boil the chromic acid solution after the addition of a little sulfuric acid to expel any carbon dioxide which might be present.

APPARATUS

The form of apparatus finally adopted is essentially different from any proposed heretofore and for that reason will be taken up somewhat at length. The essential details are given in Fig. 1, although the apparatus may be arranged on the table in any manner which circumstances demand. As set up in this lab-

oratory, 4 units occupy less than 6 ft. of table space. The air enters the apparatus through A, which is simply a tube filled with calcium chloride. It next passes through a column of 30-mesh soda lime in B and a small volume of concentrated potassium hydroxide in C. This potassium hydroxide solution is the only liquid in the train and is in place simply as a means of keeping check on the rate of flow of air through the apparatus. The dropping funnel D holds the sulfuric acid before its introduction into the combustion flask E, which is a 300 cc. long-necked Kjeldahl flask. The rate of flow of air through the apparatus is regulated entirely by the stopcock shown as part of the dropping funnel. The first of a series of three scrubbers shown at F is filled with glass beads wet with sulfuric acid. This scrubber takes the place of a condenser usually employed as a part of the purifying train and under operating conditions removes most of the sulfur trioxide fumes which come over from the combustion flask E. The dilute sulfuric acid condensed in F is caught in a 100 cc. Erlenmeyer flask, G, with a second flask, H, of the same size serving to prevent any acid from getting into the scrubber shown at I, which is filled with 30-mesh zinc amalgamated with mercury. The trap H may be partially filled with a concentrated solution of silver sulfate if the scrubber I does not remove all the chlorine as well as sulfur trioxide fumes. It has been found necessary to renew the zinc after about 300 determinations and, if coarser pieces are used, it will be necessary to make the renewal at more frequent intervals. The upper half of J is filled with calcium chloride and the lower half with phosphoric anhydride, the two being separated by a layer of glass wool. The various materials in the three scrubbers are supported by layers

¹ THIS JOURNAL, 7 (1915), 561.

of glass wool extending above the lower inlet or outlet openings. The scrubbers themselves are simple in design and may be easily constructed by any glass blower. After leaving the scrubber, the air current, free from the last traces of sulfur trioxide and water, passes through the U-tube filled with calcium chloride and into the Nesbitt carbon combustion bulb¹ which is filled with 20- to 30-mesh soda lime, except for a small space at the top, which is occupied by a thin layer of phosphoric anhydride. The U-tube K is not a necessary part of the train if a glass stopcock is available, as its only use is to avoid any chance of a current of air passing in reverse direction through the apparatus while the combustion flask E is cooling. The U-tube M completes the train, being filled with calcium chloride and soda lime to avoid any possible contamination of the combustion bulb by stoppage of the pump. The whole system is connected with a suction pump, or any other means of pulling a current of air through the apparatus.

Before making any determinations, it is well to pass a current of carbon dioxide through the entire apparatus² to ensure the saturation of the calcium chloride with carbon dioxide. This is done with a piece of glass tubing replacing the combustion bulb L.

METHOD OF OPERATION

From 5 to 15 g. of soil are introduced into the combustion flask E, together with 5 cc. of the chromic acid solution. Fifty cc. of sulfuric acid are then run into the flask rapidly and the amount of air passing through the apparatus regulated by observing the rate of passage of the bubbles of air through the potassium hydroxide solution contained in C. A gas flame of a height which will ensure a boiling temperature of the mixture in the combustion flask within a time period of 5 min. is started as soon as all the acid has been run into the flask. Heating is continued for about 20 min., after which the combustion flask E is allowed to cool, aspiration being continued for 5 min. longer, however. The only operation remaining is to close and weigh the absorption bulb L. Aspiration should proceed throughout the entire time period at a rate which will ensure about 5 liters of air being drawn through the apparatus, but not so rapidly that the sulfur trioxide fumes will be carried over in excessive amounts.

In weighing the absorption bulbs, it is well to use a second bulb filled, like the first one, with soda lime, as a counter balance. This procedure renders insignificant errors in weighing, due to differences in the amount of moisture condensed on the surfaces of the bulbs. Under normal working conditions, it has been found possible to weigh with an average error of 0.0010 g. or, in terms of carbon, about 0.02 per cent. It is well to have two complete sets of bulbs so that it will not be necessary to make the weighings while the apparatus is idle. With two sets, it is possible to allow 20 min. after the determination is completed for the bulbs to cool and still have the weigh-

ings made and the bulbs ready for the next series of determinations. In this way the author has made 48 determinations in a day, using four units of the apparatus as shown in Fig. 1.

Whenever it becomes necessary the zinc, calcium chloride, or phosphoric anhydride may be easily removed from the scrubbers by simply removing the rubber stoppers at either end and pushing the material out. A scrubber may be easily renewed in 10 min. with a minimum danger of breakage as compared to the difficulties of renewal and danger of breakage of the U-tubes usually used in drying trains. With a soil containing one per cent of carbon, about 100 determinations may be made with a combustion bulb before the soda lime is exhausted. If desired, phosphoric acid may be used in the combustion chamber as proposed by Schollenberger.¹ If present in an amount greater than the limits of error for the total carbon, carbon in the carbonate form must be determined and subtracted from the figure obtained by above method.

ACCURACY

It is recognized that a method which sacrifices accuracy for a gain in time is of very questionable value. As stated above, the error in weighing the combustion bulb amounted to 0.02 per cent in terms of carbon. That the determination itself is subject to practically the same error is shown by the data given in Table I. Ten determinations are recorded, all made upon a sample of soil thoroughly mixed and ground. The maximum variation between any two determinations is 0.03 per cent, while the average variation is less than 0.010 per cent. The absolute accuracy of the determination for carbon on this particular sample was checked by P. L. Hibbard, using a modification of the method proposed by Ames and Gaither, his data agreeing with that in Table I, within the limits of error already given.

TABLE I

No.	Carbon Per cent	No.	Carbon Per cent
1.....	1.358	6.....	1.372
2.....	1.377	7.....	1.354
3.....	1.358	8.....	1.361
4.....	1.351	9.....	1.351
5.....	1.374	10.....	1.372

A series of ten determinations made in duplicate on two soils is given in Table II. These determinations are selected at random from 200 determinations run in duplicate in a study of field variability made upon these soils.

TABLE II

DAVIS SOIL Per cent Carbon		OAKLEY SOIL Per cent Carbon	
No.	I II	No.	I II
1.....	1.168 1.167	6.....	0.624 0.641
2.....	0.883 0.910	7.....	0.179 0.178
3.....	1.186 1.210	8.....	0.355 0.382
4.....	1.125 1.120	9.....	0.279 0.311
5.....	1.025 1.044	10.....	0.420 0.442

It will be noted that the greatest difference between the duplicate determinations amounts to 0.027 and 0.032 per cent, respectively. These differences are somewhat greater than the error in weighing the combustion bulbs, but is regarded as an error due to sampling rather than in the method of making the determination.

¹ Made by Scientific Materials Co. Full directions for filling the bulb are furnished with the apparatus.

² *J. Am. Chem. Soc.*, **39** (1917), 2057.

¹ *This Journal*, **8** (1916), 1126.

A sample of Merck's urea gave 20.28 per cent carbon against a calculated 19.99 per cent, while sucrose gave 41.98 per cent against a calculated 42.08 per cent. It is probable, as has already been noted by Salter,¹ that any oxides of nitrogen which may be formed are reduced in the zinc tube and hence are not a source of error in the determination.

SUMMARY

A simple, inexpensive apparatus is here reported for the determination of carbon in soils and similar substances by the wet combustion method, using chromic and sulfuric acids. The total time for the determination is about 25 min. Data have been presented showing that the method as outlined is subject to errors of small magnitude.

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EFFECT OF EXPOSURE ON RAW LINSEED OIL

By E. J. SHEPPARD

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The most important property of linseed oil is that, when spread in thin layers and exposed to air, it absorbs oxygen and undergoes little-known changes in composition, yielding an elastic solid skin. This phenomenon is termed "drying" and on it depends the extensive industrial use of linseed oil in the manufacture of paint, varnish, linoleum, etc.

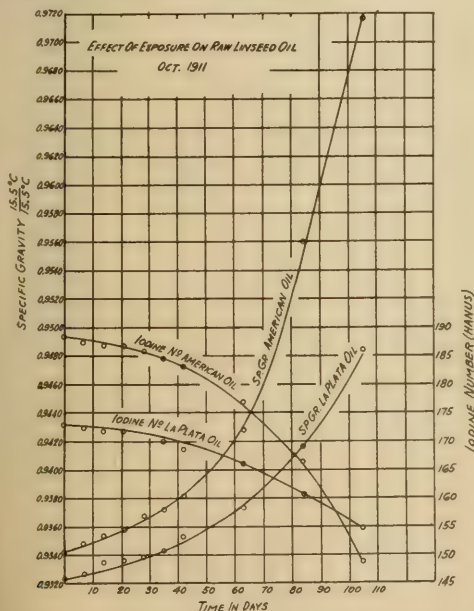


FIG. 1

The changes which take place in linseed oil when exposed to air have been studied by a number of in-

¹ THIS JOURNAL, 8 (1916), 637.

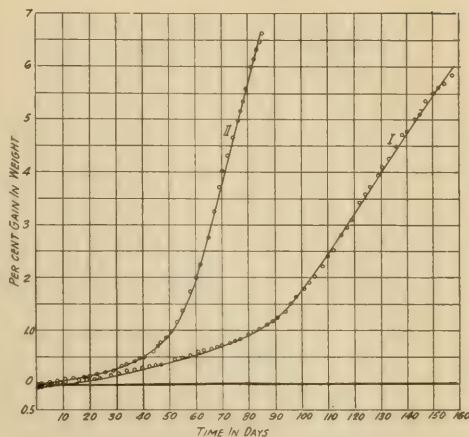


FIG. 2—EFFECT OF EXPOSURE ON RAW LINSEED OIL

I = 0.95 Sq. Cm. Surface per Gram Oil
II = 2.00 Sq. Cm. Surface per Gram Oil

vestigators. Ballantyne¹ allowed linseed oil to stand in an uncorked bottle exposed to light. The oil was shaken daily and at intervals analyzed. Ballantyne found that under these conditions the iodine number decreased, while the specific gravity and acid number increased without a change in volume.

Sherman and Falk² studied the same question similarly and found a lower iodine number and higher specific gravity and a small increase in acidity. These authors found a 3.43 per cent increase in specific gravity calculated on the original weight, while elementary analysis showed that the oil had taken up 3.16 per cent oxygen. They concluded that the greater increase in specific gravity was probably due to a slight contraction in volume.

Sabin³ exposed raw linseed oil in thin films for 8 mo. and found a specific gravity of 1.098 and a gain in weight of not more than 2 per cent. Assuming a specific gravity of 0.932 for the original oil, Friend⁴ calculated a contraction in volume of 13.4 per cent for Sabin's film.

Thompson⁵ exposed two varieties of raw linseed oil in thin films for 212 days and found

	Sp. Gr.	Gain in Wt. Per cent	Decrease in Vol. Per cent
North American Oil...	1.16	8.25	13.0
South American Oil.....	1.15	7.70	12.4

Friend⁶ oxidized raw Calcutta oil by passing air through the oil and by spreading in thin films on glass. He found that as the oil gained in weight the density increased, while the volume increased to a maximum and then slowly decreased.

Except for the determinations of Sabin, of Thompson, and of Friend, there are no data known to the writer

¹ J. Soc. Chem. Ind., 10 (1891), 29.

² J. Am. Chem. Soc., 25 (1903), 711; 27 (1905), 605.

³ THIS JOURNAL, 3 (1911), 84.

⁴ J. Chem. Soc., 111 (1917), 162.

⁵ Trans. Am. Inst. of Chem. Eng., 8 (1915), 251.

⁶ Loc. cit.

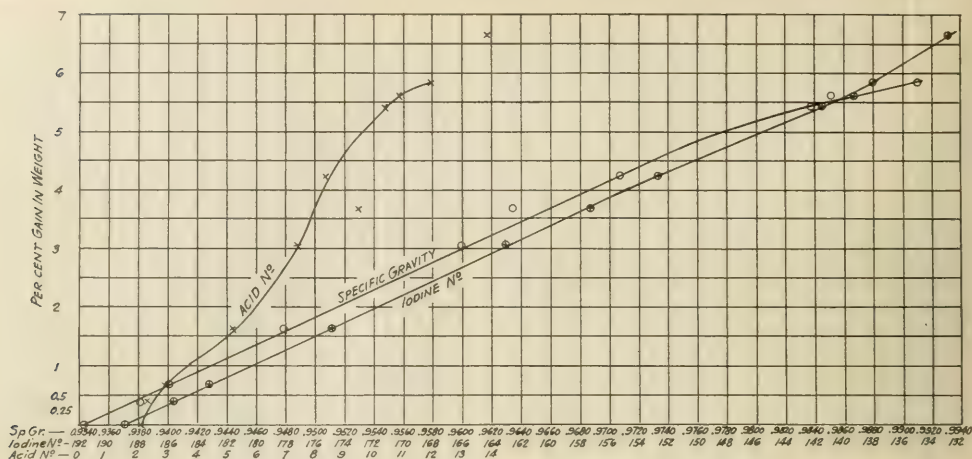


FIG. 3.—CHANGES IN CONSTANTS WITH GAIN IN WEIGHT OF RAW LINSEED OIL.

showing the variation of the constants with gain in weight of raw linseed oil on exposure to atmospheric oxidation. In 1911 the writer exposed two samples of raw linseed oil in shallow glass dishes of approximately 12.5 cm. diameter in a dust-proof glass top cabinet which permitted circulation of air. In order to prevent the formation of a skin, the oils were thoroughly stirred at least twice a day. At intervals the oil in each dish was thoroughly mixed and the specific gravity and iodine number determined, with the results as shown in Table I and Fig. 1.

TABLE I.—EFFECT OF EXPOSURE ON RAW LINSEED OIL

Age Days	NORTH AMERICAN		LA PLATA	
	Sp. Gr. 15.5° C.	Iodine No. (Hanus)	Sp. Gr. 15.5° C.	Iodine No. (Hanus)
0	0.9342	188.4	0.9323	173.0
7	0.9348	187.3	0.9327	172.4
14	0.9355	186.8	0.9335	171.9
21	0.9357	186.8	0.9336	171.8
28	0.9368	185.6	0.9338	171.5
35	0.9372	184.6	0.9343	170.0
42	0.9382	183.2	0.9353	168.6
63	0.9428	177.0	0.9374	166.4
84	0.9561	166.4	0.9417	160.6
105	0.9717	149.0	0.9485	154.9

By withdrawing portions of the oils for determination of the constants, the volumes of the oils were gradually reduced, thus increasing the oil surface per gram of oil; or, in other words, decreasing the thickness of the oil layer. Now, since it is well known that, other things being equal, thin layers dry more rapidly than thick layers, these experiments suggested two questions: First, given layers of different thicknesses, are the changes in the constants the same for the same change in weight? Second, what is the quantitative effect of thickness of layer upon the rate of change in the constants?

In order to determine the variation of the constants for determined gains in weight, some pure, raw North American linseed oil was exposed in 10 shallow round glass dishes, eight of 9.2 cm. diameter and two of 9.7 cm. diameter, and the dishes kept in a glass top cabinet protected from dust but permitting circulation of air.

About 70 g. of oil, accurately weighed, were placed in the eight smaller dishes, and about 36.9 g. in the two larger dishes. Each dish held throughout the test a glass stirring rod. Twice daily each sample was thoroughly stirred and at intervals the gain in weight noted. At longer intervals, the samples, one by one, were removed from the cabinet and certain constants determined. The length of exposure was limited by the formation of a skin, which would destroy the homogeneous character of the sample.

TABLE II.—PER CENT GAIN IN WEIGHT OF RAW LINSEED OIL.

0.95 Sq. Cm. Oil Surface			2.0 Sq. Cm. Oil Surface			0.95 Sq. Cm. Oil Surface			2.0 Sq. Cm. Oil Surface		
Age Days	Per Gram Oil		Per Gram Oil			Age Days	Per Gram Oil		Per Gram Oil		
1	—0.05		—0.04			71	....		4.14		
2	—0.05		—0.015			72	....		4.30		
3	—0.035					73	0.75		....	
5	—0.025		+0.01			74	....		4.65		
7	+0.01					75	0.80		4.78		
8			0.05			76	....		4.96		
9	0.03					77	0.88		5.14		
11	0.04		0.065			78	....		5.33		
12	0.04					79	....		5.58		
14			0.10			80	0.92		....	
16	0.06					81	....		5.99		
18			0.115			82	0.96		6.14		
19	0.07					83	....		6.31		
20			0.135			84	1.01		6.46		
22	0.08					85	....		6.63		
23			0.18			87	1.11		....	
24	0.11					89	1.18		....	
26			0.20			91	1.23		....	
28	0.15					94	1.36		....	
29			0.24			96	1.50		....	
31	0.19		0.32			98	1.64		....	
34	0.23		0.36			101	1.79		....	
37	0.25		0.42			103	1.91		....	
39			0.47			105	2.01		....	
40	0.28					108	2.21		....	
41			0.50			110	2.42		....	
43	0.33					112	2.57		....	
44			0.61			115	2.80		....	
45	0.34					117	2.95		....	
46			0.70			119	3.09		....	
47	0.35		0.77			122	3.41		....	
49	0.39		0.86			124	3.58		....	
51			0.99			126	3.72		....	
52	0.45					129	3.93		....	
53			1.16			131	4.08		....	
55	0.48		1.37			133	4.23		....	
58	0.525		1.74			136	4.49		....	
60			2.00			138	4.69		....	
61	0.60					140	4.76		....	
62			2.25			143	5.00		....	
63	0.625		2.76			145	5.09		....	
65						147	5.33		....	
66	0.655					150	5.49		....	
67			3.25			152	5.60		....	
68	0.69					154	5.68		....	
69			3.71			157	5.84		....	
70	0.71		4.02								

Table II and Fig. 2 give the time-gain in weight results. It is worthy of note that all samples showed a loss in weight during the first few days, although a well-settled oil was used. The longer the exposure the paler the oils became; Samples 6, 7 and 8, however, show practically no difference. The amount of oil placed in the large dishes made a layer about one-half as thick as the oil placed in the small dishes. In Fig. 2 the effect of thickness is clearly brought out showing that the thin layer gained in weight about twice as rapidly as the thick layer.

Without regard to the thickness of the layers, the evolution of pungent volatile products became distinctly noticeable when the oils had gained about one per cent in weight.

In Table III are assembled the analytical results shown in Fig. 3. Samples 7 and 8 skinned very slightly when 152 days old; this skin was stirred up with the oil and Sample 7 removed, while Sample 8 was continued 5 days longer, when it skinned again. It is remarkable to note, however, that Sample 10 did not skin, although it had gained about 1 per cent more in weight. There is a change in the specific gravity curve at the point of skinning of Samples 7 and 8 but no noticeable effect is produced in the iodine number curve. The acid numbers are rather irregular. Calculations of the per cent change in volume have been made but yield results not so decisive as those reported by Friend.

TABLE III—DATA SHOWING THE EFFECT OF EXPOSURE ON RAW LINSEED OIL

Sample No.	Age in Days	Gain in Weight Per cent	Sp. Gr. 15.5° C.	Iodine No. (Hanus)	Acid No.	Change in Volume Per cent	Relative Viscosity	Oil Surface per Gram Oil
Raw	0	...	0.9345	188.7	2.2	...	1.00	0.95
1	49	0.38	0.9383	185.2	2.4	-0.02	1.15	0.95
2	70	0.69	0.9403	183.0	3.0	+0.07	1.25	0.95
3	98	1.63	0.9481	174.6	5.3	+0.17	2.00	0.95
4	119	3.05	0.9602	162.8	7.5	+0.29	4.30	0.95
5	135	4.22	0.9710	152.4	8.5	+0.30	7.35	0.95
6	148	5.41	0.9840	141.2	10.5	+0.10	...	0.95
7	152	5.60	0.9854	139.2	11.0	+0.14	...	0.95
8	157	5.84	0.9913	137.7	12.1	-0.22	...	...
9	69	3.67	0.9638	157.0	9.6	+0.52	6.00	2.0
10	85	6.63	...	132.6	14.0	...	...	2.0

It was found that 1 g. of each of the oils would easily and completely dissolve in 100 cc. of benzene. The figures in column "Relative Viscosity" are rough approximations only and were obtained by measuring the time required for 10 cc. of the oil to flow from a pipette, taking the time of efflux of the raw oil as 1.00.

It will be observed in Fig. 3 that the iodine numbers of the oils in thin layers fall exactly on the curve of the oils in thick layers; while the specific gravity of Sample 9 is not far from the specific gravity curve of the thick layers.

SUMMARY

The effect of exposure on certain constants of raw linseed oil has been determined over a limited range of gain in weight. The thickness of the exposed layer of oil appears to affect only the rate of change in the constants. For any gain in weight over the range covered by these experiments, the changes occurring in the constants appear to be independent of the rate of gain in weight.

NATIONAL LEAD COMPANY
St. Louis, Missouri

CARBON TETRACHLORIDE, CHLOROFORM AND CARBON HEXACHLORIDE FROM NATURAL GAS¹

By G. W. JONES AND V. C. ALLISON

Received December 21, 1918

As a result of the war, the Government desired the maximum amount of carbon tetrachloride and chloroform to carry on the gas program. A great many of the gases used in modern warfare are derived from these sources. In view of the above fact, and also because after the war a great amount of chlorine, which is now being used for war purposes, will be turned back toward peaceful enterprises, the Bureau of Mines has undertaken an investigation on the production of useful products by the chlorination of natural gas and thus utilize part of this excess chlorine. The gas from many fields of natural gas in the United States which yield a pure methane gas, free from the higher saturated hydrocarbons, ethane, propane, etc., is especially desirable for making chlorinated products. The natural gas from several of these fields, notably those in Texas and Louisiana, in locations too far removed from industrial centers and large cities to warrant the expense of piping, could be successfully made into chlorinated products.

In this report only a preliminary survey of work done on a small scale is given and more elaborate results of the investigation will be published as the work develops.

A large amount of experimental work has been done along these lines during the last 25 years but so far nothing of practical value, that the authors are aware of, has been accomplished.² The general tendency has been to use a large excess of either chlorine or natural gas to prevent explosion. If a large excess of either gas is used the products desired are hard to separate from the excess of inert gas, since the deposition of the chloroform and carbon tetrachloride depends upon the partial pressure of these products in the gaseous state at the given temperature at which they are separated and the reaction cannot be controlled to produce the products desired. That the chlorination may work successfully there is required a catalyzer which will cause the reaction to proceed smoothly without explosions or deposition of carbon, and which will accomplish the substitution of the chlorine in the methane and ethane molecule according to the reaction $\text{CH}_4 + 4\text{Cl}_2 = \text{CCl}_4 + 4\text{HCl}$ instead of the production of carbon and hydrochloric acid in accordance with the reaction $\text{CH}_4 + 2\text{Cl}_2 = \text{C} + 4\text{HCl}$. A great many catalyzers will cause chlorine and methane to react, when the temperature is high enough. In fact, no catalyzer is needed at all, but the reaction takes place violently and, being exothermic in character, explosively, and gives very little, if any, products other than carbon and hydrochloric acid. It is desirable to make the chlorination complete at one operation, hence if the desired product is carbon tetrachloride, four volumes of chlorine are caused to react with one volume of methane (natural gas), or in other words, the gases are caused to react in the ratios necessary to

¹ Published by permission of the Director of the Bureau of Mines.

² Phillips, Baskerville, and others.

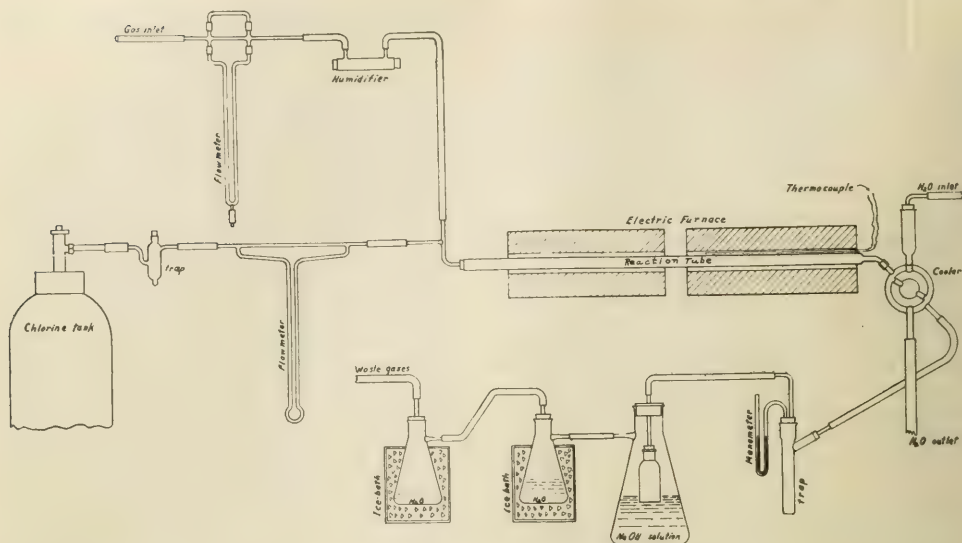


FIG. 1—APPARATUS FOR CHLORINATING NATURAL GAS

produce the most highly chlorinated products without any waste of chlorine.

Of the saturated hydrocarbons, methane is very much more inert toward chlorine than those of higher molecular weights. The authors found that at certain temperatures the chlorine reacted readily with the ethane while there was very little reaction with the methane. In fact, the chlorine reacted with the ethane to form carbon hexachloride before any chloroform or carbon tetrachloride was formed.

By using certain catalyzers, such as war-gas charcoal, steamed anthracite coal, and bachtite, the reaction took place smoothly without explosions or deposition of carbon even when the chlorine ratio was four or more to one of gas. When other catalyzers such as cokes impregnated with different metals and metallic oxides were used and four volumes of chlorine to one of gas were caused to react, a small amount of chlorine came through without reacting.

The best catalyzers for complete chlorination were those which had a high absorption coefficient for chlorine. The increased concentration of the chlorine causes an increase in the reaction velocity and the chlorination goes to completion.

War-gas charcoal was loaned to the Bureau by the American University Experiment Station and is the same as that used for filling canisters in gas masks. This is a high-grade charcoal and far superior to other charcoals tried. Nearly all others were practically useless as a catalyzer and were no better than inert material such as broken porcelain and silica.

Bachtite is a patented material made by the National Carbon Company. This has also been used for war-gas purposes.

The steam treated anthracite coal was made by reducing a commercial coal to a 4 to 10 mesh size.

The coal thus prepared was next placed in an iron retort kept at a temperature of approximately 700° F. and steamed for 70 hrs. Coal treated in this manner has the property of absorbing gases to a high degree, although the outward physical appearance shows no change.

GAS

The natural gas used was taken from the mains at the Bureau of Mines laboratories, Pittsburgh, Pa. This gas is supplied by the Consolidated Gas Company. On account of having ethane present, this gas is not so desirable as a pure methane gas, but on account of the accessibility and ease of application it was used in this work.

The average analysis of the gas during the time in which these experiments were made was as follows:

	Per cent
Methane.....	89.5
Ethane.....	10.1
Nitrogen.....	0.4

For computing the theoretical yield the gas was assumed to contain 90 per cent methane and 10 per cent ethane.

CHLORINE

The chlorine used was supplied by the Electro Bleaching Gas Co., of New York, in containers of 100 lbs. each.

APPARATUS

Fig. 1 shows the general plan of the apparatus for testing the effect of varying temperature and humidity on the reaction.

The gas and chlorine rates were regulated by flow meters calibrated against the gases used. The flow meters were of a very small capacity and were calibrated by passing a given volume of the gas from a

TABLE I—RESULTS WITH WAR-GAS CHARCOAL AS CATALYZER

CHARCLOR AS CATALYZER												
TEST No.	Humidity Per cent	Average Temperature Deg. C.	Av. Chlorine Rate Liters per Hr.	Av. Gas Rate Liters per Hr.	Time of Run Hrs.	Products Recovered Cc.	Theoretical Yield Cc.	Percentage Efficiency Per cent	Distillation Results—			REMARKS
									65° to 80° C. Per cent	Sp. Gr.	Above 80° C. Per cent	
1	1.1 per cent H ₂ O vapor	250	2.5	1	1	6.5	24.1	27	80	1.59	20	Chlorination not complete. Unable to use required amount of chlorine for complete chlorination
2	1.1 per cent H ₂ O vapor	300	4	1	6	15	24.1	62	90	1.60	10	Reacted smoothly without deposition of carbon or explosions
3	1.1 per cent H ₂ O vapor	350	4	1	6	22.5	24.1	93	84	1.59	16	Reacted smoothly without deposition of carbon or explosions
4	1.1 per cent H ₂ O vapor	400	4.5	1	6	24	24.1	99	95	1.60	5	Reacted smoothly without deposition of carbon or explosions
5	1.1 per cent H ₂ O vapor	450	4	1	5	17	20.0	85	90	1.60	10	Reacted smoothly without deposition of carbon or explosions
6	1.1 per cent H ₂ O vapor	500	4	1	6	23.5	24.1	97	85	1.59	15	Carbon began to deposit and smoke badly. Catalyst ignited but did not explode. Dense white fumes formed throughout the run
7	Gas saturated	400	5	1	6	19.5	24.1	81	90	1.58	10	It was necessary to use an excess of chlorine to chlorinate completely
8	Water removed	400	3.5	1	6	15.5	24.1	64	85	1.58	15	No fumes formed. Could not use four volumes of chlorine without coming through unacted upon

burette through the flow meter, at such a rate that by keeping the two columns of liquid in the U-tube at a certain height, a certain length of time was required to empty the burette. From these data the rate can be determined. After calibrating several points, a scale was made to read the rate directly.

The reaction tube shown in Fig. 1 contained 100 g. of catalyzer protected on either end by glass wool. An electric furnace surrounded the tube and the temperature was read on a millivoltmeter in conjunction with the thermocouple shown in the drawing. The hot gases after leaving the reaction chamber passed through a triple-walled condenser for cooling, then through a trap, sodium hydroxide scrubber, and two ice baths as shown. Most of the solid carbon hexachloride separated out in the cooler, while the carbon tetrachloride, being heavier than water or the sodium hydroxide solution, settled to the bottom of the scrubber and ice baths. The chief object of the sodium hydroxide solution was to remove the hydrochloric acid formed during the reaction. In all the tests made on this apparatus the gas rate was 1 l. per hr. For higher rates the apparatus shown in Fig. 2 was used.

After each run the distillates were collected from the scrubbers and ice baths, separated in a separatory funnel, measured, and then treated with a small piece of stick sodium hydroxide, to remove the dissolved chlorine, and calcium chloride, to remove the water. The distillations were carried out in a 50 cc. distillation flask at a rate of 2 drops per sec.

On all tests shown in Table I but a few drops came over below 70° C., indicating that very little, if any, was chloroform.

The gravities were determined with a specially designed plummet of small size which could be used on a Westphal balance and gravities on as low as 4 cc. of product were easily determined. Table I shows the results in tabulated form.

The reaction begins at a little below 250° C. and tends upward to around 500° C., where carbon begins to deposit and the catalyzer is attacked. The best results were obtained with a small amount of moisture present (1 per cent by volume). This tends to help the reaction.

All the products boiling below 85° C. were water-white and free from carbon.

CALCULATION OF YIELD

Yields were calculated from the volume of natural gas used, assuming that a liter of methane weighs 0.65 g. and ethane 1.22 g. when measured at 25° and 740 mm. pressure, the average condition under which the natural gas was measured. One liter of natural gas (90 per cent CH₄, 10 per cent C₂H₆) completely chlorinated should produce 4.01 cc. of liquid chlorination products, CCl₄ and C₂Cl₆.

The carbon hexachloride is very soluble in the carbon tetrachloride and that which crystallized out in the cooler was added each time to the product from the scrubber and distilled together. The distillate above 80° C. consisted of a mixture of carbon tetrachloride and carbon hexachloride. This could be separated by fractional distillation. The process is long and tedious and takes several distillations and subsequent coolings in an ice-salt bath, to freeze out the carbon hexachloride.

No other chlorine compounds have been identified in the products obtained by using four or more volumes of chlorine to one of gas when the rate of natural gas was 1 l. per hr.

When all the products boiling between 65° C. and 80° C. from the eight tests were put together and distilled, less than 1 cc. came over below 65° C., indicating a negligible amount of chloroform present.

The percentage efficiency of each run was obtained by multiplying the volume of gas used by 4.01 to give the theoretical yield which would be expected if the gas were chlorinated to carbon tetrachloride and carbon hexachloride and then the volume of products recovered was divided by the theoretical yield. This gave the efficiency on the basis of the amount of gas used.

Certain modifications of the apparatus were necessary in order to handle larger quantities of gas. The scrubbers were designed to work with low pressure and to be convenient for removal of the products and hydrochloric acid formed.

Fig. 2 shows the modified form including the scrubbers, drying tube, ice baths, and sampling device for testing the residual gas for methyl chloride.

The gas rates were determined with flow meters as

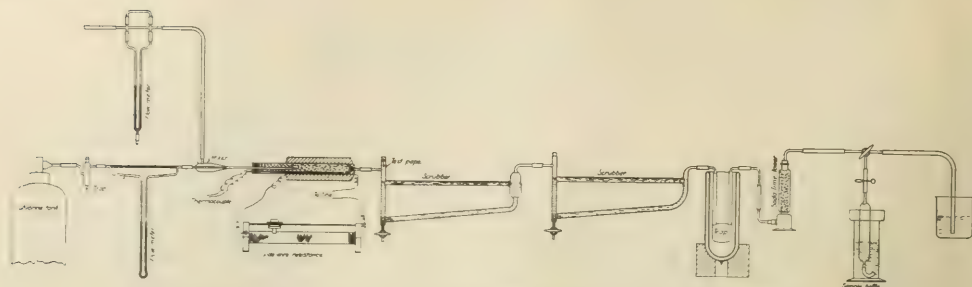


FIG. 2—MODIFIED FORM OF APPARATUS INCLUDING SCRUBBERS, DRYING TUBE, ICE BATHS, AND SAMPLING DEVICE

in the previous work. The gas and chlorine were introduced into the reaction tube through a mixer made on the order of an injector. The reaction tube is shown in Fig. 2, also the electric furnace surrounding it. After trying a great many tubes of different lengths and diameters, the one found most suitable for chlorinating up to 6 l. of gas per hr. was of Pyrex glass 16 in. long and $1\frac{1}{2}$ in. in diameter drawn down at one end so as to make connection with the scrubber. The tube protruded out of the furnace about 6 in. and this end was covered with asbestos paper to exclude the light. By having the gases mix in the cool part of the tube in the presence of the catalyzer, no explosions were produced on entering the heated section. The tube contained 200 g. of the catalyzer, held in place by glass wool placed at each end. This was then closed with a two-holed rubber stopper; through one hole passed the thermocouple

A thermocouple indicated the temperature in the reaction tube at all times. It was found that the temperature was somewhat higher at the point where the gases entered the reaction tube, due to the heat of reaction, and that after the reaction had commenced very little heat was necessary to maintain the desired temperature; the higher the rate of gas, the less heat was necessary.

The hot gases, on leaving the reaction chamber, are passed through low-pressure scrubbers of a special design shown in Fig. 3. These scrubbers, containing water, cool the heated gases and remove the hydrochloric acid formed during the reaction; the carbon tetrachloride, carbon hexachloride, and chloroform, which are heavier than water, sink to the bottom and can be drawn off by means of the stopcocks provided for the purpose at the bottom of each scrubber. One scrubber was found sufficient to completely remove

TABLE II

										Distillation Results in Per cent of Recovered Product									
TEST No.	Catalyzer	Humidity	Av. Temp. Deg. C.	Av. Gas Rate Liters per Hr.	Av. Chlorine Rate Liters per Hr.	Time of Run Hrs.													
							Product Recovered Cc.	Theoretical Cc.	Per Cent (a)	Efficiency (b)	To 70°		70° to 85°		Above 85° C.				
											Per Cent	Sp. Gr. 20/20	Per Cent	Sp. Gr. 20/20	Per Cent	Sp. Gr. 20/20			
9	War-Gas Charcoal	1.1 per cent H ₂ O vapor	375	3.4	19.0	6	77.0	81.8	94	95	10	1.55	85	1.58	5	1.65			
10	War-Gas Charcoal	1.1 per cent H ₂ O vapor	385	5.6	22.6	6	126	134.7	94	95	10	1.34	64	1.58	26	1.61			
11	War-Gas Charcoal	1.1 per cent H ₂ O vapor	395	5.3	24.6	5	105	106.3	99	99	3	1.55	82	1.59	15	1.63			
12	War-Gas Charcoal	1.1 per cent H ₂ O vapor	325	2.5	15.0	6	42.0	60.1	70	72	20	1.55	72	1.36	8	1.64			
13	War-Gas Charcoal	1.1 per cent H ₂ O vapor	400	4.0	16.0	16.5	217.1	264.7	82	82	0	0	78	1.59	22	1.62			
14	Bachite	1.1 per cent H ₂ O vapor	395	4.0	16.0	18.0	238.7	288.7	83	84	7	1.54	70	1.58	22	1.61			
15	Bachite	1.1 per cent H ₂ O vapor	375	2.7	14.0	6.5	65.0	70.4	92	93	4	1.56	65	1.59	31	1.60			
16	Bachite	1.1 per cent H ₂ O vapor	370	4.1	17.3	3.0	32.0	49.3	65	69	41	1.50	38	1.55	21	1.60			
17	Steamed Coal	1.1 per cent H ₂ O vapor	380	2.2	8.2	6.5	55.0	57.2	96	96	1	1.57	75	1.58	24	1.61			
18	Steamed Coal	1.1 per cent H ₂ O vapor	390	3.9	16.0	15.5	155.0	242.6	64	71	63	1.48	14	1.53x	32	1.62			

(a) On assumption that products are CCl₄ and C₂Cl₆. (b) On assumption that product to 70° C. is CHCl₃ and the rest CCl₄ and C₂Cl₆.

TABLE III

Compound	Formula	At 25° C.	Boiling Point Deg. C.	Specific Gravity
Methyl chloride	CH ₃ Cl	Gas	-23.7	0.9915 at -23.7
Dichloromethane	CH ₂ Cl ₂	Liquid	41.8	1.378 at 0/4
Chloroform	CHCl ₃	Liquid	61.2	1.50 at 15/15
Carbon tetrachloride	CCl ₄	Liquid	76.7	1.58 at 20/20
Ethyl chloride	CH ₃ CH ₂ Cl	Gas	12.5	0.923 at 2/2
Dichloroethane	CH ₃ CHCl ₂	Liquid	83.7	1.259 at 15/15
Ethylidene chloride	CH ₂ CHCl ₂	Liquid	57.4	1.18 at 15/15
Trichloroethane	CH ₃ CHClCH ₂	Liquid	115.0	1.45 at 15/15
Trichloroethane	CH ₂ CCl ₃	Liquid	74.5	1.32 at 15/15
Tetrachloroethane	CH ₂ CCl ₂ CH ₂	Liquid	135.0	1.61 at 0/0
Tetrachloroethane	CHCl ₂ CHCl ₂	Liquid	147.0	1.59 at 15/15
Carbon tetrachloride	CHCl ₂ CCl ₂	Liquid	199.0	1.71
Carbon hexachloride	C ₂ Cl ₆	Solid	M. P. = 187.0	2.0

well and through the other, the tube leading from the mixer.

The furnace was made by winding 40 ft. of No. 22 nichrome wire in the form of a helix, wrapping on an asbestos mandrel, and covering with a mixture of calcined magnesium oxide and sodium silicate, then covering this with several layers of asbestos paper. After drying, the furnace is ready for use.

the hydrochloric acid, but two were used to aid in condensing the products. Starch-potassium iodide test papers were hung at the entrance of each scrubber to indicate the presence of chlorine. The unchlorinated natural gas and other gases after leaving the scrubbers pass through a trap enclosed in an ice-salt bath. Here most of the water vapor is frozen out and the dichloromethane, and other chlorides, condensed.

The gas next passes through a drying tower containing soda lime and calcium chloride, thence through a 3-way stopcock and on out of the apparatus through a water seal. By means of the 3-way stopcock samples of the residual gas could be taken at pleasure for the analysis of methyl chloride.

Table II shows results of chlorinating larger amounts of gas, using the three most promising catalyzers. A great many charcoals, cokes, etc., were tried but the yields, from a carbon tetrachloride standpoint, were not as good and are not given in this report.

Increasing the gas rate produced products of a boiling point below 70°C . The boiling point and specific gravity of these fractions indicate a mixture of chloroform and carbon tetrachloride. The products boiling above 85°C . indicate a mixture of carbon tetrachloride, carbon hexachloride, and other chlorine products. These percentage yields may be in error to some extent, due to the above assumptions, but are of value in that they are useful for comparing the relative efficiency of the different catalyzers.

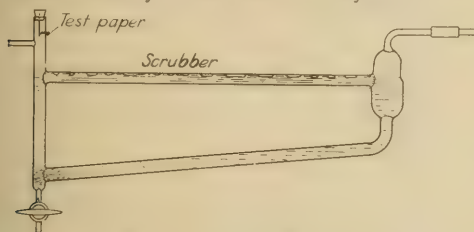


FIG. 3—LOW-PRESSURE SCRUBBER

Table III shows the different chlorides of methane and ethane with their boiling points and their specific gravity, as given in Watts' chemical dictionary and Landolt-Bornstein tables. These are given here for comparison of the products obtained by chlorination of natural gas.

POSSIBILITIES

Processes and methods must be found to use the large supply of chlorine which will be available at the conclusion of peace. Natural gas is a very cheap commodity in out-of-the-way places, and chlorine can be made by using part of the natural gas for power. In this way the expense for raw material will depend only on the value of the natural gas.

Chloroform besides being used in surgery is a good solvent.

Carbon tetrachloride is a good solvent, non-explosive and non-inflammable. It can be used for the extraction of certain fats, resins, waxes, dry cleaning, and for fire-extinguishing compounds.

Carbon hexachloride has no uses at present but can be reduced to ethane tetrachloride which is a good solvent used extensively in the manufacture of motion picture films, aeroplane dope, varnish manufacture, paint remover, etc.,

CONCLUSIONS

Apparatus is shown and described for the chlorination of natural gas.

Results of tests are given pertaining to the complete chlorination of the gas.

Results show that natural gas can be completely chlorinated on a laboratory scale at one operation.

The temperature range extends from about 225°C . to 500°C . when using war-gas charcoal.

Moisture helps the reaction.

At a rate of 1 l. of natural gas per hr. the methane goes completely to carbon tetrachloride and the ethane to carbon hexachloride when using a maximum amount of chlorine.

When larger rates of gas were used chloroform was found along with the carbon tetrachloride.

That carbon tetrachloride and chloroform can be produced successfully is proven, provided the right catalyzer is used, the conditions of the reaction are carefully watched, and efficient means for removing the products are used.

Ethane is chlorinated much more easily than methane and at a lower temperature. Catalyzers for complete chlorination must be such that they have a high absorption value for chlorine.

ACKNOWLEDGMENTS

In compiling this report the authors wish to acknowledge the helpful suggestions made by G. B. Taylor, chief chemist of the Pittsburgh Station, Major A. C. Fieldner, of the Chemical Warfare Service, Lt. S. H. Katz and Sgt. Linchfield for supplying two of the catalyzers, M. H. Meighan and W. L. Parker for carrying on the tests, and F. E. Donath, glass blower, for making the scrubbers and other parts of the apparatus.

BUREAU OF MINES
DEPARTMENT OF INTERIOR
WASHINGTON, D. C.

THE TANNIN CONTENT OF REDWOOD

By CHARLES C. SCALIONE AND DAVID R. MERRILL

Received December 16, 1918

The rapid depletion of the more accessible supplies of tanbark oak (*Quercus densiflora*), which is the only natural source of tannin largely utilized on the Pacific Coast, suggested the desirability of a study of the wood of the coast redwood (*Sequoia sempervirens*), which is known to contain tannin and of which a large supply is available in the form of refuse from the lumber industry.

With this idea in view, samples of bark, heartwood, and sapwood were obtained from Mendocino County. The bark was shredded and ground in a mill to pass a 20 mesh screen. Samples of the heartwood and sapwood were prepared by sawing, and grinding the sawdust to pass 20 mesh. The moisture contents were determined by drying samples to constant weight. The undried samples were extracted by soaking them for several hours in warm water, pouring off this extract, and extracting the residue with more water in an extractor of the Soxhlet type. The extraction was stopped when the extract gave a negative test with the salt gelatin reagent for tannin. The mixed solutions were diluted to volume, and clarified by adding washed kaolin and sucking them into a flask through an alundum extraction thimble. After this treatment the samples passed the require-

ments for optical clearness as given in the A. L. C. A. specifications.

The following results were obtained using the A. L. C. A. hide powder method. The results are calculated to a dry basis in each case.

	Bark Per cent	Sapwood Per cent	Heartwood Per cent
Soluble solids	2.76	4.77	25.7
Non-tannins	1.89	3.62	13.5
Tannin	0.86	1.15	12.2

It is evident from these figures that the only part of the redwood which has any possible value as a source of tannin is the heartwood. The principal source of raw material here would be the sawdust. The proportion of soluble non-tannins is high, which is in part due to the method of extraction used. The extract gave a qualitative test for pyrogallol derivatives. The liquors were quite dark from the coloring matter which occurs in the redwood. A sample tanning was run on some strips of hide. The grain developed quickly and struck through in about four days. The outside of the hide was colored a dark purplish brown, but the color did not penetrate through the hide. For heavy sole leather this material might be satisfactory.

Another possible source of tannin from redwood is in the liquor which collects on steam-kilning the wood. While a quantitative analysis of these liquors was not made, they appeared to contain about 7 to 10 per cent tannin when the salt gelatin test was made. In the same connection it should be noted that Scalione and Blakemore¹ found that the leaves of *Ceanothus velutinus* were quite rich in tannin. This shrub covers a large acreage in certain regions of California and could be collected in large quantities at but small cost.

The experimental work outlined above was performed in the chemical laboratory of the University of California in the fall of 1917.

AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.

TREATMENT OF LOW-GRADE NICKEL ORES²

By C. W. DAVIS

Received November 4, 1918

INTRODUCTION

This investigation was undertaken at the Golden, Col., Station of the Bureau of Mines in an attempt to find some practical method for the commercial separation of nickel from low-grade ores. The use of nickel in nickel steel for the manufacture of gun forgings, structural work, automobile parts, etc., makes it indispensable in normal times and doubly so under conditions brought about by a state of war. Although the United States is the largest refiner of nickel, the crude copper-nickel matter comes principally from the Sudbury district of Canada and from New Caledonia. A comparatively small quantity of nickel is recovered in the refining of blister copper from domestic ores, and no direct production of nickel from nickel ores in the United States is known to have been made since

1909, at which time the American Lead Company operated a smelter at Fredericktown, Mo., for a short period.¹ Altogether the situation for the production of nickel from ores found in the United States is not encouraging.²

Two nickel ores were used in this work, one from North Carolina, the other from Chichagof Island, Alaska.

THE NORTH CAROLINA ORE—The North Carolina ore occurs as an extensive deposit near Webster, Jackson County. This ore, as received, was in two forms, the lump and the fine. The lump material was a weathered, massive conglomerate, containing inclusions of mica, magnetite, and ferric oxide with incrustations of serpentine and genthite. When pulverized, a brown powder resulted which resembled ferric oxide. The fine portion, which constituted more than three-quarters of the total ore, was similar to the ground lump material but of a somewhat lighter color.

An analysis of a representative sample of the nickel ore is as follows:

	Per cent
SiO ₂ and insoluble matter	56.5
Fe ₂ O ₃	22.0
Al ₂ O ₃	4.1
NiO	1.2
MgO	7.2
CaO	0.0
Loss on ignition	8.9
	99.9

The ore thus contains 0.97 per cent metallic nickel and must be considered very low grade, since it has been shown³ that an ore from New Caledonia containing less than 4.4 per cent nickel, as silicate, is of no commercial value at present, the cost of treatment equalling the value of the nickel contained. The same thing is true of the sulfide ore from Sudbury carrying 2.03 per cent nickel. In fact it is considered unprofitable to treat a Sudbury ore for nickel alone if it runs less than 3 per cent nickel. The genthite portion of the North Carolina ore when roughly separated gave a content of 9.5 per cent nickel oxide.

W. L. Morrison,⁴ who did considerable work on ore from Webster, which averaged 1.75 per cent nickel oxide, states: "The present plant for commercial operations is out of the question. The wet process now existing is also out of the question. The only process available for this ore at present is the electric furnace process in a first-class, efficient plant."

THE ALASKA ORE—The massive sulfide ore occurring at Chichagof Island, Alaska, consists mainly of pyrite, chalcopyrite, and pentlandite. An average analysis is as follows:

	Per cent		Per cent
Cu	1.7	Ca	1.7
Ni	3.7	Mg	0.5
Fe	36.5	S	22.6
Al	4.5	SiO ₂	20.4

In portions the nickel runs as high as 5.7 per cent, and the copper up to 4 per cent.

¹ Report of the Royal Ontario Nickel Commission, 1917.

² Eng. and Min. J., Jan. 20, 1917.

³ Report of the Royal Ontario Nickel Commission, Loc. cit.

⁴ Trans. Am. Electrochem. Soc., 20, 315.

¹ THIS JOURNAL, 8 (1916), 341.

² Published by permission of the Director of the Bureau of Mines.

Treatment of this ore has been attempted but none of the methods tried were successful. The Seattle Station of the U. S. Bureau of Mines has effected a removal of copper by flotation. It has also given the tails from this separation a table treatment thereby securing a nickel concentration of 11 per cent. The recovery, however, is only 21 per cent. The material treated at this Station consisted of tails from the copper flotation separation furnished by the Seattle Station. A few tests were also made on table concentrates from these tails. The massive ore was not available for experimental purposes.

CONCENTRATION

An effective concentration would render the ores suitable for treatment by various well-known methods. Since the Seattle Station had tried various schemes of concentration, this phase of the treatment of the Alaska nickel ore was not considered here.

In search of a way to concentrate the North Carolina ore, the following methods were employed: (a) Sizing tests, (b) Panning, (c) Tabling, (d) Magnetic separation, (e) Segregation by flotation.

A little work sufficed to show that no concentration was effected by means of sizing or panning.

The results of experiments on table concentration showed that although there was a separation of magnetite, mica, etc., the nickel was so well disseminated through the ore that no concentration was achieved.

In attempts to separate the nickel magnetically, different strengths of magnetization were employed, the ore previous to the tests being treated variously. About 30 per cent of the untreated ore was magnetic, while a roast at 500° C. made 80 per cent of the material magnetic. Neither of these treatments resulted in a concentration of the nickel. A reduction of the North Carolina ore by producer gas or charcoal at 900° C. gave a product which was magnetically concentrated from 0.97 per cent nickel to 3.6 per cent, the recovery being 45 per cent.

Morrison¹ was unable to remove the nickel from this ore by reduction followed by tabling.

It was thought that the North Carolina ore could be converted to the sulfide and then concentrated by flotation, or that the reduced ore could be floated at once. A number of tests on the ore which had been reduced or sulfidized showed a maximum concentration of nickel of from 0.97 per cent to 1.1 per cent. The Alaska ore, as has been stated, was concentrated by the Seattle Station by flotation.

Failure to get an adequate concentration led to the various schemes which follow. These may be outlined as: (1) extraction with various solvents of (a) the unsaturated ore, (b) the reduced ore, (c) the reduced and oxidized ore, and (d) the chloridized ore; (2) volatilization of the nickel as the chloride; and (3) a sulfide and sulfate treatment to render the nickel soluble in water or dilute acids.

EXTRACTION OF THE UNTREATED ORES

The ore from North Carolina was submitted to the various extractions shown in Table I in the search for a suitable solvent for the nickel.

¹ Loc. cit.

TABLE I

TREATMENT OF THE ORE	Extraction of Nickel Per cent
Extracted with excess HNO ₃ and KClO ₃	100
Extracted with excess HCl.....	38
Extracted with excess HNO ₃	90
Extracted with excess Cl ₂ soln.....	10
Extracted with excess NaOH soln.....	None
Extracted with excess NH ₄ OH soln.....	None
Extracted with excess NH ₄ Cl soln.....	None
Extracted with excess (NH ₄) ₂ CO ₃ soln.....	None
Extracted with excess (NH ₄) ₂ SO ₄ soln.....	Trace
Extracted with excess H ₂ SO ₄ soln. ¹	30
Extracted with excess Fe ₂ (SO ₄) ₃ soln. ²	None
Extracted with excess (NH ₄) ₂ CO ₃ soln.....	None
Extracted with excess FeCl ₃ and CaCl ₂ soln. ³	None
Extracted with excess hot water after fusing with Na ₂ SO ₄	30

¹ Morrison (Loc. cit.) leached ore from North Carolina with sulfuric acid, extracting 29 per cent of the nickel.

² Hybinette (Chem. Abs., 10, 563) treats ore with ferric sulfate to dissolve the nickel.

³ It has been stated by W. Koehler (Elec. Met. Ind., 6, 145) that ferrous sulfate would dissolve nickel oxide forming nickel sulfate and iron oxide.

⁴ Herrenscheidt (J. Soc. Chem. Ind., 11, 613) extracts nickel from its ores with a solution of ferric and calcium chlorides.

The Alaska ore digested with an excess of 2 per cent sulfuric acid gave an extraction of 5 per cent of the nickel, while a sodium carbonate fusion of the ore rendered none of the nickel soluble in water.

EXTRACTION OF THE REDUCED ORE

The North Carolina ore was reduced with producer gas at 1000° C. and extracted with various reagents as shown in Table II.

TABLE II

TREATMENT OF THE REDUCED ORE	Extraction of Nickel Per cent
Extracted with excess NH ₄ OH.....	None
Extracted with excess H ₂ SO ₄ , 2 per cent.....	100
Extracted with excess CaCl ₂ soln., made acid with HCl.....	30
Extracted with excess FeSO ₄	20
Extracted with excess NH ₄ Cl.....	5
Extracted with excess (NH ₄) ₂ SO ₄	5
Extracted with excess (NH ₄) ₂ CO ₃ soln.....	10
Extracted with excess KCN soln., 1.4 per cent.....	30
Extracted with excess HCl, 1 per cent.....	70
Extracted with excess HNO ₃ , 1 per cent.....	65
Extracted with excess Fe ₂ (SO ₄) ₃ , large excess sat. soln.....	95

The sulfuric acid required for the extraction of 90 per cent of the nickel from the reduced ore was 360 lbs. of acid per ton of ore treated. This is a far greater quantity than could be used commercially, the large amount being necessary because the iron in the reduced ore was attacked as readily as the nickel.

The Alaska ore, roasted free from sulfur, was reduced and a few tests made as indicated in Table III.

TABLE III

TREATMENT OF REDUCED ORE	Extraction of Nickel Per cent
Extracted with excess H ₂ SO ₄ soln.....	10
Extracted with excess Fe ₂ (SO ₄) ₃ soln.....	70
Extracted with excess H ₂ SO ₄ , 2 per cent.....	85

A large acid consumption was necessary in this case also, due to the iron content of the ore.

Attempts to find conditions of oxidation such that the iron would be insoluble in dilute acid and the nickel rendered soluble were fruitless.

EXTRACTION AS THE CHLORIDE

Croasdale¹ finds that when a sulfide ore is roasted with salt and sulfur the chlorine is freed to act on the metal in the ore. A series of tests were made to see if the nickel in the North Carolina ore could be converted into a soluble chloride. The ore was roasted with salt and with a mixture of salt and sulfur. The best extraction of the nickel as the chloride from this ore was, with water, 10 per cent, and with 1 per cent

¹ "Volatilization of Nickel as the Chloride," Eng. & Min. J., August

acid, 37 per cent. This is but little better than the extraction secured from untreated ore. These results are in accord with those obtained by Rutherford,³ that is, that nickel extraction as the chloride either with water or dilute acid is not satisfactory.

Morrison¹ heated the North Carolina ore with ammonium chloride and with sodium chloride, and also passed chlorine gas over the dry and moist ore. He found that this did not improve the sulfuric acid extraction.

VOLATILIZATION AS THE CHLORIDE

Croasdale³ showed that a sulfide ore mixed with salt formed volatile chlorides on heating. Rutherford³ states that an oxidized nickel ore to which sulfur and salt have been added can be heated so as to volatilize part of the nickel as the chloride. It was thought that a satisfactory volatilization might take place with the ore from North Carolina, the nickel chloride being collected in a Cottrell precipitator. This ore was roasted with salt, calcium chloride, lime, and sulfur in various proportions. It was also heated with the passage of chlorine and hydrochloric acid gas. A volatilization of about 50 per cent of the nickel together with considerable iron was obtained by heating a mixture of 100 parts ore, 10 parts salt, and 2 parts sulfur for some time at 1000° C.

EXTRACTION OF THE SULFIDIZED ORE

Since nickel has a strong affinity for sulfur it was suggested⁴ that the silicate ore could be disintegrated by roasting it with sulfur and then extracting the nickel with dilute acid. The best conditions found for this treatment gave an extraction of 70 per cent, the acid consumption being about the same as that required for a 90 per cent extraction of nickel from the reduced ore, that is, 360 lbs. of sulfuric acid per ton of ore treated.

EXTRACTION OF THE SULFATIZED ORE

Eustice⁵ finds that an oxidized ore of nickel, iron, aluminum, etc., can be treated so as to render the iron insoluble, the nickel being made soluble. He does this by heating the dry ore, passing sulfur dioxide over it, and then leaching with hot, dilute sulfuric acid. The North Carolina ore treated by this method gave an extraction of 30 per cent of the nickel.

Borchers⁶ states that nickel can be removed from a sulfide ore containing iron by roasting to convert the nickel to the sulfate, leaving the iron as the oxide. Pecourt⁷ says that an oxidized ore heated with sulfur or pyrite and then roasted at a low red heat can be leached with water for its nickel content. Herrenschildt⁸ finds that a nickel oxide ore heated with sulfur dioxide and air will give a water-soluble nickel sulfate. Eustice⁹ roasts the ore with sulfuric acid at 500° C. and leaches with hot, dilute sulfuric acid.

To convert the nickel of the North Carolina ore to the sulfate, samples of the ore were roasted with sulfur and oxidized in air, roasted with pyrite and oxidized in air, roasted while passing sulfur dioxide and air over it, roasted with calcium sulfate, and roasted with sulfuric acid. Dilute sulfuric acid removed but 30 per cent of the nickel from any of the samples. Water extracted about 25 per cent of the nickel from the sulfuric acid roast. In the other cases, only a trace of the nickel was rendered soluble in water.

Morrison¹ roasted the North Carolina nickel ore with sodium sulfate and charcoal which did not affect the extraction.

The Alaska sulfide ore was given a sulfatizing roast in which 10 per cent of the nickel was water-soluble and 30 per cent soluble in dilute acid.

FUSION WITH SODIUM BISULFATE

By fusing the reduced ore from North Carolina with an equal weight of niter cake, 90 per cent of the nickel was rendered water-soluble; with one-half as much niter cake as ore, the water-soluble nickel was 60 per cent.

TABLE IV

Test No.	Ni in Sample Per cent	Weight Ore Grams	Weight NaHSO ₄ Grams	Temperature °C.	Time Heating Min.	Approximate Extraction Nickel Per cent	REMARKS
1	2.3	1	0.25	400	30	10	.....
2	2.3	1	0.25	500	10	None	.....
3	2.3	1	0.25	500	30	None	.....
4	2.3	1	0.25	700	15	None	.....
5	2.3	1	0.5	400	30	30	.....
6	2.3	1	0.5	450	30	30	.....
7	2.3	1	0.5	500	30	50	.....
8	2.3	1	0.5	500	120	75	Crude NaHSO ₄ used
9	2.3	1	0.5	700	5	None	Crude NaHSO ₄ used
10	2.3	1	0.5	700	15	None	Crude NaHSO ₄ used
11	2.3	1	1.0	350	30	30	.....
12	2.3	1	1.0	400	30	70	.....
13	2.3	1	1.0	400	15	75	.....
14	2.3	1	1.0	500	10	75	.....
15	2.3	1	1.0	500	30	75	.....
16	2.3	1	1.0	500	30	90	.....
17	2.3	1	1.0	500	45	80	.....
18	2.3	1	1.0	500	120	95	.....
19	2.3	1	1.0	500	60	95	Crude NaHSO ₄ used
20	2.3	25	25.0	500	120	95	Crude NaHSO ₄ used
21	2.3	1	1.0	500	5	75	.....
22	2.3	1	1.0	500	5	60	.....
23	2.3	1	1.0	500	30	10	.....
24	2.3	1	1.5	400	5	80	.....
25	2.3	1	1.5	500	30	95	.....
26	2.3	1	1.5	500	30	90	.....
27	2.3	1	1.5	500	180	95	.....
28	2.3	1	1.5	700	5	90	.....
29	2.3	1	2.0	400	30	90	.....
30	2.3	1	2.0	600	5	90	.....
31	2.3	1	0.75	500	120	85	.....
32	3.4	1	0.25	500	9	15	.....
33	3.4	1	0.50	500	10	40	.....
34	3.4	1	1.0	240	240	40	.....
35	3.4	1	1.0	300	120	40	.....
36	3.4	1	1.0	400	45	75	.....
37	3.4	1	1.0	500	30	75	.....
38	3.4	1	1.0	500	45	75	.....
39	3.4	1	1.0	500	120	70	.....
40	3.4	1	1.5	500	10	85	.....
41	3.4	25	37.5	500	120	85	Crude NaHSO ₄ used
42	3.4	1	2.0	500	30	90	.....
43	3.4	1	2.0	500	120	90	Crude NaHSO ₄ used
44	3.4	1	2.0	700	5	60	.....
45	3.4	1	2.0	700	15	60	.....
46	3.4	1	2.0	500	120	60	Crude NaHSO ₄ used
47	3.8	1	1.0	500	120	60	Crude NaHSO ₄ used
48	3.8	1	1.5	500	120	90	.....
49	3.8	25	50.0	500	120	90	.....
50	8.1	1	1.0	500	120	70	.....
51	8.1	1	2.0	500	120	75	.....
52	8.1	1	3.0	500	120	90	.....
53	8.1	10	30.0	500	120	85	Crude NaHSO ₄ used
54	11.0	1	2.5	500	120	40	.....
55	11.0	1	3.0	500	120	85	.....
56	11.0	10	30.0	500	120	85	Crude NaHSO ₄ used

¹ "The Chloride Treatment of Nickel Ores," *J. Can. Min. Inst.*, **6**, 336.

² *Ibid.*

³ *Ibid.*

⁴ C. L. Parsons, U. S. Bureau of Mines.

⁵ *Chem. Abs.*, **11** (1917), 31.

⁶ *Ibid.*, **7** (1913), 2039.

⁷ *J. Soc. Chem. Ind.*, **29**, 97.

⁸ *Loc. cit.*

⁹ *Chem. Abs.*, **11** (1917), 1.

¹ *Loc. cit.*

A fusion of the Alaska ore after dead roasting with sodium bisulfate made 15 per cent of the nickel water-soluble. By fusing this ore, which had been dead roasted and reduced, with crude acid sodium sulfate

a satisfactory recovery of the nickel was obtained in the water leach.

To determine the best conditions for extracting the nickel from the Alaska ore by roasting with sodium bisulfate, several experiments were performed, the results being shown in Table IV. In all of these experiments the ore was roasted free from sulfur and then reduced with charcoal at 900° C.

The results indicate that the quantity of sodium bisulfate required for a satisfactory treatment of the Alaska ore depends upon the percentage of nickel present, the ratio of ore to acid being, for a 2.3 per cent ore, 1 to 1; for a 3 to 4 per cent ore, 2 to 3; and for an 8 to 11 per cent ore, 1 to 3.

The temperature best suited for the roast was 500° C. while the time required for treatment of small samples was 30 min.

With the quantities used, the procedure is a roast rather than a fusion, the resulting material being in the form of a friable lump.

NITRIC ACID TREATMENT OF ALASKA ORE

Nitric acid heated with pyrite oxidizes it to the sulfate, freeing oxides of nitrogen, which can be removed by heating, and recovered by absorption in towers.¹

A preliminary trial showed that the Alaska nickel ore was readily attacked by nitric acid. To determine the best conditions for treatment experiments shown in Tables V and VI were carried out.

TABLE V

Test No.	Ratio of Ore to Acid by Weight (70% HNO ₃)	Temperature Deg. C.	Time of Heating Hrs.	Nickel Extracted with Water Per cent	HNO ₃ Left in Residue Per cent by Weight
1	1 : 5	100	1	100	28
2 ¹	1 : 5	100	1	100	5.1
3	1 : 5 and excess H ₂ SO ₄	140	1	100	10.7
4	Excess	240	1	95	2.0
5	1 : 1	250	2	95	1.2

¹ Test 2 was tried because there was not sufficient sulfur in the ore to satisfy the reactions assumed by Westby (*Loc. cit.*).

TABLE VI

Ratio of Ore to Acid by Weight (70% HNO ₃)	Extraction of Nickel Per cent
1 : 2	100
1 : 1	95
1 : 0.9	80
1 : 0.75	75
2 : 1	50
3 : 1	30
4 : 1	20

The best conditions were a 1 : 1 ratio of ore to acid, 250° C., and 2 hrs. of heating. The extraction was 95 per cent, and 1.2 per cent of the nitric acid remained with the ore.

It is thus seen that with a good recovery of the evolved oxides of nitrogen a commercial treatment of the Alaska ore by means of nitric acid is possible.

Mond's process, the volatilization of the nickel as carbonyl by means of carbon monoxide, is only applicable when the material treated has a high nickel content. Therefore, no attempts were made to treat the ores by this method.

SUMMARY

1—No satisfactory concentration of the ores was obtained by sizing tests, panning, tabling, magnetic concentration, or flotation. Magnetic treatment of

the reduced North Carolina ore brought the concentration of nickel from 0.97 per cent to 3.6 per cent, the recovery being 45 per cent.

2—An excess of concentrated nitric acid or aqua regia extracted the nickel from the finely ground ores by hot digestion. Other solvents in large excess dissolved only part of the nickel.

3—Hot, dilute sulfuric acid (2 per cent), in excess, extracted the nickel from the ores which had been reduced with water gas at 1000° C. A large excess, however, was required to react with the iron present before much of the nickel was attacked.

4—The nickel in the reduced ores was largely extracted with an excessive amount of ferric sulfate solution.

5—No state of oxidation was found at which the nickel was soluble in dilute acid without having the iron soluble also.

6—The best extraction of nickel as the chloride from the North Carolina ore was, with water, 10 per cent, and with 1 per cent acid, 37 per cent. The acid requirement is nearly the same as that for the extraction of nickel from untreated ore.

7—By mixing the North Carolina ore with an excess of salt and sulfur, and heating for some time at 1000° C., it was found possible to volatilize 50 per cent of the nickel as the chloride.

8—A sulfide roast of the North Carolina ore followed by a treatment with dilute sulfuric acid gave an extraction of about 70 per cent; the acid consumption, however, was prohibitive.

9—By fusing the reduced North Carolina ore with an equal weight of niter cake, 90 per cent of the nickel was rendered water-soluble; with one-half as much niter cake as ore, only 60 per cent was water-soluble.

10—The quantity of niter cake required for the extraction of the nickel from roasted and reduced Alaska ore varied with the nickel content; the ratio of the ore to sodium bisulfate was, for a 2.3 per cent ore, 1 to 1; for a 3 to 4 per cent ore, 2 to 3; and for an 8 to 11 per cent ore, 1 to 3.

11—The best temperature for the niter cake roast was 500° C.

12—Thirty minutes were sufficient for the fusion of small quantities of reduced ore with niter cake.

13—By treating the Alaska nickel ore with an equal weight of nitric acid (70 per cent), and heating for 2 hrs. at 250° C., 95 per cent of the nickel was made water-soluble, while all but 1.2 per cent of the nitric acid was driven off. Most of this acid could be recovered by absorption.

CONCLUSIONS

Results obtained from the work on the low-grade nickel ore from North Carolina indicate that it cannot be profitably treated with the chemical market as it is at present; but that a silicate ore even of as low grade as the one examined might be economically worked, if of low iron content, by reduction and subsequent leaching with dilute sulfuric acid.

With a favorable price for large quantities of niter cake, the sulfide ore from Alaska might be treated for

¹ Westby, *Met. & Chem. Eng.*, March 15, 1918.

the removal of nickel by roasting the tails from the copper flotation separation free from sulfur, reducing with charcoal, roasting with niter cake, and extracting with water, the nickel to be recovered electrolytically or by precipitation with lime after the removal of iron by means of calcium carbonate. The complexity of this treatment would be an important factor in determining whether the process could be used.

The Alaska ore might be treated with nitric acid, heated to remove most of the oxides of nitrogen, and the nickel extracted with water, the nitric acid being recovered by water absorption. The quantity of nitric acid recovered on large runs would largely determine the availability of this treatment.

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BUREAU OF MINES
GOLDEN, COLORADO

THE MODIFICATION OF THE COMPOSITION OF VEGETABLE OILS, WITH SPECIAL REFERENCE TO INCREASING UNSATURATION¹

By HORACE L. WHITE

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INTRODUCTION

The possibility of the modification of the constants of fats and oils of animal and vegetable origin, but more particularly because of the abundance of those of vegetable origin, is a matter of great economic importance. If a vegetable oil could be dehydrogenated, that is, if its fatty acids could be modified so as to contain more unsaturated linkages, there is the possibility of greatly increasing its value in the paint industry. A brief consideration of the respective iodine values of linseed and soy bean oils will indicate this more clearly. Linseed oil with an iodine number around 180 is one of the best examples of a drying oil, while soy bean oil with an iodine number around 126 is classified as a semidrying oil. Nemzek^{3*} has pointed out the limited uses of soy bean oil in paints and he is authority for the statement that in 1916 there were imported into the United States 98,171,275 lbs. of soy bean oil. If some of the constants of this oil could be modified, its value, particularly in the paint industry, would be greatly increased.

Many observers have pointed out the modifications of oils that seem to take place spontaneously, but which in reality are caused by the influence of light, temperature, bacterial and enzyme action, and inorganic

catalysts. This investigation is devoted to a study of the biochemical reactions induced by the processes of germination, and of enzyme and bacterial action on the degree of unsaturation and the extent of hydrolysis of linseed and soy bean oils. In addition, attention has been directed to the action of light, heat, and the presence of inorganic catalysts on the same constants.

EXPERIMENTAL

From reference in the literature it is evident that but few attempts have been made to dehydrogenate oils. The use of nickel⁵ in the absence of hydrogen has been suggested. In the field of biochemistry the observations of Hartley and others^{6,7} on the desaturating power of the pig's liver, as shown in the fatty acids obtained from the liver, is of great interest. The results^{8,9} obtained in a study of the effects of germination of various oil-bearing seeds seems to indicate a saturation of unsaturated fatty acids during the process, yet the behavior of the castor bean¹⁰ in this particular shows some variation.

The question was raised as to whether there might not be conditions of metabolism during germination and growth of soy beans (*Glycine hispida*) of such a nature as to increase the degree of unsaturation of the fatty acids. The prevailing idea in the arrangement of the conditions of growth was to make them abnormal in order to develop any latent powers of the plant. This was accomplished by growing the plants in a greenhouse in diffuse light and at lower temperatures than ordinarily employed.

Other samples were sprouted in darkness and some were grown in the sunlight at ordinary temperatures. The germination was carried through three stages: Stage I, in which the sprout was $\frac{1}{2}$ cm. long; Stage II, in which the plants were from 4 to 6 cm. in height with cotyledons standing at right angles to the hypocotyls; and Stage III, in which the plants were from 6 to 12 cm. long and the first set of leaves had formed.

TABLE I—CONSTANTS OF THE OIL OF SOY BEANS GERMINATED AND GROWN IN DIFFUSE LIGHT

	Resting Seed Control	Stage I Germinated Sprout $\frac{1}{2}$ Cm. Long	Stage II Growth Height 4 to 6 Cm.	Stage III Growth Height 6 to 12 Cm.
Wt. 100 beans, grams.....	15.6800	37.0520	71.1560	....
Moisture, per cent.....	4.80	61.90	86.60	....
Ether extract (moisture-free), per cent.....	18.44	18.51	13.31	10.11
Color of oil.....	Amber	Green	Red Green ¹	Greenish
Specific gravity.....	0.9234	0.9215	0.9272	12.5
Acid number.....	1.0	30.2	2.6	121.10
Iodine number.....	131.1	122.6	133.1	120.95
Iodine number.....	129.9	125.5	133.0	117.7
Fatty acids.....	135.6	125.2	133.6	116.1
Reichert-Meißl number.....	0.30	...	1.05	...
Unsaponifiable matter, per cent.....	1.21	1.01	1.14	2.75
Sterols, per cent.....	0.27	0.43	0.46	0.86

¹ Red by reflected light, green by transmitted light.

The whole plant was used for analysis. Each plant was washed free from sand, dried at 37° C. in an incubator, and the oil extracted by ethyl ether in the cold. After distilling off most of the ether, the oil was heated to 110° C. for 2 hrs., while a current of dry carbon dioxide was bubbled through it to remove traces of ether and water. The method of analysis and of purification of reagents used were those described by Holland.¹² Iodine numbers were deter-

¹ Abstract of a thesis submitted to the University of Wisconsin for the degree of doctor of philosophy in agricultural chemistry, 1917.

* Numbers refer to corresponding numbers in "Bibliography," p. 651.

mined by the Hanus method. Table I shows some of the constants of the oils.

The results given in Table I show that the iodine number of the ether extract of soy beans grown in diffuse light does not fall much below that obtained from the seed, and seem to indicate that while the oil is being used for the nourishment of the growing plant in diffuse light the processes of metabolism continue to supply fatty acids of practically the same degree of unsaturation, at least up to the formation of the first set of leaves. The drop in iodine number of fatty acids in Stage III indicates a rapid utilization of unsaturated acids, possibly for the formation of sugars.

For comparison, beans were planted in sand and grown in the light to Stages II and III. The results are shown in Table II.

TABLE II—CONSTANTS OF SOY BEAN OIL FROM BEANS GROWN UNDER VARYING CONDITIONS

DESCRIPTION	Ether Extract (Dry Basis) Per cent	Acid Number	Iodine Number	Iodine Number Fatty Acids
Resting seed.....	18.44	1.0	131.1	133.9
			129.9	135.6
Stage I—Germinating seed.....	18.51	29.8	122.6	125.2
				125.5
Stage II—Diffuse light.....	13.31	2.6	133.1	133.6
			133.0	136.2
Stage II—Sunlight.....	5.00	16.6	134.1	...
			133.7	...
Stage III—Diffuse light.....	10.11	12.5	121.10	116.1
			120.95	117.7
Stage III—Darkness.....	8.34	...	128.7	...
			130.1	...
Stage III—Sunlight.....	3.61	1.85	128.1	...
			130.5 ¹	...
			130.4	...

¹ Petroleum ether extract.

From the analytical results given in Table II, the conclusion is reached that the processes of germination and growth of soy beans up to the stage of the formation of the first set of true leaves do not greatly modify the degree of unsaturation of the oils in the ether extract. There is, moreover, no evidence of increasing unsaturation of the oil.

Working along the same general line, that of creating abnormal conditions, the effect of carbon dioxide on germination and iodine number of oil was studied. Carbon dioxide was bubbled through a mass of beans in distilled water, with chloral hydrate (0.1 g.) for a preservative, for varying lengths of time. The effect of carbon dioxide is shown in Table III.

TABLE III—EFFECT OF CARBON DIOXIDE ON GERMINATION AND IODINE NUMBER

TREATMENT	EXTENT OF GERMINATION	Iodine No. Ether Extract
Resting seed, control.....	129.9
		131.1
Carbon dioxide for 1 hr. a day, 2 days. Slight, seed coat intact		128.0
		129.0
Carbon dioxide for 1/2 hr. a day, 6 days. Slight, seed coat intact		118.1
		121.8

It is evident that the exclusion of oxygen by carbon dioxide for a period of 6 days decreases the degree of unsaturation of the oil.

The possible stimulating effect of dilute solutions of manganous chloride which was noted by Brencley¹⁵ as favoring germination and growth of starchy seeds was studied with soy beans, but with inconclusive results.

BACTERIAL AND ENZYME ACTION

From many samples of raw linseed oil there separates out on standing a heavy flocculent deposit which

is known to the trade as "foots." From the oil filter presses the same material is obtained as a dark colored semisolid material known as "filter press foots."

A sample of raw linseed oil, containing 40 per cent "foots" by volume, was used in a preliminary examination as to the nature of the bacterial contents of the foots, and the effects of their metabolism on some of the constants of linseed oil.

On shaking some of this oil in a mixture of sterile sand and water and plating out the resultant liquid on nutrient agar, a heavy growth of organisms, chiefly bacteria with some molds, was obtained. The bacterial colonies seemed to be of the same general form. A pure culture was obtained from one of the colonies and was used in a further study of the characteristics of the organisms which were similar to those of *B. subtilis*.

In order to determine whether the organisms in linseed oil "foots" had any relation to the acid number and iodine number of the oil, samples of raw linseed were inoculated with "foots" known to contain the organism described above. Four-ounce sterilized sample bottles were filled with oil, plugged with cotton, and a short cork inserted in the neck of the bottle above the cotton. Controls were prepared by heating at 10 lbs. pressure on each of three successive days. In some cases 10 per cent of water was added. The samples were analyzed after decantation and filtration through anhydrous sodium sulfate.

TABLE IV—OILS INOCULATED WITH BACTERIA AND KEPT AT 38° C.

TREATMENT OF SAMPLE	ACID NO.			IODINE NO.		
	At once	5 Mo.	18 Mo.	At once	5 Mo.	18 Mo.
Oil, not filtered.....	2.75	4.3	5.7	184.06	173.3	154.2
				184.43	173.5	...
Oil, filtered through paper.....	2.9	5.6	...	170.6	153.9	...
				172.6	155.4	...
Oil, sterilized.....	3.0	6.0	...	172.2	149.5	...
				173.4	151.6	...
Oil + "foots".....	3.8	5.5	...	170.7	157.7	...
				172.5	158.6	...
Oil sterilized + "foots".....	3.7	5.4	...	171.4	157.6	...
				174.0	...	...
Oil + 10 per cent water.....	7.2	6.5	...	169.3	157.0	...
				171.2	...	...
Oil sterilized + 10 per cent water, sterilized.....	3.3	4.1	6.4	184.49	171.8	153.7
				184.83	173.0	155.0
Oil sterilized + "foots" + 10 per cent water.....	8.6	7.6	...	174.6	164.4	...
				175.2	164.4	...

In all samples the acid number has doubled in 18 mo. The inoculation with organisms affects the acid number when water is present, but not otherwise. As already pointed out,^{16,19} the necessity for heating and clarifying oils to prevent rapid hydrolysis is further shown by the difference in the rate of change of acid number in 5 mo. between the unfiltered oil and the samples of filtered and of sterilized oil.

TABLE V—HYDROLYSIS OF OILS KEPT AT 37° C.
50 g. Oil Emulsified with 50 g. Water Containing 1 Per cent Gum Arabic, Kept at 37° C.

SAMPLE	ACID NO. At Beginning	5 Wks.	DESCRIPTION OF OIL
D 18	18.6	20.2	Acid-refined linseed oil
D 19	1.2	1.8	Alkali-refined linseed oil
D 20	3.0	6.7	Raw linseed oil
D 21	5.1	12.6	Acid-refined oil
D 22	5.9	6.8	Boiled linseed oil
D 23	9.1	11.9	Corn oil (old sample)
D 24	17.5	19.7	Cottonseed oil (old sample)
D 25	5.5	5.8	Castor oil (old sample)
D 26	1.8	5.9	Soy bean oil, imported
D 27	2.7	12.3	Soy bean oil, American No. 2

In order to observe the effect of naturally occurring impurities, such as bacteria and enzymes in the oils,

when mixed with water, emulsions of equal weights of oil and water with gum arabic were kept in full, stoppered bottles at 37° C. for 5 wks. The changes are shown in Table V.

The acid numbers of the untreated oils, as raw linseed oil and the soy bean oils, show an increase of from 100 to 600 per cent in 5 wks. These results emphasize the necessity of heating and filtering such oils before storage and use.

Extensive experiments were carried on, the details of which cannot be given here, to determine if there were any enzymes in flaxseed that could desaturate soy bean oil, as it is recognized that there is inherent in the flax plant the ability to synthesize an oil with a larger per cent of unsaturated acids than is found in soy bean oil. The results were negative in all experiments. Similar attempts were made with fresh pig's liver which has been shown⁶ to have the power of desaturating fatty acids to a marked degree. After incubation of oil and tissue for 42 days at 37° C. there was no increase in iodine number.

ACTION OF LIGHT, HEAT, AND CATALYSIS

The extent of the hydrolysis of oils by various agencies is a matter of great economic importance in certain industries, and methods for its control are being given consideration in industrial laboratories. The agencies causing hydrolysis are discussed in detail by workers in industrial and biological chemistry.^{16,19,2,17,18} Neuberger²² has shown, also, that triolein when emulsified with a little sodium oleate is easily hydrolyzed by the action of sunlight if a uranyl salt is present. It was decided to repeat some of his work, using salts of other metals in addition to uranyl acetate, and replacing sodium oleate by a vegetable emulsifier. Two sets of samples of emulsified oil were prepared, using Indian gum as an emulsifier, and adding 0.1 g. of the catalyst in each case. One set of samples were kept at 37° C. in absence of light for 100 days, while the second set of samples was kept in a greenhouse for the same period. The catalysts employed were lead acetate, uranyl acetate, ferrous sulfate, manganous chloride, cobalt acetate, and zinc lactate. At the close of the 100-day period the oils were separated from the emulsification by filtration through anhydrous sodium sulfate, or by extraction with ether, and acid and iodine numbers determined.

Summarizing the results obtained by the use of catalysts: At 37° C. for 100 days the acid number of the control increased from 2.5 to 4.3. Only one sample of oil, that containing manganous chloride, showed a higher acid number, being 23.7. No satisfactory explanation can be given for this high number and it is not given much weight in the final conclusion arrived at relative to the use of catalysts. Exposed to the light for 100 days, the acid number of the control did not change. The oil containing zinc lactate had an acid number of 6.3, while that containing cobalt acetate had an acid number of 4.8. All other samples were below 3.0. A peculiar action of zinc lactate was noted—the oil was bleached to a marked degree, while the iodine number of the sample was the lowest (176.6)

of any in the series, the control being 184.9. In no instance was the iodine number increased by the use of catalysts.

EFFECT OF HEAT AND THE ULTRAVIOLET LIGHT

Continuing the general line of experiments on the effect of heat and light on oils, it was decided to study the effect of ultraviolet light on these constants. Accordingly, samples of raw soy bean oil were subjected to the action of ultraviolet light while exposed in Petri dishes at a distance of 10 cm. from the bulb of a Cooper-Hewitt lamp. Other samples, consisting of 40 g. oil, 80 cc. water, or 80 cc. of a *N*/100 solution of a catalyst, were thoroughly emulsified and exposed to the light for 6 hrs. In another series, lampblack and finely divided nickel on kaolin was used. It was soon noticed that the heat from the lamp was intense, and its effect might be sufficient to explain any action taking place. However, the acid number of the sample of raw oil, emulsified oil, oil and lampblack, and oil emulsified with lampblack are about the same as that of the untreated raw oil; therefore, the higher acid number obtained by the use of *N*/100 ferrous sulfate and manganous chloride and of nickel may be considered as due to catalytic action. In every experiment, however, the iodine number has been lower, indicating an increase in the degree of oxidation of the acids set free. In this connection a sample of soy bean oil was mixed with lampblack and heated to 250° C. in an atmosphere of carbon dioxide. While hydrolysis proceeded rapidly under these conditions, the iodine number remained fairly constant, due to the protective influence of the atmosphere of carbon dioxide.

The effect of ultraviolet light and of heating in presence of carbon dioxide on acid number and iodine number are shown in Table VI.

TABLE VI—ACTION OF ULTRAVIOLET LIGHT ON ACID AND IODINE NUMBERS OF OILS IN THE PRESENCE OF CATALYSTS

Time of Exposure Hrs.	Treatment of Sample	Acid Number	Iodine Number
0	Raw soy bean oil.....	2.4	132.0
			123.4
6	Oil, only.....	2.7	115.5
			116.5
6	Oil, emulsified.....	2.8	117.4
			118.1
6	Oil emulsified + <i>N</i> /100 FeSO ₄	4.4	108.6
			108.7
6	Oil emulsified + <i>N</i> /100 MnCl ₂	3.8	110.3
			110.3
6	Oil + 1 g. lampblack.....	2.9	112.9
			113.9
6	Oil emulsified + 1 g. lampblack.....	2.7	114.3
			114.4
7	Oil + 1 g. Ni.....	3.4	108.7
			108.9
7	Oil emulsified + 1 g. Ni.....	3.7	111.5
To note effects of heat alone, oil + lampblack heated to 110° for 6 hrs., then to 250° for 1 hr. in atmosphere of carbon dioxide. Results obtained were.....		13.9	119.4
			119.9

The effect of heat was studied by the use of an acid-refined oil, which was presumably free from enzymes and bacteria. The results shown in Table VII indicate the changes brought about by heat alone and by heat and storage at 37° C. for 35 days.

TABLE VII—EFFECT OF HEAT ON ACID NUMBER OF HIGH ACID OIL

Days Time	Treatment of Sample	Acid Number
0	Oil used in series.....	7.0
0	Heated at 15 lbs. pressure for 1/2 hr.....	11.7
35	Heated 1/2 hr. and kept at 37° C.....	25.0
35	Oil, control at 35° C.....	7.7

Oils which have not been acid-refined do not react to heat in such a degree. The hydrolytic action of heat over 100° is marked, and this must be taken into consideration in bacteriological examinations involving the sterilization of oils.

CONCLUSION

1—The processes of germination and growth of soy beans up to a height of 8 to 12 cm., even under favorable conditions of growth, do not result in an increase of unsaturated acids in the ether extract from such plants. On the other hand, while there is a decrease in iodine number of the extracted material, this decrease is not as pronounced as is the case with some other oily seeds. The soy bean seems to maintain acids of a high degree of unsaturation for the metabolism of the young plant up to the stage of the formation of the first set of leaves.

2—Bacteria and enzymes exert a marked hydrolytic action on oils in the presence of sufficient water, but in dry oils their action is slight. They have no action tending to increase the unsaturation of oils. From a practical standpoint, because of their presence in oils and sediments of oil containers, the possibilities of their hydrolytic action should be carefully considered.

3—The hydrolytic action of heat should be kept in mind in the sterilization of all fatty materials for bacterial culture purposes.

4—Salts of some metals, in certain concentrations, at 37° C. or in sunlight, act as catalyzers and increase hydrolysis, but they do not act to increase unsaturation.

5—Ultraviolet light acting on oils and emulsions containing salts exerts a slight hydrolyzing action.

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REACTION PRODUCTS OF ALKALI-SAWDUST FUSION
ACETIC, FORMIC, AND OXALIC ACIDS AND
METHYL ALCOHOL¹

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In 1829 Gay-Lussac² discovered that oxalic acid is formed by fusing cellulose, sawdust, sugar, etc., with caustic potash. This process was used in the manufacture of oxalic acid by Dale³ in 1856. Later Thorn⁴ made a systematic study of the formation of oxalic acid by fusion of sawdust with sodium and potassium hydroxides separately and with mixtures of the two.

These earlier investigators, however, say very little about other products formed by the action of alkalis on sawdust. In connection with researches on the formation of acetic acid by the decomposition of lignocellulose, W. H. Higgin patented a process for the production of sodium acetate from alkaline waste liquor from straw and esparto boiling in paper manufacture.⁵ Following this, Cross, Bevan, and Isaac⁶ conducted a series of experiments on the action of alkalis on typical carbohydrates at elevated temperatures, with the object of determining, among other things, the maximum yield of acetic acid. Although their work was confined largely to the simpler carbohydrates, they obtained from 18 to 28 per cent of acetic acid from pine wood. Gases given off were found to be one-third to one-half hydrogen and to amount to 2 to 3 per cent of the substance decomposed. Oxalic acid was formed to some extent. They also found the yield of acetic acid was increased as the proportion of alkali to carbohydrates is increased from one to three. Potassium hydroxide proved better than sodium hydroxide and acted at a lower temperature.

In 1911 patents were taken out covering the production of oxalates⁷ and acetates⁸ by the action of alkali and air on woody fiber at elevated temperatures. Patents have also been obtained for the production of organic acids from waste pulp liquor⁹ and attempts to improve the method of producing oxalic acid from sawdust have been made.¹⁰

Whatever success these various processes have met with in practice, the facts are that prior to the war the chief sources of oxalic and acetic acids were producer gas and hardwood distillates, respectively.

The demand for acetic acid for war purposes has exceeded the supply and has led to the seeking of new sources of this important chemical. The present investigation was therefore undertaken to determine the amount of acetic acid obtainable from various species of wood, in the form of sawdust, by fusion with

¹ Read at the 56th Meeting of the American Chemical Society, Cleveland, September 10 to 13, 1918

² *Ann. chim. phys.*, **41** (1829), 398.

³ *Eng. P.*, 2,767, 1856; 3031, 1856.

⁴ *Dingler's Polytechnisches Journal*, **210** (1873), 24; Hubbard, "Utilization of Wood Waste," Edition II, Chapter III.

⁵ *Eng. P.*, 13,408, 1891.

⁶ *J. Soc. Chem. Ind.*, **2** (1892), 966.

⁷ *U. S. P.*, 1,001,937.

⁸ *U. S. P.*, 1,002,034.

⁹ *U. S. P.*, 999,551, 1,217,218.

¹⁰ *Eng. P.*, 23,682, 1893; 2,308, 1897; *U. S. P.*, 1,018,092, 1,065,577; *Chem. Abs.*, **6** (1911), 3729.

alkali—a treatment which gives the largest yield of acetic acid.¹ Hardwood sawdust was used principally, since it is less suitable for the production of ethyl alcohol² and also since hardwoods give larger yields of acetic acid on destructive distillation.

While the production of acetic acid was the chief aim in this work, it was appreciated that other products of value might be produced in sufficient quantities to warrant recovery. Consequently yields of oxalic acid, formic acid, and methyl alcohol were also determined.

EXPERIMENTAL

Ten-gram samples of sawdust were employed. The samples were placed in iron crucibles 7.5 cm. in diameter and 6.2 cm. deep, and enough 1 : 1 alkali added to give the desired proportion of alkali to sawdust. Owing to the scarcity and high cost of caustic potash, caustic soda was used throughout the experiments. In the preliminary runs on basswood the crucibles were not covered and were heated on a sand bath for the length of time indicated. In all subsequent runs the contents of the crucibles were brought to the desired temperature on a sand bath and the crucibles then placed in an electric oven for the length of time indicated in each run. During the preliminary heating the crucibles were covered with lids, having a hole large enough to admit a thermometer, as this arrangement permitted a more uniform heating of the contents of the crucible. From time to time the mass was stirred.

After heating, the reaction mixture was leached with water. Where much woody material remained, as in the runs at lower temperatures, this was filtered off and the filtrate made up to 200 cc., but in the runs at 170° and above, the unfiltered leach liquor was made up to this volume. Fifty-cc. portions were taken for analysis.

The alkaline liquor always contained some woody material either in suspension or solution, which on acidification was thrown down. The action of very strong phosphoric acid on this material apparently gave rise to some acetic acid not previously produced by the interaction of the alkali and sawdust.² The following procedure was therefore adopted in determining acetic acid.³ A 50-cc. sample was placed in a 250 cc. flask fitted with a rubber stopper carrying a 50 cc. separatory funnel and an outlet tube, including a Kjeldahl bulb, leading to a condenser. Fifteen cubic centimeters of phosphoric acid (85 per cent H_3PO_4) were added through the separatory funnel and the mixture distilled until the volume of liquid in the flask was reduced to 50 cc. The volume was then maintained at approximately 50 cc. by adding water through the separatory funnel while 300 cc. of distillate were collected. Although higher homologues are probably formed in small amounts, the acids in the distillate appear to be almost entirely formic and acetic. One-half of the distillate was titrated with $N/10$ sodium

hydroxide, using phenolphthalein as indicator, and the per cent total volatile acid was calculated in terms of acetic acid. The other half was treated with the number of grams of mercuric oxide corresponding to the number of cubic centimeters of $N/10$ alkali required in the above titration, and digested for 3 hrs. on the steam bath. The mixture was then transferred to the 250 cc. flask used in the determination of total acid, an excess (25 cc.) of phosphoric acid added, and the acidified mixture distilled to small volume and then washed with 100 cc. of water added through the separatory funnel. In this way about 250 cc. of distillate were obtained, which was titrated with $N/10$ sodium hydroxide, using phenolphthalein as indicator, and the acid calculated as acetic acid. The molecular difference between the total acid and the acetic acid represents formic acid. Since there is no point in the original distillation with phosphoric acid at which the evolution of acid is entirely complete, an accuracy greater than 1 per cent cannot be claimed for the results dependent on this portion of the analysis.

Oxalic acid was determined, using 50 cc. of the leach liquor. This was acidified with acetic acid and boiled to expel carbon dioxide. The solution was then made alkaline with ammonium hydroxide, boiled, and filtered to remove precipitated iron. An excess of a saturated solution of calcium acetate was added to the boiling filtrate and the calcium oxalate allowed to settle. The precipitate was filtered off, dried, and ignited at red heat to remove organic matter and to decompose the oxalate. The residue which contained small amounts of iron was then dissolved in hydrochloric acid and the calcium determined in the usual way as sulfate.¹

PRELIMINARY RUNS—Basswood (*Tilia americana*) gives a high yield of acetic acid on simple acid hydrolysis² and was consequently selected for the preliminary runs. The 20-mesh sawdust was placed in a crucible, the alkali solution added, and the two thoroughly mixed. The mixture darkens as the temperature rises. At about 130° boiling sets in, partial solution takes place, and the mixture becomes black.

TABLE I

Ratio Alkali to Sawdust	Mean Temp. of Run Deg. C.	Time of Heating Hrs.	Volatile Acid Calc. as Acetic Acid (Dry Base) Per cent
2 : 1	105	3	8.6
2 : 1	Steam Bath	24	7.6
2 : 1	Steam Bath	48	9.1
3 : 1	145	Min.	10.1
3 : 1	145	30	12.1
3 : 1	170	15	10.1
3 : 1	170	15	10.1
3 : 1	173	30	12.1
3 : 1	205	30	23.1
3 : 1	205	60	25.8
3 : 1	205	105	26.5
3 : 1	205	165	29.0
3 : 1	210	30	6.1
3 : 1	230	30	26.4
3 : 1	230	60	25.3
3 : 1	230	110	26.4
3 : 1	230	150	24.3
3 : 1	245	10	22.2
3 : 1	245	15	18.2

Calcium hydroxide was the alkali used in this run. Ratio of water to alkali 4 : 3.

¹ Cross and Bevan, "Cellulose," p. 191.

² Forthcoming Forest Service Bulletin.

³ Allen, "Commercial Organic Analysis," 1, 509 (4th Ed.); Gladding, THIS JOURNAL, 1 (1909), 250.

¹ Treadwell-Hall, "Analytical Chemistry," 2, 72.

² THIS JOURNAL, 9 (1917), 556.

TABLE II

SPECIES	Hrs. Time	Ratio NaOH to Sawdust	170° C.					200° C.					230° C.					260° C.					290° C.						
			Total Volatile Acid Calc. as Acetic Per cent	Acetic Per cent	Oxalic Acid (H ₂ C ₂ O ₄ ·2H ₂ O) Per cent	Total Volatile Acid Calc. as Acetic Per cent	Acetic Per cent	Oxalic Acid (H ₂ C ₂ O ₄ ·2H ₂ O) Per cent	Total Volatile Acid Calc. as Acetic Per cent	Acetic Per cent	Oxalic Acid (H ₂ C ₂ O ₄ ·2H ₂ O) Per cent	Total Volatile Acid Calc. as Acetic Per cent	Acetic Per cent	Oxalic Acid (H ₂ C ₂ O ₄ ·2H ₂ O) Per cent	Total Volatile Acid Calc. as Acetic Per cent	Acetic Per cent	Oxalic Acid (H ₂ C ₂ O ₄ ·2H ₂ O) Per cent	Total Volatile Acid Calc. as Acetic Per cent	Acetic Per cent	Oxalic Acid (H ₂ C ₂ O ₄ ·2H ₂ O) Per cent									
White Oak (<i>Quercus alba</i>)	3/4	3:1	9.3	4.1	6.6	14.7	5.9	12.5	25.7	11.0	37.5	26.7	12.0	37.5	26.7	12.0	37.5	26.7	12.0	37.5	26.7	12.0	37.5	26.7	12.0	37.5	26.7	12.0	37.5
	1 1/2	3:1	9.5	4.3	6.6	17.7	7.1	19.6	26.7	12.0	39.5	26.7	12.0	39.5	26.7	12.0	39.5	26.7	12.0	39.5	26.7	12.0	39.5	26.7	12.0	39.5	26.7	12.0	39.5
	3	3:1	15.9	6.4	24.1	26.2	10.2	31.5	24.5	17.0	38.4	24.5	17.0	38.4	24.5	17.0	38.4	24.5	17.0	38.4	24.5	17.0	38.4	24.5	17.0	38.4	24.5	17.0	38.4
	6	3:1	21.2	8.4	...	23.6	13.6	55.3	20.6	17.6	35.3	20.6	17.6	35.3	20.6	17.6	35.3	20.6	17.6	35.3	20.6	17.6	35.3	20.6	17.6	35.3	20.6	17.6	35.3
	12	3:1	30.3	11.4	38.0	21.6	15.6	62.5	19.9	18.9	40.4	19.9	18.9	40.4	19.9	18.9	40.4	19.9	18.9	40.4	19.9	18.9	40.4	19.9	18.9	40.4	19.9	18.9	40.4
	24	3:1	25.2
Hard Maple (<i>Acer saccharum</i>)	3/4	3:1	7.7	4.3	...	16.5	7.3	...	22.0	11.5	...	22.0	11.5	...	22.0	11.5	...	22.0	11.5	...	22.0	11.5	...	22.0	11.5	...	22.0	11.5	...
	1 1/2	3:1	8.0	4.7	...	22.6	10.0	24.9	23.8	14.1	42.0	23.8	14.1	42.0	23.8	14.1	42.0	23.8	14.1	42.0	23.8	14.1	42.0	23.8	14.1	42.0	23.8	14.1	42.0
	3	3:1	9.6	5.3	...	27.3	12.8	46.4	19.3	17.8	58.7	19.3	17.8	58.7	19.3	17.8	58.7	19.3	17.8	58.7	19.3	17.8	58.7	19.3	17.8	58.7	19.3	17.8	58.7
	6	3:1	18.1	8.1	...	23.4	15.7	59.3	21.0	18.1	46.4	21.0	18.1	46.4	21.0	18.1	46.4	21.0	18.1	46.4	21.0	18.1	46.4	21.0	18.1	46.4	21.0	18.1	46.4
	12	3:1	16.0	7.2	...	32.2	16.3	...	22.9	19.1	...	22.9	19.1	...	22.9	19.1	...	22.9	19.1	...	22.9	19.1	...	22.9	19.1	...	22.9	19.1	...
	24	3:1
Elm (<i>Ulmus americana</i>)	3/4	3:1	10.2	6.7	...	17.7	9.9	...	23.6	12.8	...	23.6	12.8	...	23.6	12.8	...	23.6	12.8	...	23.6	12.8	...	23.6	12.8	...	23.6	12.8	...
	1 1/2	3:1	9.7	6.1	...	19.0	9.9	26.8	24.7	15.5	33.9	24.7	15.5	33.9	24.7	15.5	33.9	24.7	15.5	33.9	24.7	15.5	33.9	24.7	15.5	33.9	24.7	15.5	33.9
	3	3:1	13.4	7.8	...	20.9	11.2	34.6	20.9	19.1	56.1	20.9	19.1	56.1	20.9	19.1	56.1	20.9	19.1	56.1	20.9	19.1	56.1	20.9	19.1	56.1	20.9	19.1	56.1
	6	3:1	15.8	8.6	...	27.9	14.4	73.6	24.9	18.7	50.6	24.9	18.7	50.6	24.9	18.7	50.6	24.9	18.7	50.6	24.9	18.7	50.6	24.9	18.7	50.6	24.9	18.7	50.6
	12	3:1	18.8	9.5	...	31.4	13.9	...	21.1	18.5	...	21.1	18.5	...	21.1	18.5	...	21.1	18.5	...	21.1	18.5	...	21.1	18.5	...	21.1	18.5	...
	24	3:1
Longleaf Pine (<i>Pinus palustris</i>)	3/4	3:1	6.0	2.2	1.5	13.0	4.2	14.9	19.5	7.9	43.6	19.5	7.9	43.6	19.5	7.9	43.6	19.5	7.9	43.6	19.5	7.9	43.6	19.5	7.9	43.6	19.5	7.9	43.6
	1 1/2	3:1	6.6	2.3	2.2	12.7	4.1	13.5	22.0	9.4	54.6	22.0	9.4	54.6	22.0	9.4	54.6	22.0	9.4	54.6	22.0	9.4	54.6	22.0	9.4	54.6	22.0	9.4	54.6
	3	3:1	9.1	3.1	6.5	17.6	6.4	30.0	18.4	12.0	68.9	18.4	12.0	68.9	18.4	12.0	68.9	18.4	12.0	68.9	18.4	12.0	68.9	18.4	12.0	68.9	18.4	12.0	68.9
	6	3:1	24.0	8.4	37.2	17.4	14.4	70.0	16.4	14.0	69.3	16.4	14.0	69.3	16.4	14.0	69.3	16.4	14.0	69.3	16.4	14.0	69.3	16.4	14.0	69.3	16.4	14.0	69.3
	12	3:1	32.6	12.6	58.0	21.4	14.7	74.0	16.2	14.6	67.4	16.2	14.6	67.4	16.2	14.6	67.4	16.2	14.6	67.4	16.2	14.6	67.4	16.2	14.6	67.4	16.2	14.6	67.4
	24	3:1

† Ignited. ‡ Partially charred.

As the water boils off, the temperature gradually rises and the mixture becomes thicker and lighter in color. At 170° the mixture is quite stiff and rolls up when stirred. Fusion begins at 190° to 200°, and at 220° the mass is a paste. Soon after fusion begins, a marked exothermic reaction sets in, the temperature rises quite rapidly, and there is considerable evolution of gas. The color changes to light yellow on fusion and to greenish yellow as the reaction proceeds. On cooling, the mass becomes hard and the yellow color changes to brown on contact with the moisture of the air. The resulting product is almost completely soluble in water, giving an almost black solution. The original wood particles are perceptible as such until fusion takes place. In the case of the lime run no fusion took place, the reaction mixture became light colored and crumbled when stirred. Under varying conditions the results obtained are found in Table I.

The results show that both length of time of heating and the temperature at which this heating is carried out are factors which determined the yield of total volatile acid and that a maximum is reached for a half-hour period of heating at 230° and for a 2 3/4-hr. period at 205°.

EXPERIMENTS WITH WHITE OAK, HARD MAPLE, AND ELM.—To determine the optimum conditions as to time of heating and temperature for the production of acetic acid from sawdust the above woods, from which a large percentage of commercial sawdust is obtained, were selected. Runs were made on longleaf pine for the purpose of comparison with the hardwoods. The preliminary runs with basswood indicated that the most favorable temperature lay between 170° and 245°. Consequently, runs were made at 170°, 200°, and 230° on all three woods, and at 260° and 290° on elm. The time was varied from three-quarters of an hour to 12 hrs., except in two runs on oak, where the time was extended to 24 and 48 hrs. Sawdust produced at the laboratory sawmill was used, and for the sake of uniformity was passed through an 8-mesh

sieve. The runs were made in groups of five and the results of some typical series are recorded in the table. Percentages are calculated on the dry weight of the wood.

The yield of total volatile acid reaches a maximum at 170° and a 12-hr. heating period with oak and pine, and at 200° for the same period with maple and elm. Roughly, however, only 50 per cent or less of this acid is acetic. The yield of acetic acid increases both with time and temperature up to 230° for a 3-hr. period, so that these appear to represent the optimum conditions for the production of acetic acid. The results on elm indicate that it is possible to shorten the heating period by raising the temperature to 260°, but at this higher temperature there is danger of the reaction mixture igniting. The yield of oxalic acid is highest for the longer periods of heating at 200°. At higher temperatures the yield decreases and at 260° most of the oxalate previously formed is decomposed. Pine gives a higher yield of oxalic and a lower yield of acetic acid than the hardwoods.

The formation of oxalic acid appears to be independent of the acetic acid produced. On the other hand, at least part of the formic acid formed is converted into oxalic acid at 200° and over as indicated by a decreasing percentage of total acid and increasing percentages of acetic and oxalic acids. Some of the acetic acid results from hydrolysis of acetyl groups in the lignocellulose, but the greater portion of it is probably produced by a more profound change of the original wood substance. Cross, Bevan, and Isaac¹ obtained large yields of acetic acid from cane sugar under similar conditions—a compound which contains no acetyl groups or acetic acid residues.

Experiments with smaller ratios of alkali to sawdust not only gave smaller yields of acid for corresponding temperature and heating periods, but the reaction is difficult to control, only partial fusion takes place, and the mass is very apt to char as a result of the heat

¹ Loc. cit.

generated by the exothermic reaction. The results of these experiments are given in the following table:

TABLE III

SPECIES	Hrs. Time	Ratio NaOH to Sawdust	170° C.			230° C.		
			Total Volatile Acid Calc. as Per cent	Acetic Acid Per cent	As a % of Total Volatile Acid	Total Volatile Acid Calc. as Per cent	Acetic Acid Per cent	As a % of Total Volatile Acid
White Oak	3/4	1 1/2	1	12.2	4.9	12.3 ¹	11.2	20.0
	1 1/2	2	1	14.4	5.2	12.3 ¹	7.7	26.9
	3	1 1/2	1	14.2	5.2	12.3 ¹	11.6	37.7
	6	1 1/2	1	15.3	5.4	23.6 ²	12.2	40.3
White Oak	12	1 1/2	1	16.0	5.5	22.4 ²	13.9	39.8
	3/4	2	1	.....	.....	21.9 ²	.....	38.9
	1 1/2	2	1	.....	.....	6.1 ¹	.....	12.5
	3	2	1	.....	.....	21.4 ²	.....	40.5
Maple	6	2	1	.....	.....	14.1 ¹	.....	35.8
	12	2	1	.....	.....	8.9 ¹	.....	19.2

¹ Charred.

² Partially charred.

The minimum amount of alkali for maximum production of acids under favorable conditions appears to be approximately 3 parts to 1 of sawdust.

In order to check on a somewhat larger scale the results thus far obtained and also to investigate the volatile materials formed in the course of the reaction between sodium hydroxide and sawdust at higher temperatures, duplicate runs were made using a 10 l. autoclave. The autoclave is of the ordinary type and is provided with a stirring device and an outlet tube connected to a coil condenser. Thermometer tubes are provided for securing the temperatures of the charge and the escaping vapors. The heating unit consists of a sodium-potassium nitrate bath heated by a gas flame. The temperature of the bath is determined by a recording thermometer.

The size of the charge found most suitable was 2 lbs. (907.2 g.) of bone-dry sawdust, and this amount, with 6 lbs. of alkali, was used in all runs. The conditions which it was attempted to approximate were those for the maximum production of acetic acid together with as large an amount of oxalic acid as possible, that is, a 3-hr. heating period at approximately 230°.

The results obtained on runs with oak, elm, and maple are given in Table IV. The methyl alcohol was determined by taking the specific gravity of a distillate obtained by fractionally distilling the original distillate and again distilling the methyl alcohol fraction after acidification with sulfuric acid to remove volatile bases. A 12-in. Hempel column was used, and the distillations were continued until the temperature of the vapor passing over became 100°. Acetone was determined in the final methyl alcohol distillate by the iodoform reaction, the excess of iodine being titrated with thiosulfate solution.¹

TABLE IV

SPECIES	Temp. during 3-Hr. Heating Period Deg. C.		Total Volatile Acid Calc. as Acetic Per cent	Acetic Acid Per cent	Oxalic Acid (H ₂ CO ₄ ·2H ₂ O) Per cent	Methyl Alcohol Per cent	Acetone Per cent
	Av.	Max.	Per cent	Per cent	Per cent	Per cent	Per cent
Oak	225	235	18.3	15.9	2.6	2.37	0.004
Elm	227	235	20.9	17.5	5.8	2.33	0.003
Maple	231.5	234	19.3	15.1	3.5	2.51	0.004

The results agree very well with those previously obtained, except for oxalic acid. A subsequent run at 200° on oak gave the following yields:

	Per cent
Total volatile acid.....	20.4
Acetic acid.....	13.9
Oxalic acid.....	35.0

The temperature reached in the above runs appears, therefore, to have been high enough to decompose most of the oxalate previously formed.

The yield of methyl alcohol is greater than that obtained by the destructive distillation of these woods,¹ but less than is theoretically possible from the methoxy content of the wood as determined by the Zeisel method.² As was to be expected, the amount of acetone produced is negligible.

In order to determine at what stage during the reaction the larger portion of methyl alcohol is produced, the original distillates were collected in three fractions and the methyl alcohol in each determined.

TABLE V

SPECIES	Fraction	Vol. of Original Fraction Cc.	Temp. of Reaction Mixture, Deg. C.	Methyl Alcohol Grams	Total Methyl Alcohol Per cent
Oak	1	2095	Up to 162	5.51	22.13
	2	424	172-177	1.26	5.06
	3	490	177-235	18.13	72.81
Elm	1	1492	Up to 159	3.72	26.55
	2	576	159-183	0.73	5.21
	3	610	183-235	9.56	68.24
Maple	1	1230	Up to 160	4.07	17.51
	2	1010	160-180	1.97	8.48
	3	311	180-234	17.20	74.01

The figures show that about 30 per cent of the methyl alcohol is produced by simple hydrolysis, while approximately 70 per cent results from the more drastic action involved in the fusion of the alkali and wood. It appears probable that there are methyl esters as well as methyl ethers in the original ligno-cellulose.

ALKALI RECOVERY—Since any process for the production of acetic acid and other valuable products from sawdust, using such a large excess of alkali, must involve the recovery of most of this alkali to be successful commercially, preliminary experiments were made to determine how and to what extent the sodium hydroxide used could be recovered. These experiments having indicated the possibility of recovery of a sufficiently large percentage of alkali as carbonate to make this process a practical one, further experiments were conducted to determine more exactly what result could be attained. In general, the method employed was to treat a given volume of the solution of the melt with carbon dioxide to a point where a test portion no longer reacted alkaline to phenolphthalein after treatment with an excess of barium chloride. It was then concentrated to the desired strength and crystallized at room temperature or lower as desired. Crystallization was hastened by "seeding" the solution with a few crystals of Na₂CO₃·10H₂O. The crystals were filtered off on a Buchner funnel, using muslin as a filtering medium. Approximately 200 cc. of water were used in each of the washings, which were carried out by removing the crystals each time from the funnel and mixing them thoroughly with the wash water. Since sodium carbonate has a negative heat of solution there was no difficulty encountered

¹ Forest Service Bulletin 129 and 508.

² Cross and Bevan, "Cellulose," p. 189.

¹ Sherman, "Organic Analysis," p. 30.

TABLE VI

		Grams per 100 Cc.		Calc. as NaOH at Time		Approximate Temp. at Crystallization Deg. C.	Vol. of Mother Liquor	DISTRIBUTION OF ACID										DISTRIBUTION OF ALKALI					
Run No.	Wood Used in Fusion	Vol. of Time of Crystallization	Crystallization	Crystallization	Volume of Washings Cc.			Acetic Acid in Mother Liquor Per cent	Acetic Acid in Washings Per cent	Acetic Acid in Washings Per cent	Acetic Acid in Washings Per cent	Acetic Acid in Washings Per cent	Alkali in Mother Liquor Per cent	Alkali in Washings Per cent	Alkali in Washings Per cent	Alkali in Washings Per cent	Alkali in Washings Per cent	Alkali in Washings Per cent	Alkali in Washings Per cent	Alkali in Washings Per cent	Alkali in Washings Per cent		
						1	2															3	1
1	Oak	660	28.8	10	258	212	186	202	65.6	22.4	7.4	2.3	97.7	2.3	21.8	14.2	10.9	10.1	57.0	43.0			
2	Elm	1150	24.9	13	352	376	278	330	52.4	30.9	11.1	3.6	98.1	1.9	14.3	12.1	8.5	10.0	44.8	55.1			
3	Elm	950	30.1	25	298	242	179	177	60.5	27.8	6.1	2.5	96.9	3.1	17.8	15.4	12.2	10.3	55.5	44.5			
4	Elm	1250	30.0	15.5	415	340	298	250	61.4	22.8	9.0	2.7	95.9	4.1	14.9	11.6	10.5	7.6	44.9	55.1			
5	Elm	1050	35.0	20.0	292	386	252	401	56.6	29.0	10.4	2.8	98.8	1.2	11	17.6	18.4	21.0	68.4	31.6			
6	Elm	925	30.9	25.0	290	258	216	225	76.5	16.5	2.9	2.6	98.3	1.0	22.9	17.4	13.3	12.4	66.0	34.0			
7	Maple	950	27.4	17.0	295	255	256	236	58.1	25.4	11.8	3.0	98.3	1.7	16.7	15.1	13.9	11.7	57.5	42.5			

¹ Selective washing employed. ² Centrifuged instead of filtered.

in maintaining the reduced temperatures employed in some of the runs. Results obtained under varying conditions are given in Table VI.

From 96 to 99 per cent of the acetic acid is separated from the crystals by three washings, while 45 to 68 per cent of the alkali is also carried into solution, the amounts depending upon the temperature at which the process of separation is carried out and the volume of wash water used. To make the operation successful with respect to the recovery of alkali it would be necessary to remove a much larger percentage of the alkali from the mother liquor and washings. This could be done by selective washing as carried out in Runs 4 and 5 on elm. In these runs the following scheme was followed:

1—First washings from previous runs added to original solution, the solution treated with carbon dioxide, concentrated, and the carbonate "seeded" out.

2—Second washings from previous runs used for first washing.

3—Third washings from previous runs used for second washing.

4—Fresh water used for third washing.

Run 4 resulted in 95.9 per cent of the acetic acid going into the mother liquor and washings, and represents the amount of acetic acid which would be recovered unless one or more additional washings with pure water proved feasible. Since the washings obtained would be used for washing in subsequent runs, the only alkali lost would be that contained in the mother liquor, which in this case amounts to 14.8 per cent of the total alkali contained in the original solution and wash water used, or 20.1 per cent of the alkali in the original solution. This loss of alkali could be further reduced by cooling the mother liquor. In the case under consideration, if the 415 g. of mother liquor were cooled to 0°, only 22.2 g. of alkali, calculated as sodium hydroxide, would remain in solution, representing a loss of 7.77 per cent of the alkali used. A similar result could be obtained by concentrating the mother liquor to approximately 100 cc. and allowing the carbonate in solution to crystallize at room temperature.

To check the above conclusions, the mother liquor in Run 5 was cooled to 0° C. and the carbonate crystals formed filtered off. It was found that the loss of alkali could be reduced in this way to 9 per cent of the original amount used, 5.4 per cent of which is in combination with the acetic acid present in the mother liquor. It seems probable, therefore, that a

recovery of alkali of 85 to 90 per cent could be obtained without difficulty.

The runs on the different species were made primarily to determine what effect, if any, the organic matter in solution or suspension might have in carrying out the separation of acid and alkali. Any effect this material has is negligible, and since it is concentrated in the mother liquor the crystals are probably sufficiently free from organic matter to make calcining unnecessary before causticizing.

SUMMARY

The data given show that 17 to 20 per cent of acetic acid can be obtained from hardwood sawdust by fusion with sodium hydroxide.

A simultaneous production of oxalic acid amounting to approximately 50 per cent of the dry weight of the wood is obtained.

If the reaction is carried out in a closed vessel, a simultaneous production of methyl alcohol results amounting to 2.4 per cent; but, as the temperature is increased beyond 200°, the yield of oxalic acid is considerably reduced.

At lower temperatures both formic and acetic acids are produced, amounting to approximately 15 per cent each.

Higher yields of oxalic acid than those obtained by Thorn¹ with pine wood and caustic soda have been obtained. It appears that the yields of this acid obtained with caustic soda will more nearly approach those obtained with caustic potash if the temperature is kept at approximately 200°, the heating prolonged, and the ratio of alkali to sawdust maintained at 3 : 1.

Somewhat lower yields of acetic acid than those obtained by Cross, Bevan, and Isaac² with caustic potash have been obtained using caustic soda.

It has been found possible to recover as much as 91 per cent of the alkali used.

FOREST PRODUCTS LABORATORY
IN COOPERATION WITH THE UNIVERSITY OF WISCONSIN
MADISON, WISCONSIN

AN AEROBIC SPORE-FORMING BACILLUS IN CANNED SALMON

By ALBERT C. HUNTER AND CHARLES THOM
Received April 19, 1919

Failures in the sterilization of canned goods are well recognized from the occurrence of swelled cans, cans which give out foul odors when opened, or of glass jars in which there is turbidity or other visible

¹ Loc. cit.

² Ibid.

evidence of decomposition. The presence of living bacteria in such products without active spoilage is less well known, but accounts for some of the discordant bacteriological results which have been frequently attributed to errors in manipulation. Such living bacteria may bear no relation to the present condition of the product whether sound or spoiled. Bacteriological examination of about 500 cans of salmon has furnished a striking example of such survival.

The salmon examined represented nine brands packed at different factories and included salmon designated by the trade as red or sockeye salmon, coho or silver salmon, chum or dog salmon, and humpback or pink salmon. Routine examination designed to test sterility was first applied. When living organisms were found, all species were isolated and studied to test their relationship to the conditions met with. The large number of unsterile cans encountered, 44.7 per cent (Table I), forced a careful discrimination between unsterility and active spoilage.

The cans were first examined for leaks or dents and as to whether or not they were "swells" or "springers." They were then opened aseptically by means of a flamed can opener. By means of a sterile pipette, from 5 to 10 mm. in diameter and not tapered at the end, a small amount of the salmon was transferred to each of two Petri dishes. Care was taken to obtain some of the flesh together with the liquor. Small amounts were also carefully placed in each of two test tubes and about 5 g. in dextrose broth. Dextrose agar was poured over the fish in the Petri dishes and the test tubes and all cultures were incubated at 37° C. for 4 days. Notice was taken of the odor and general appearance of the fish in each can and a record of this was kept with the bacteriological data.

Table I gives a summary of the cans examined and the number and per cent of cans found not sterile.

TABLE I

BRAND	Number Examined	Number Not Sterile	Per cent Not Sterile
A.....	202	110	54.4
B.....	66	38	57.5
C.....	72	31	43.05
D.....	32	19	59.37
E.....	32	19	59.37
F.....	24	13 ¹	54.1
G.....	24	7	29.1
H.....	32	0	0
I.....	46	0	0
TOTAL.....	530	237	44.7

¹ These 13 cans were "swells" and did not show the characteristic organism discussed in this paper.

A study of this table shows that nearly one-half of these cans of salmon were found to contain living bacteria in contrast to the findings of Weinzi¹ who reports very few unsterile cans of salmon. In some brands the proportion of non-sterile cans is greater than 50 per cent, while in other cases, for example, the fish from Brands H and I, all the cans examined were found to be sterile. The presence of these living bacteria has little significance as to the quality of the product at the time the can is opened, since some of the sterile cans were found, on chemical examination, to contain putrid and decomposed fish, while many of

the cans from which bacteria were grown contained fish apparently sound.

Comparative study of the organisms found in these cans showed that a particular variety had been found in 224 out of 237 non-sterile cans, or 42.2 per cent of all cans examined. The 13 unsterile cans failing to show this species were the "swells" belonging to a single group of Brand F. Cans showing a mixed flora are not uncommon but in many cases this form alone survived the processing. This organism was first isolated from still another lot of salmon in this laboratory by Mrs. Obst during the summer of 1918. The frequency of this species in salmon, together with its survival in commercially processed goods, makes a study of its characteristics especially important. The other organisms found were isolated for study but thus far have furnished no significant information.

DESCRIPTION OF THE ORGANISM

The morphological, cultural, and biochemical features of this organism as described here indicate that it is probably a member of the mesentericus group, although not clearly identified with any of the well-known species.

MORPHOLOGY		
Bacillus 3.2 μ \times 0.7 μ	Spore-forms measure 1.6 μ \times 0.8 μ	Motile
Forms spores within 24 hrs.		Gram-positive
CULTURAL CHARACTERS		
Grows on all media	Growth on dextrose agar slant spreading, tough and wrinkled	Pellicle on dextrose broth, medium dark brown
Produces red ring in dextrose agar	On dextrose agar plates growth covers entire surface of plate	Gelatin liquefied
Growth on nutrient agar slant along streak, wrinkled, gray	Heavy pellicle in plain broth, medium clear	Litmus milk peptonized turned brown in 48 hrs.
BIOCHEMISTRY		
No gas in dextrose and lactose broth with and without fish	Acid produced in dextrose and lactose broths. Later turns alkaline	dextrose broth plus fish. Much less in lactose broth
No indole in tryptophan broth	2.8 per cent normal acid produced in	Spores of this organism very resistant to heat

The outstanding feature of this organism is the production of a dark red ring when grown on solid carbohydrate medium. This ring is produced in the medium at about a half-inch from the growth on the slant or from the growth on the surface of the column of agar. When sterile fish is present in the medium, this red color is often imparted to it and a marked softening of the fish takes place. No such red ring is obtained when the organism is grown on plain agar.

The action of this organism on sterilized salmon is very marked. Approximately 500 g. of fish were ground in a food chopper and sterilized for 90 min. at 15 lbs. pressure. This fish was inoculated with 10 cc. of a 48-hour broth culture of the organism and incubated at 37° C. for one week. Within that time the fish became very soft, in fact, liquid, and gave off a very offensive odor. The color of the decomposed fish was a dark brown. Chemical examination¹ of the decomposed salmon in this particular case failed to show the presence of indol, skatol, or hydrogen

¹ "The Bacteriology of Canned Foods," *J. Med Res* 39 (1919), [1] 394

¹ Determinations made by Dr. H. W. Houghton, of the Food Investigation Laboratory, Bureau of Chemistry

sulfide, although a very pronounced test for methyl mercaptan was obtained. Further work, however, is necessary to establish the correlation between the action of this organism on the salmon and the decomposition products resulting therefrom.

The spores of this organism are resistant to heat and in broth culture have been found to survive heating in the Arnold sterilizer at 100° C. for one hour. Broth cultures of the spores survived 15 lbs. pressure in the autoclave for 15 min., but were killed at 15 lbs. pressure for 30 min. It is very evident that these forms when embedded in the center of the salmon within the can may survive the temperature of processing in the cannery.

Study of the detailed records summarized in Table I shows that some cans of Brands H and I, in which all cans were found sterile, consisted of markedly decomposed fish. In the other samples with part of the cans sterile there was no correlation between sterility and the soundness of the fish except in Brand F, in which active spoilage is reported. An obligate aërobe such as this may be found in viable condition in a can properly sealed and showing no apparent spoilage. In fact, organisms of several species were found in cans of fish in which no physical or chemical evidences of spoilage were detected. Some cans containing soft and obviously putrid fish contained no living organisms.

The presence of these organisms may result in quick decay when opening the can supplies the oxygen needed for activity. On the other hand, their presence may or may not supply information as to the previous history of the material canned. Such correlation depends upon the establishment of a correlation between a particular microorganism and a condition or process. The salmon organism is a heat-resistant spore-former capable of decomposing salmon with great rapidity, but its exact source and significance in the canned products remains to be demonstrated.

The survival of such an organism shows that the method of cooking or processing the commercial product has failed to produce sterility. The temperature may not have reached the proper limit, the period may have been too short, or the heat may not have been evenly applied, hence some cans escaped the adequate cooking which sterilized the remainder. The large number of unsterile cans found among well-known brands of salmon points to a widespread failure in factory operation.

Sterility merely means that whatever organisms may have been present in the material at some time are now dead. The material itself may have been rotten or putrid from the activity of these organisms before canning, hence totally unfit for food. Some of this salmon was manifestly putrid but not in active spoilage as it came from the can. The evidences of decay were, however, manifest to sight and smell. In specially prepared foods these evidences are commonly masked or more or less completely destroyed. Jams, jellies, apple butter, canned pumpkin, mince meat, soup stock, and tomato products such as catsup, pulp, and paste, may be made up in large part of

decomposed material yet so comminuted and so flavored in cooking as to leave neither visible evidence nor flavor to guide the consumer who would unhesitatingly reject the raw materials if he could examine them. Yet these products are commonly sterile. Sterility is not to be confused with fitness for food; it does establish the presumption that the material under examination is in the same condition as when packed.

Similar observations have been made in this laboratory in a considerable variety of canned foods. Living bacteria rather frequently are found in canned foods which show no signs of decomposition which are apparent to the senses. The organism described in this paper is only one of many forms, both cocci and bacilli, isolated from canned products apparently sound. This leads to the conclusion that lack of fermentation or active spoilage of canned food is not a guarantee of sterility. This condition in sardines is discussed by Obst.¹ The bacteria in the product may be in a dormant state while in the can and only grow when more favorable conditions are supplied. Many of the bacteria isolated, as the organism described above, are obligate aërobes and could not grow under the anaërobic conditions occurring in a properly exhausted and sealed can.

Processing, to use the commercial term, should then be distinguished from sterilization.

SUMMARY

Bacteriological examination of 530 cans of salmon, representing 9 brands, showed 237 unsterile cans. 224 of these cans contained the same organism of the mesentericus group either in pure culture or in connection with other species. Only 13 of these cans showed active spoilage.

The organism is an obligate aërobic spore-former, gram positive, motile, and produces a dark red ring about a centimeter below the colony in carbohydrate media. It decomposes fish rapidly.

Such obligate aërobic spore-formers may be present in viable condition in canned products without any appearance of spoilage.

Actual sterility is very properly the aim of the packer. The survival of viable organisms in the final product may occasionally be unavoidable but calls for a careful survey of their source and significance with a view to their complete destruction.

BUREAU OF CHEMISTRY
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WASHINGTON, D. C.

TEMPERATURE-TIME RELATIONS IN CANNED FOODS DURING STERILIZATION

By G. E. THOMPSON

Received June 26, 1918

I—INTRODUCTION

It is well known that the death rates of the bacteria which caused spoilage in canned foods depend on the temperature and composition of the substrate. As these death rates, under varying conditions of temperature and substrate, become accurately established, a knowl-

¹ "A Bacteriologic Study of Sardines," *J. Infect. Dis.*, **24** (1919), 158.

edge of the temperature-time relations in the cans during the sterilizing process is desirable as an aid to their application in the scientific study of food sterilization.

Only a few brief reports concerning the temperature variations in canned foods during sterilization have been published. J. Kochs and K. Weinhausen,¹ by the use of maximum thermometers, determined the maximum temperatures attained in given times, under practical conditions, in cabbage, carrots, asparagus, green peas, etc. A. W. Bitting and K. G. Bitting,² by using both thermocouples and mercury thermometers, secured complete temperature-time curves for pumpkin, sweet potatoes, tomatoes, peaches, etc., while being heated in a water bath.

It is the purpose of this paper to state the results of experiments on temperature measurement in cylindrical cans during the sterilizing process and to see what use may be made of the mathematical theory of heat conduction in extending the value of these results. It is certain that the application of this experimental data will be greatly extended if it can be put in the form of mathematical equations which may be used for plotting temperature-time curves.

It is not claimed that the present paper contains all data and results necessary for the practical utilization of the method in either home or commercial canning, but rather it is to be regarded as a preliminary communication outlining methods of procedure for the preparation of reference tables and curves. A more extended discussion of the development of the theory will probably be published later in the research bulletin series of the Iowa Agricultural Experiment Station.

The procedure used consisted in determining, by means of thermocouples embedded in the center of cans of food, the temperature-time curves when the cans are subjected to various temperatures in hot water, steam, cool air, and cool water. The effect of the size and shape of container on the heat penetration has been calculated and values of the diffusivity, *i. e.*, conductivity

specific heat \times density, found for a variety of canned foods. The mathematical theory has been quite fully developed, and a study made of the correspondence of theoretical and experimental temperature-time curves. It is shown to be possible to use a mathematical expression for plotting curves from which may be found the temperature of some food substances at any time and at any point in the can, provided the initial temperature distribution in the can and the bath temperature are known. The accuracy of this method depends on the nature of the food.

II—PREPARATION OF MATERIALS FOR CANNING

The fruits and vegetables were chosen with the idea of securing as great a variety of conditions as practicable. Those which require a large amount of free liquid to fill the cans permit considerable convection and those requiring no liquid permit practically none.

The food was prepared for canning as follows:

ASPARAGUS—The stalks of asparagus were cut in lengths approximately equal to the height of the can, blanched in boiling water during the time indicated in Table II, and then cold dipped. They were then packed in the can as neatly as possible and the free space filled with water.

CARROTS—The carrots were peeled and sliced, the slices being circular and about $\frac{1}{2}$ in. in thickness, and no careful attempt being made to have all pieces alike in size or shape.

CHARD—Stalks and leaves were both used. After blanching and cold dipping, the chard was packed into the cans without regard to the arrangement of the stalks in the can. They were pressed down rather closely so as to get a maximum amount in the can. Hot water was used to fill the free space. Undoubtedly a considerable amount of air was left in the cans by this process of filling.

CHERRIES—The cherries were washed and packed directly into the cans. No. 3 syrup, made by adding 3 lbs. 9 oz. of sugar to 1 gal. water, was used.

CORN—The corn was blanched on the cob in boiling water and cold dipped. It was then cut from the cob as quickly as possible; placed in the cans and filled with hot water. Golden Bantam and Country Gentleman were the varieties used. The Golden Bantam corn was not all of even sized grains and sometimes a little over mature. The initials G. B. and C. G. in Table II indicate the two varieties. The C. G. was in prime condition. The corn was cut into whole grains and the cob not scraped.

PEAS—The peas were hulled and blanched in boiling water for the length of time indicated in Table II, and then cold dipped. Ordinary tap water was used as liquid for filling.

STRAWBERRIES—The berries were washed in cold water and packed directly into the cans without blanching. No. 3 syrup was used.

SPINACH—Spinach was prepared in the same manner as chard except blanched in steam. The spinach used was of the New Zealand variety.

STRING BEANS—Stringless, green pod variety, broken in about 2-in. lengths was used. Free space was filled with water.

SQUASH—The squash used in these experiments had been processed once so that it was in a pasty form at the beginning of these experiments. Information concerning the water content cannot be supplied.

III—APPARATUS AND EXPERIMENTAL METHOD

COLD PACK METHOD—The hot water sterilizing bath used in the cold pack method consisted of an 8-gal. Wearever aluminum, steam-jacketed cooker, filled with tap water. This gave a very easy means of controlling the temperature of the bath, it being possible to bring the water from room temperature to boiling in from 20 to 30 min. Two general methods of procedure were employed. In one, the bath was brought to the boiling point and the can suddenly dropped in; in the other, the can was put in when the

¹ Ber. Kgl. Gart.-Lehranst., Dahlen, 1906-07, 146

² National Canners' Association Research Laboratory, Bull. 14, 32-8.

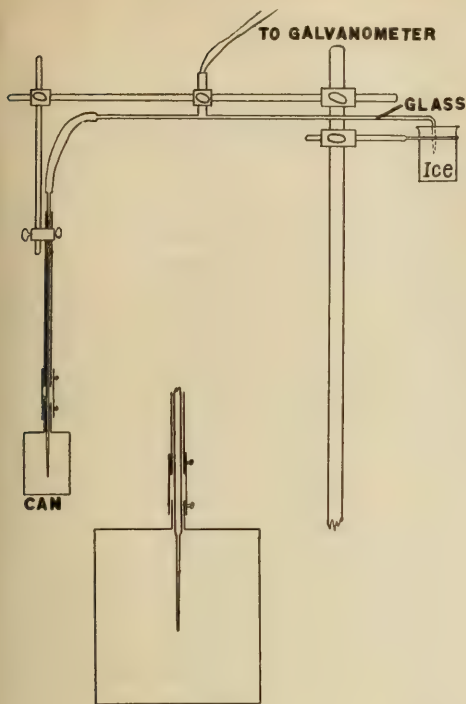


FIG. 1

bath reached 60° or 70°C. , and the bath temperature was then gradually brought to the boiling point. These are the methods most commonly employed in the cold pack process.

The temperature readings were usually made with a thermocouple and sensitive galvanometer (1.88×10^6 volt/mm.) calibrated by reference to a mercury thermometer. In a few cases a mercury thermometer was used. The thermocouple was of bare constantan wire (No. 27) and enameled copper wire (No. 30), mounted as shown in Fig. 1. The wires were protected by enclosure in glass and rubber tubing. The glass tube was narrowed down to about 2 mm. diameter at the point where it entered the can, and at the end was drawn out very thin and sealed. The presence of the thin glass surrounding the junction did not prevent the junction from attaining the temperature of its surroundings promptly. A test showed that in 20 sec. after immersion in boiling water the junction was practically at the temperature of the water.

This junction was placed as near the center of the can as possible. In locating the center of glass cans the surface of the food was considered to be the top of the can. The other junction was placed in a bath of cracked ice.

The can was supported by a brass tube held fast to the can by solder. The glass tube containing the

thermocouple entered the can through this brass tube. In order to make the interchange of cans easy, the brass tube was made in two pieces held together by a collar with set screws. The same method of support was employed for glass as for tin cans.

STEAM PROCESSING—The steam processor consisted of a piece of heavy steam-pipe, 12 in. long and 8 in. in diameter, with cast-iron plates bolted on the ends. The top plate was fastened with thumb nuts, in order that it might be easily removed. The steam was let in at the bottom and condensation was discharged through a second opening in the bottom. Another small leak was left in the top, so that any air not forced out at the bottom had opportunity to escape. The small volume of the processor made it possible to attain any desired pressure in a few seconds.

It was necessary to lead the thermocouple wires in through a steam-tight joint, capable of withstanding a gauge pressure of at least 20 lbs. per sq. in. Fig. 2 shows details of this connection. The pressure was regulated by hand by means of a needle valve.

IV—SUMMARY OF MATHEMATICAL THEORY

In developing the mathematical theory, it is assumed that the heat penetration takes place entirely by conduction. Obviously, convection plays an important part in many cases but it is thought that if the convection is very local in character, the theory will still apply approximately enough for ordinary purposes, the convection being in effect equal to an increase in conduction.

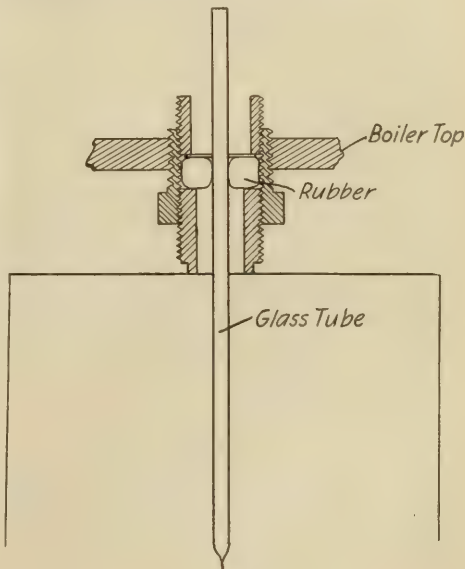


FIG. 2

The simplest case we have to consider is the one in which the contents of the can are of uniform temperature throughout before immersion in the sterilizing

bath, and in which the bath is maintained at uniform temperature after the immersion. In this case the temperature v , at any time t , and at any point in the can, is given by the expression:

$$v = C - v_0 \sum_{\mu} \sum_{m=1}^{\infty} A_{\mu m} e^{-k(\mu^2 + \lambda^2)t} J_0(\mu r) \sin \lambda(z+l) \dots (1)$$

where v_0 is the difference in initial temperatures of can and bath; r and z are the cylindrical coordinates of a point in a can, the origin being at the center of the

can; μ a root of $J_0(\mu a)$; $\lambda = \frac{m\pi}{2l}$; $A_{\mu m}$ is a constant depending on the initial temperature distribution in the

can; C is the centigrade temperature of the bath; k is the diffusivity of the material and is equal to conductivity

specific heat \times density.

A simple approximate form of this equation which serves well enough for all practical purposes is:

$$v = C - A_1 v_0 e^{-k(\mu^2 + \lambda_1^2)t} J_0(\mu_1 r) \sin \lambda_1(z+l) \dots (2)$$

This is merely the first term of Equation 1. The other terms become smaller and smaller as t increases and finally may be neglected with small error.

Another case which will be considered is one in which the bath temperature, after the can has been put in, increases uniformly to the boiling point and remains constant thereafter. The solution¹ for this case is:

$$v = C - \sum_{\mu} \sum_{m=1}^{\infty} A_{\mu m} [A e^{-Rt} + \frac{B}{R} (1 - e^{-Rt})] e^{-R(t-t_1)} J_0(\mu r) \sin \lambda(z+l) \dots (3)$$

when $t > t_1$, and

$$v = C - \sum_{\mu} \sum_{m=1}^{\infty} A_{\mu m} [A e^{-Rt} + \frac{B}{R} (1 - e^{-Rt})] J_0(\mu r) \sin \lambda(z+l) \dots (4)$$

when $t < t_1$. A is the initial temperature difference between the bath and the can; B is the rate of increase of temperature of the bath; $R = k(\mu^2 + \lambda^2)$; t_1 the time at which the bath temperature becomes constant.

In commercial canning the cans are sometimes exhausted at one temperature before processing at another. If D represents the difference between the exhaust and sterilizing temperatures, the interior temperature at time t is

$$v = C - \sum_{\mu} \sum_{m=1}^{\infty} A_{\mu m} [v_0 e^{-Rt_1} + D] e^{-R(t-t_1)} J_0(\mu r) \sin \lambda(z+l) \dots (5)$$

where t_1 is the time of completion of the exhaust. It is assumed in developing the above equation that the time elapsing between the completion of the exhaust and the beginning of sterilization is small.

We have now to consider the case of cooling. The contents of the can remain hot for some time after the removal of the can from the sterilizing bath. For

¹ The author is indebted to Professor James McMahon, of Ithaca, N. Y., for Equations 3 and 4.

the case of water cooling Equations 1 and 2 may be used, provided the heating has been continued until the contents of the can are of practically uniform temperature throughout. This is usually the case in practice so that no other conditions will be considered. The value of v_0 is negative for heating and positive for cooling. C in this case is the temperature of the cooling bath.

For air cooling an equation¹ of similar form may be employed, the constants having different values. The approximate form of the equation is

$$v = v_0 A_1' e^{-k(\mu^2 + \lambda_1^2)t} J_0(\mu_1 r) \cos \lambda_1 z + C \dots (6)$$

where $A_1' = \frac{8h \sin \lambda_1 l}{(2\lambda_1 l + \sin 2\lambda_1 l) a(h^2 + \mu_1^2) J_0(\mu_1 a)}$, μ_1 is the

first root in order of magnitude of $J_0'(\mu a) + h J_0(\mu a) = 0$, and λ_1 is the first root of $h \cos \lambda l - \lambda \sin \lambda l = 0$.

At the center of the can where $r = z = 0$, the expressions² given are somewhat simpler because for this point $J_0(\mu r) = J_0(0) = 1$, $\sin \lambda(z+l) = \sin \frac{m\pi}{2} = \pm 1$, and $\cos \lambda z = \cos(0) = 1$.

V—THE DETERMINATION OF k

The diffusivity, k , is numerically equal to the temperature change produced in unit time in a unit cube of material by the heat which is conducted across a unit area by unit temperature gradient, assuming all the heat so conducted to be equally distributed throughout the cube.

The value of k may therefore be used as a numerical index for comparing the rates of heating in various materials. The length of time required for a certain temperature to be reached under a given set of conditions is inversely proportional to k .

In finding the value of k for a given substance we make use of Equation 2 and an experimental temperature-time curve for the substance when placed in a can of known dimensions and subjected to known temperature conditions. In order to use Equation 2 we must specify a uniform temperature distribution in the can before being placed in the bath and also a uniform and unchanging bath temperature.

KIND OF CAN Tin:	TABLE I Diameter Length		μ	λ_1	$\mu^2 + \lambda_1^2$
	Cm.	Cm.			
No. 1.....	6.7	10.0	0.718	0.314	0.616
No. 2.....	8.4	11.4	0.572	0.275	0.403
No. 2 1/2.....	10.3	12.0	0.472	0.262	0.292
No. 3.....	10.4	12.2	0.463	0.258	0.282
Glass:					
Pint, Ball Ideal.....	8.9	10.2	0.540	0.308	0.387
Pint, Foster Seal Fast.....	8.6	11.2	0.558	0.280	0.401
Pint, Sure Seal.....	8.6	11.4	0.538	0.276	0.399
Pint, Mason.....	7.9	11.4	0.608	0.276	0.447
Qt., Ball Ideal.....	9.9	15.6	0.485	0.201	0.277
Qt., Foster Seal Fast.....	10.2	15.9	0.470	0.197	0.260
Qt., Sure Seal.....	9.9	15.9	0.485	0.201	0.262
Qt., Mason.....	9.9	15.9	0.485	0.201	0.262
Half-gal., Mason.....					0.210

As an example, let us determine the value of k for a pint Mason jar filled with corn. An experimental curve for this is shown in Fig. 3. The constants for several kinds of cans are shown in Table I. $\mu_1 a$ is the

¹ Carslaw, "Introduction to the Theory of Fourier's Series and Integrals," p. 327.

² $J_0(\mu r) = 1 - \frac{(\mu r)^2}{2^2} + \frac{(\mu r)^4}{2^2 \cdot 4^2} - \frac{(\mu r)^6}{2^2 \cdot 4^2 \cdot 6^2} + \dots$ and is called a Bessel function of the zero'th order.

TABLE II

No. MATERIAL	Kind of Can	How Processed	Ratio of Solid to Liquid	Time of Blanching, Min.	Bath Temperature, Deg. C.	Initial Temperature, Deg. C.	k
1 Asparagus	No. 2 tin	C.P.	.....	4	100.0	30.0	0.847
2 Asparagus	No. 2 tin	C.P.	.....	4	100.0	29.0	1.505
3 Asparagus	No. 2 tin	S.P.	.....	4	111.0	31.0	3.64
4 Asparagus	No. 3 tin	S.P.	.....	4	111.0	24.0	2.61
5 Asparagus	Qt. Mason	C.P.	.....	4	100.0	34.0	0.935
6 Asparagus	Pt. Sure Seal	C.P.	1.79	4	99.5	24	0.736
7 Asparagus	Pt. Sure Seal	C.P.	1.68	4	99.5	24	0.513
8 Carrots	No. 2 tin	C.P.	2.1	6	99.5	60	1.61
9 Carrots	Pt. Mason	C.P.	2.15	5	99.5	57.5	0.413
10 Carrots	Qt. Mason	C.P.	2.27	5	99.5	59.0	0.227
11 Chard	No. 3 tin	C.P.	.....	10	99.5	52.5	0.26
12 Chard	No. 2 tin	C.P.	.....	10	99.5	33.0	0.19
13 Chard	No. 2 tin	C.P.	.....	10	99.5	57	0.249
14 Chard	No. 3 tin	C.P.	.....	10	99.5	36	0.366
15 Chard	No. 3 tin	C.P.	.....	10	99.5	53	0.232
16 Chard	No. 2 tin	C.P.	.....	10	99.5	34	0.153
17 Cherries, with seeds	Pt. Mason	C.P.	3.77	0	99.5	24.0	0.42
18 Cherries, seeded	Pt. Mason	C.P.	13.3	0	99.5	24	0.225
19 Corn, G. B.	Pt. Mason	C.P.	2.44	5	99.5	55.0	0.34
20 Corn, G. B.	Pt. Mason	C.P.	4.79	5	99.5	52	0.17
21 Corn, G. B.	Pt. Mason	C.P.	No liquid	5	99.5	39	0.106
22 Corn, G. B.	Qt. Mason	C.P.	3.45	5	99.5	60.5	0.258
23 Corn, G. B.	No. 2 tin	S.P.	2.07	5	118.0	58.0	1.16
24 Corn, G. B.	No. 2 tin	S.P.	4.33	5	113	56	0.301
25 Corn, G. B.	No. 2 tin	S.P.	2.97	5	117	58	0.114
26 Corn, G. B.	No. 2 tin	S.P.	2.97	5	99.5	58	0.417
27 Corn, G. B.	No. 2 tin	C.P.	3.3	5	99.5	60	0.287
28 Corn, G. B.	Qt. Mason	C.P.	3.54	5	99.5	58	0.238
29 Corn, G. B.	Pt. Mason	C.P.	8.62	5	99.5	59.5	0.405
30 Corn, G. B.	Pt. Mason	C.P.	8.5	5	99.5	43.0	0.137
31 Corn, G. B.	No. 2 tin	S.P.	3.7	5	109.0	52.5	0.68
32 Corn, G. B.	Pt. Mason	C.P.	4.3	5	99.5	51.0	0.163
33 Corn, G. B.	Pt. Mason	C.P.	5.16	5	99.5	41.0	0.148
34 Corn, G. B.	Pt. Ideal	C.P.	3.82	5 1/4	99.5	59.0	0.233
35 Corn, C. G.	No. 2 tin	S.P.	3.66	5 1/4	105.0	47.0	0.321
36 Corn, C. G.	No. 2 tin	C.P.	3.45	5	99.5	59.0	0.228
37 Corn, C. G.	No. 2 tin	C.P.	3.5	5	99.5	58.0	0.194
38 Peas, all sizes	No. 2 tin	C.P.	2.42	8	99.5	61.0	1.31
39 Peas, all sizes	No. 2 tin	C.P.	1.70	8	99.5	63.0	1.46
40 Peas, all sizes	Pt. Mason	C.P.	2.16	5	99.5	54.0	0.573
41 Peas, all sizes	No. 2 tin	C.P.	1.80	5	99.5	57.0	1.66
42 Peas, all sizes	No. 3 tin	C.P.	1.73	5	99.5	60.5	1.61
43 Peas, small	No. 2 tin	C.P.	1.77	5	99.5	62.5	1.71
44 Peas, large	No. 2 tin	C.P.	1.83	5	99.5	57.0	1.66
45 Peas, large	No. 3 tin	S.P.	1.76	5	115.0	50.0	3.1
46 Peas, large	No. 2 tin	C.P.	2.05	5	99.5	61.5	1.86
47 Spinach	No. 2 tin	C.P.	4.43	5	99.5	39.0	0.175
48 Spinach	No. 2 tin	C.P.	4.67	10	99.5	45.0	0.153
49 Spinach	No. 2 tin	C.P.	4.00	10	99.5	53.0	0.181
50 Spinach	Pt. Mason	C.P.	3.33	5	99.5	38.0	0.145
51 Squash	No. 2 tin	C.P.	.....	99	99.5	19.0	0.105
52 Squash	No. 1 tin	C.P.	.....	99	99.5	18.0	0.102
53 Squash	No. 3 tin	C.P.	.....	99	99.5	24.0	0.110
54 Squash	No. 2 tin	S.P.	.....	99	128.0	30.0	0.104
55 Strawberries	Pt. Ideal	C.P.	2.22	0	99.5	24.0	0.256
56 String beans	Pt. Mason	C.P.	1.91	8	99.5	58.0	0.59
57 String beans	Qt. Mason	C.P.	1.60	5	99.5	59.5	0.75
58 String beans	Pt. Mason	C.P.	1.75	5	99.5	55.0	0.58
59 String beans	No. 2 tin	C.P.	1.23	7	99.5	58.5	1.08
60 String beans	No. 2 tin	S.P.	1.38	5	118.0	62.0	1.92
61 String beans	No. 2 tin	S.P.	1.95	5	117.0	50.0	1.14
62 String beans	No. 2 tin	S.P.	1.90	5	117.0	47.0	1.21
63 Water	Pt. Mason	C.P.	.....	99	99.5	31.5	0.72
64 Water	Qt. Mason	C.P.	.....	99	99.5	27.5	0.93
65 Water	No. 2 tin	C.P.	.....	99	99.5	24.5	1.60

first root in order of magnitude of $J_0(\mu a) = 0$ and is found from mathematical tables to be 2.405. Hence

$$\mu_1 = \frac{\mu_1 a}{a} = \frac{2.405}{3.95} = 0.608, \text{ where } a \text{ is the radius of the}$$

can. $\lambda_1 = \frac{\pi}{2l} = \frac{3.14}{11.4} = 0.276$, where $2l$ is the height of the can. The value of A is found from the expression.

$$A_{\mu m} = \frac{4(1 - \cos m\pi)}{\pi(\mu a) J_1(\mu a)}.$$

$$A_1 = \frac{4(1 + 1)}{\pi \times 2.405 \times 0.52} = 2.04, \text{ since } m = 1 \text{ and}$$

$(\mu a) = 2.405$ for the first term of the series of Equation 1. This value of A_1 is the same for all cases in which the initial temperature distribution is uniform, no matter what the variations

of the bath temperature. The double summation sign $\sum_{m=1}^{\infty}$ means that μ and m are to be

given all possible positive values in pairs and all terms so obtained added algebraically. The values of μ are those computed from the roots of $J_0(\mu a) = 0$ and the values of m are to be positive integers. The curve shows that a temperature of 90°C. is reached in 30.5 min. $C = 99.5^\circ \text{C.}$ and $t_0 = 47.5^\circ \text{C.}$ Making appropriate substitutions in Equation 2 we have

$$90 = 99.5 - 47.5 \times 2.04 e^{-k(0.608^2 + 0.276^2)30.5}.$$

Since we are dealing with the center of the can the terms $J_0(\mu r)$ and $\sin \lambda_1(z+l)$ are each equal to unity. Simplifying we have

$$9.5 = 0.098 = e^{-13.6k}.$$

In the table of exponentials we find the value of x which gives $e^{-x} = 0.098$ to be 2.32. Hence,

$$13.6k = 2.32 \text{ and } k = \frac{2.32}{13.6} = 0.170.$$

Table II gives the values of k for the various materials tested. These values are expressed in centimeter-gram-minute units.

VI—DISCUSSION OF RESULTS

The results of nearly all the tests made are shown in Table II. The initials C. P. and S. P. stand for cold pack and steam process, respectively. The rest of the table is self-explanatory.

Substances which contain a great deal of free liquid heat almost as fast as water. Asparagus, carrots, and string beans are examples. A large variation in results is shown for these cases, however. The change of viscosity with temperature evidently is very effective in increasing the heat flow in the steam processing. An increase of about 15 per cent in the temperature range is shown to produce a heat flow twice as great. This effect is not noticeable in cases where convection is absent, as in corn and squash containing no free liquid.

The effect of the glass can in retarding the heat flow is very marked when k is large but vanishes altogether when k is less than 0.375, which is approximately the value of k for glass.

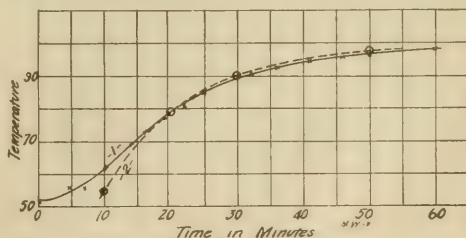


FIG. 3

It will be seen on examination of the figures that the theoretical curve follows the experimental quite closely regardless of the kind of container and the

nature of the material. This is also true of the large number of curves which are not shown.

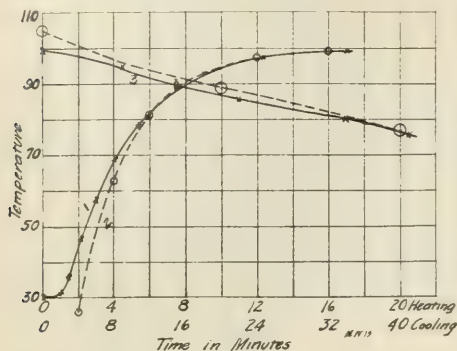


FIG. 4

Curve 1 in Fig. 3 is an experimental curve for corn in a pint Mason jar. Curve 2 is the theoretical as computed from Equation 2. The reason why the two curves vary from each other greatly at the beginning is because the terms in Equation 1 which are neglected in forming Equation 2 become larger when time is small. The value of k for this case is 0.170, bath temperature 99.5° C.

Curves 1 and 3 of Fig. 4 are the experimental heating and cooling curves for asparagus in a No. 2 tin can. Curve 2 is from Equation 2 and Curve 4 from Equation 6. The temperature of the bath was 100° C. and of the air 28° C. The constants in Equation 4 have been determined by the cut-and-try method rather than from the formula given in the summary of mathematical theory. Before these formulas can be used, several physical constants which are rather difficult to determine accurately must be known. In the few attempts that have been made to use these formulas very poor agreement between the theoretical and experimental curves for air cooling was secured so that this method has been abandoned for the present in favor of the cut-and-try method.

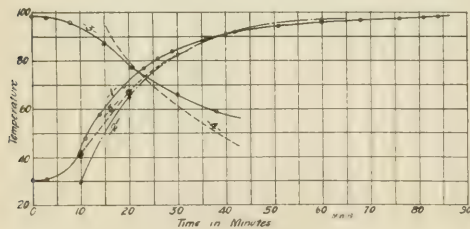


FIG. 5

The constant A' is easily estimated because $A'n_0$ is the intercept of the theoretical curve on the temperature axis, considering the air temperature zero. The trend of the experimental curve indicates pretty definitely the point of intersection of the theoretical curve with the axis.

The fact that these constants cannot be easily obtained in a straightforward manner from the theory is sure to restrict the usefulness of the theory in the case of air cooling. It is hoped that this difficulty may be overcome by further study.

Fig. 5 shows five curves for a can of corn as follows: 1, the experimental heating curve; 2, the approximate form of theoretical curve as computed from Equation 2; 3, the experimental cooling curve for water-cooling; 4, the approximate form of cooling curve computed from Equation 2; 5, the theoretical heating curve as computed from Equation 1, all terms of appreciable value being retained. The temperature of the sterilizing bath was 99.5° C., of the cooling bath 30° C.; k had the value 0.175 for heating and 0.129 for cooling. The container was a No. 2 tin can.

The curve computed from Equation 1 is shown in Fig. 5 only and is included for the purpose of showing the close agreement between Equations 1 and 2 after a short time has elapsed.

In corn the shape of the experimental curve differs from the theoretical in a way not found in very many substances. In most substances the value of k increases slightly as the temperature increases, but in corn as the starch goes into solution there is a decrease of k . This effect is shown by the difference in the slopes of the experimental and theoretical curves.

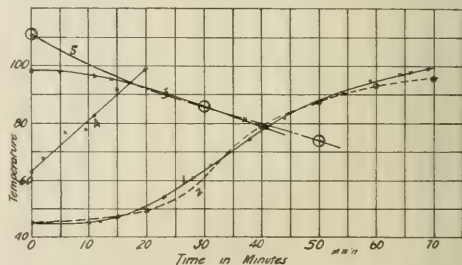


FIG. 6

This variation makes it necessary to employ a value of k in computing the cooling curve different from that used for heating. The cooling curves shown in Fig. 5 agree very poorly with each other. A great deal of this difference may be attributed to failure to keep the water of the cooling bath in good circulation.

In order to determine the effect of the solution and gelatinization of the starch in corn, one No. 2 can was processed on three successive days; 46 min. on the first, 84 on the second, and 40 on the third. The can was cooled in water after the first and second processings. The values of k on the three successive days were 0.287, 0.175, and 0.182. These results show that the first processing completed the change in the starch.

Fig. 6 shows the results obtained with spinach contained in a pint Mason jar and placed in a bath of variable temperature, the variation being from 63° C. to 99.5° C. The cooling was in air at 26° C. Curve 1 is the experimental heating curve; Curve 2, the theoretical as computed from Equations 3 and 4; Curve 3, the experimental; and Curve 5, the theoretical cool-

ing curve; Curve 4 shows the variation of the bath temperature.

The percentage of free liquid as might be expected influences very greatly the rate of heat penetration. Fig. 7 shows the results obtained for corn. The points in the circles are for glass cans and those in the squares for tin. Where the square is accompanied by the letter S, the processing was by steam. Three points are not shown in this figure, namely: (8.5, 0.137), for the cold-pack method, (∞ , 0.110) and (∞ , 0.120) for the steam process.

It is evident from consideration of this figure that steam is much more effective when the percentage of free liquid is large, the heat flow being about double that obtained at the lower temperature. The fact that this difference vanishes when there is no free liquid indicates that it is entirely due to the effect of temperature on the convection. k is determined in each case on the basis of unit temperature difference so that unless some of the supposed constants vary, the results should be the same.

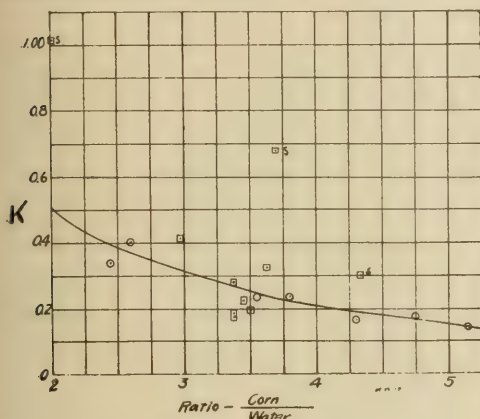


FIG. 7

It will be noticed also that the values for glass cans lie more nearly on a smooth curve than those for tin. This is perhaps due to a more uniform pack in the glass since it is possible to observe carefully as the can is being filled.

In one case a mixture of one part water to five of corn was carefully stirred while being heated to 55° C. previous to packing into the can. A rather pasty mixture with k equal to 0.105 was obtained.

The smallest value of k obtained in any trial is 0.102, which is about equal to the value for water, barring convection. Squash in paste form and corn without liquid give about this value for k . Any other pasty substance would probably give the same value. This fact points to the conclusion that the limiting value is that for pure conduction in water and that occluded air does not retard appreciably the flow of heat.

It is undoubtedly possible to modify the mathematical formula to take account of the variations of

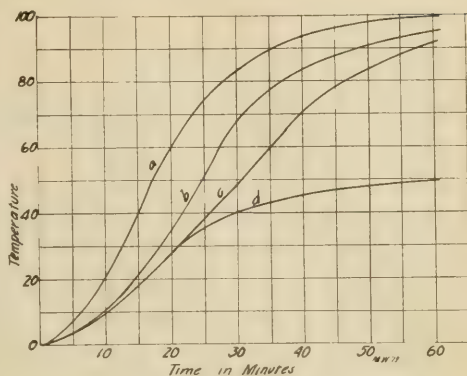


FIG. 8

k with temperature and time but it is doubtful whether such procedure is desirable at the present time. The experimental heating curves shown have been chosen almost at random so that they do not necessarily include those which agree most closely with the theoretical.

The effect of variations in the bath temperature may be seen by referring to Fig. 8. Curve a is computed from Equation 1. The initial temperature of the contents of the can was 0° C. throughout and the bath maintained at 100° C. from the beginning. Curve b was computed from Equations 3 and 4. The conditions were the same as in Curve a , except that the bath temperature varies uniformly from 50° C. to 100° C., reaching the latter value after 20 min. Curve c was computed from Equations 1 and 5. The bath temperature was maintained at 50° C. for 20 min. and then suddenly increased to 100° C. Curve d is computed from Equation 1, the bath temperature being 50° C. continuously.

VII—CHART OF TEMPERATURE-TIME RELATIONS

The chart shown in Fig. 9 may be used for determining approximately the temperature, at the center of a can, at any time after immersion in the sterilizing bath which is maintained at constant temperature.

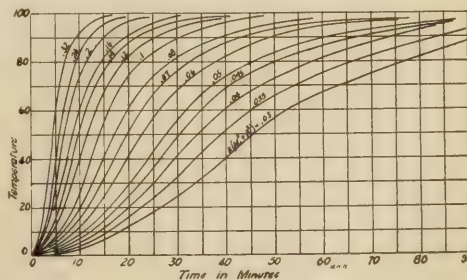


FIG. 9

The curves are computed from Equation 1 and based on an initial temperature difference of 100° C.,

the contents of the can being 0°C . throughout at the beginning.

The following example will show how to use the chart:

A No. 2 can of corn at 50°C . is to be cooked in a steam bath at 110°C . Find the time required for the center of the can to reach 80°C . $k = 0.123$.

$$\text{Solution: } k(\mu_1^2 + \lambda_1^2) = 0.402 \times 0.123 = 0.0495$$

Find on the chart (by interpolation if necessary) the curve which corresponds to this value of $k(\mu_1^2 + \lambda_1^2)$. Since the initial temperature difference is 60°C ., and the chart is based on a difference of 100°C ., the heating will be $60/100$ of that shown on the chart. The temperature to be acquired at the center of the can is 30° above the initial. Hence the temperature change

on the basis of the 100°C . difference would be $\frac{100}{60} \times 30 = 50^{\circ}\text{C}$.,

which is the temperature to look for on the curve for which $k(\mu_1^2 + \lambda_1^2) = 0.0495$. The time is found to be about 28 min.

The time for water cooling is found by using the same chart in a similar way. Suppose we wish the time for the center of the can to cool from 110°C . to 60°C ., assuming that the material is of uniform temperature throughout at the beginning of the cooling. The initial temperature difference is 90°C . and the amount of cooling is 50°C . The equivalent on the chart would be as follows:

$$\frac{100}{90} \times 50 = 55.5^{\circ}\text{C}.$$

The chart shows 30 min. as the time required for this change.

VIII—CONCLUSION

In this paper the author has purposely omitted a great many details of computation which are of small interest to the reader. The computations involved in the curves of Fig. 8 would need several pages for presentation so that it is deemed wise to omit them.

No chart similar to Fig. 9 has yet been devised for the cases involving variable bath temperatures, in fact, it will perhaps be found impossible to combine all results into a single chart.

Undoubtedly a great deal remains to be done before results of the kind presented by this paper can be put to the greatest use in solving the bacteriological problems of food canning.

The author wishes to express his thanks to Dr. R. E. Buchanan of the bacteriology department for suggesting and directing these experiments; also to the horticultural department for furnishing the materials for canning.

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LABORATORY AND PLANT

UTILIZATION OF ELECTRIC BRASS FURNACES^{1,2}

By H. W. GILLET

Received May 21, 1919

Under the caption "Electric Furnaces vs. Crucibles," a recent issue of the house organ of one of the crucible companies states:³ "We understand that as a matter of fact, the electric furnace thus far has made very little headway in the melting of brass and bronze." This statement may be either true or erroneous according to one's point of view.

Electric furnaces for steel are fairly common to-day, there being about 300 in the United States. The first furnace started up 13 years ago, and in the first 5 years thereafter the number rose to only four.

Four years ago there was no electric brass furnace in commercial operation. To-day some 40 firms are using or now installing approximately 100 electric brass furnaces. One rolling mill has about 30, though most of these are small 300 lb. furnaces. One smelting and refining company is using four 1 ton and four $\frac{3}{4}$ ton furnaces. Another firm has four 1 ton furnaces and the various offices of the United States Mint will soon have 5 furnaces. Batteries of 2 or 3 furnaces are quite common.

The furnaces average much smaller than electric steel furnaces, but, nevertheless, electric brass melting has plainly made more rapid progress than electric steel melting did in its early days.

On the other hand, only about 1 per cent of the firms melting copper alloys have as yet tried electric furnaces, and the electrically melted output is probably around

1 per cent of the total, so one can say that much or little headway has been made in electric brass melting according to the way one cares to look at the situation.

Other papers at this meeting will doubtless bring out the various advantages of electric melting over fuel-fired furnaces, such as obtaining crucible quality of metal without the use of costly and fragile crucibles, and doing this on a ton scale instead of the small scale of the past. They will point out the advantages of doing away with storage and handling of fuel and ashes, and show the savings of metal lost by oxidation and volatilization in fuel-fired furnaces and the improved working conditions that are given by electric furnaces chosen with proper reference to the conditions of use. These have been shown by furnace after furnace in plant after plant.

There is one other advantage which has so far hardly received the emphasis it deserves. While the prices of coke and oil may fluctuate widely, the price of electric power is a fairly stable, predeterminable charge. Central stations, which, save in rare instances, are the source of power for electric brass melting, are public utilities whose rates are regulated and thus stabilized. The foundryman can therefore predict his melting costs with accuracy for a much longer period than he can when he uses fuel.

With the advantages of electric melting now thoroughly demonstrated by commercial operation of many furnaces, no brass melter can afford to refuse to study the question of their application to its own work. Yet there are foundry conditions under which no electric furnace can economically compete with fuel-fired furnaces, or under which some types of electric furnaces cannot compete, while others can.

¹ Published by permission of the Director of the Bureau of Mines.

² Read at the meeting of the American Institute of Chemical Engineers, Boston, June 18, 1919.

³ Anon., "Electric Furnaces vs. Crucibles," *Graphite*, 21 (1919), 4451.

TABLE I—PERFORMANCE OF ELECTRIC BRASS FURNACES

Name	Type	Power Supply Kw.	Charge Lbs.	Power Factor	Material	Output Tons per Day on Material Given		Power Consumption Kw.-Hrs. per Ton on Material	Consumption of Graphite Electrodes Lbs. per Ton
						10-Hr. Operation	24-Hr. Operation		
Ajax-Wyatt	Vertical ring induction	30	300	85	Yellow brass	1 to 1 1/2	...	300 to 350 ¹	None
		30	300	85	Yellow brass	...	3 to 3 1/2	225 to 310	None
		60	600	72	Yellow brass	2 1/2 to 3	6 to 7	250 to 300 ¹	None
		60	600	72	Yellow brass	2 1/2 to 3	6 to 7	185 to 250	None
Bailey	Granular resistor	105	800 to 1500	98 to 100	Yellow brass	2 1/2 to 3 1/2	...	400 to 500 ¹	None
		105	800 to 1500	98 to 100	Red brass	2 1/2 to 3	...	450 to 550 ¹	None
		105	800 to 1500	98 to 100	Yellow brass	...	6 to 10	275 to 350	None
		105	800 to 1500	98 to 100	Red brass	...	6 to 9	325 to 400	None
Snyder	Direct arc	100	600	35 to 40	Leaded bearing bronze	1 1/4	...	380	(Experimental)
		300	2000	30 to 60	Leaded bearing bronze	...	12 to 18	260 to 320	3 to 5
Rennerfelt	Indirect arc	100	500	75 to 90	Red brass	1 1/2	...	450 to 500	3 to 6
		125	1000	75 to 90	Bronze	2 to 2 1/2	...	375 to 425	3 to 5
		125	1000	75 to 90	Bronze	...	7 to 10	325 to 375	3 to 5
		300	2000	75 to 90	Leaded bearing bronze	...	10 to 16	300 to 350	3 to 5
Rocking	Indirect arc	40	125	80 to 90	Red brass	3/4	...	400	(Experimental)
		225	1300	80 to 90	Red brass	3 1/2	...	325 to 340	2 1/4 to 4
		225	1300	80 to 90	Red brass	...	8 1/2	250 to 275	2 1/4 to 4
		300	2000	80 to 90	Red brass	6 to 7	...	275 to 325	2 1/4 to 4
		300	2000	80 to 90	Red brass	...	16 to 20	225 to 275	2 1/4 to 4
		300	2000	80 to 90	Yellow brass	6 to 7	...	250 to 300	2 1/4 to 4
		300	2000	80 to 90	Yellow brass	...	16 to 20	200 to 250	2 1/4 to 4
		300	2000	80 to 90	Yellow brass	...	16 to 20	200 to 250	2 1/4 to 4

¹ Including necessary night heating.

It is possible, also, to choose the right type of electric furnace for the work in hand, but to operate it so that it will bring a loss instead of a saving. Each set of conditions must be studied by itself.

Five types of furnaces have advanced far enough so that the makers can cite truly commercial performances. Various other types are in the experimental or semi-commercial stage but are not yet on the market, and a few are on the market with some at least of the experimental troubles left for the purchaser. While recognizing that there is as yet no perfect electric brass furnace, and that future development may produce a type superior to those now in commercial use, prospective users may properly pay first attention only to the types which have been commercially proven in users' hands.

These types are (1) direct arc type, with the Snyder as the only make as yet really used on copper alloys out of the dozen of that type that are used for steel; (2) the vertical ring induction furnace type (Ajax-Wyatt); (3) the granular resistor, reflected heat type (Bailey); (4) the stationary indirect arc type (Rennerfelt); and (5) the indirect arc type with stirring of the melt (rocking furnace). Clamer,¹ Bailey,² von Baur,³ Miller,⁴ the writer,⁵ and especially St. John,⁶ have previously discussed the possibilities and limitations of these various types and a mere summary is sufficient here.

The Ajax-Wyatt is the most efficient in use of power, uses up no electrodes, gives thorough mixing of the charge and perfect temperature control, and has the steadiest electrical load. It must be "primed" with previously melted metal after a shut-down and hence is not well fitted for 10-hr. operation, though it can be used on 10 hr. operation by keeping some current on and holding some metal molten over night. The

¹ "Melting Brass in the Induction Furnace," *J. Am. Inst. Metals*, **11** (1917), 381.² "Resistance Type Furnace for Melting Brass," *Trans. Am. Electrochem. Soc.*, **32** (1917), 155.³ "The Rennerfelt Electric Arc Furnace," *Trans. Am. Electrochem. Soc.*, **29** (1916), 497.⁴ "The Electric Furnace as a Medium for Heating Non-ferrous Metals," *J. Am. Inst. Metals*, **11** (1917), 257.⁵ "A Rocking Electric Brass Furnace," *This Journal*, **10** (1918), 459; "Melting Brass in a Rocking Electric Furnace," *U. S. Bur. Mines Bull.*, **171** (1918).⁶ "The Present Status of Electric Brass Melting," *Chem. & Met. Eng.*, **13** (1918), 321.

need for "priming" makes it difficult to change from one alloy to another. It has been mainly used on yellow brass, though it is applicable to red. Its greatest drawback is that so far no refractory lining has been found that will satisfactorily withstand the action of alloys containing over 3 per cent lead. It is best fitted for 24-hr. operations on the same alloy. It can be mechanically charged.

The Bailey is the least efficient in use of power, does not mix the charge, but has a steady electrical load and uses up no electrodes. This type cannot be powered as high as others without grave danger to the resistor troughs and is hence at a disadvantage as to the efficient use of power, especially in alloys of high melting point. It is best fitted for 24-hr. operation. When used for 10-hr. operation it is usually necessary to put power on part of the night to keep the empty furnace hot. It is not really charged mechanically. It has poor temperature control, due to its heat storage and consequent sluggishness. It can be used on any alloy, but is better fitted for yellow brass than for the higher melting alloys. Its greatest advantage is its simplicity of operation.

The Snyder or any other direct arc furnace is applicable only to true bronzes or other alloys low in zinc, 5 per cent zinc being the probable limit. It is entirely impractical for use on alloys high in zinc. The only installation used for copper alloys is used on lead bearing bronze, the new lead being added in the ladle. Much lead is volatilized from the scrap in the charge, and much fume results, giving bad working conditions. The installation of Snyder furnaces has a very poor power factor, though this is not necessary in a direct arc furnace.

The greatest advantage of the Snyder furnace in its limited field is its adaptability to mechanical charging, which aids in securing large output and hence in reasonable power consumption. One drawback is the single-phase arc load.

The Rennerfelt or any other stationary indirect arc furnace is most applicable to alloys low in zinc. It has been used on alloys up to 22 per cent zinc with fair results, but as the zinc increases above 10 per cent the metal losses increase, and 10 per cent zinc is prob-

ably the economical limit of its application. It has met with decided success in melting cupronickel, bronze, and silver at the Mint. It is not readily charged by mechanical means. The power consumption is fairly low.

The rocking type of indirect arc furnace is applicable to alloys of any zinc content, gives a low power consumption, is apparently efficient in small as well as large sizes, can readily be mechanically charged, has good temperature control, and mixes the charge thoroughly. Its drawbacks are the single-phase arc load and the possibility of electrode breakage in rocking too early if unskillfully operated.

The performance of the various furnaces properly operated may be expected to lie in the ranges set forth in Table I.

The figures in Table I do not in all cases agree with the catalogue claims of the makers of the furnaces, as they are based on data obtained both from makers and users. The output and power consumption depend not only on the analysis of the charge but also on the condition of it, *i. e.*, whether all ingot, heavy scrap, light scrap, borings, or mixtures, as well as on the way the furnace is operated, just as gasoline consumption varies with the roads and the way the car is run. It will be noted that there is a wide variation in power consumption among the various types of furnaces, and that for the same type, the efficiency increases with the size.

If the types of furnace unfit for use on alloys high in volatile metals are confined to use on alloys free from or sufficiently low in such metals, and if the furnaces are kept tightly closed after the charge is melted, all types of electric furnaces will give very low metal losses indeed. No fuel-fired furnaces can compete with properly chosen electric furnaces on this score. Of course, the lost metal is mainly zinc and lead, so that the value of the loss in fuel-fired furnaces is not as great as it would at first sight appear to be when the percentage loss is considered. This loss, however, usually amounts to about as much as the fuel or labor cost, and, even with cheap zinc and lead, is worth eliminating.

In making a choice of furnaces the user must first eliminate those types which will not operate satisfactorily on alloys he must melt in them, for example, the rolling mills making yellow brass would thus eliminate the direct arc and un-rocked, indirect arc furnaces, and the makers of alloys high in lead and the people who must change from one alloy to another often would eliminate the Ajax-Wyatt. The user should then select from the remainder the type and size of furnace which will best fit his particular work. If he has very cheap power available, the granular resistor type may be chosen over a more efficient arc furnace because of the avoidance of electrode consumption. Where power is high, the balance would be against the granular resistor type. One rolling mill may prefer to continue to pour very small billets and may find the Ajax-Wyatt exactly suited to its needs. Another may wish to operate on a larger scale and may find a one ton rocking furnace more suitable. A

maker of bronze who must take his power from a very small power plant may find that a single phase arc load would be unacceptable to the central station and hence might choose the two-phase Rennerfelt instead of the single-phase rocking furnace.

The size of furnace chosen will depend on the output desired and on whether 10- or 24-hr. operation is called for. While the largest sized furnace that can be kept busy should be used, it is poor economy to purchase a large furnace and then operate it with charges much under its capacity or to allow it to lie idle a good share of the time.

An electric furnace is expensive in first cost. The one or two furnaces required to melt 5 tons per day on 10-hr. operation will cost from \$10,000 to \$20,000 completely installed. For purposes of calculation, assume the cost to be \$15,000. At 300 days per year the output is 1500 tons. Taking interest at 6 per cent, the interest is \$900 per year or \$3.00 per working day, this amount being lost every day the furnace is idle. At full output the interest charge is 60 cents per ton.

On the other hand, if one furnace costing \$10,000 is operated for 300 days per year, 24 hrs. a day, with an output of 16 tons, the total output is 4800 tons, and daily interest charge \$2.00 per day, or 12½ cents per ton.

On account of the initial cost and the interest charging, one should in general not have electric furnaces standing idle to handle small peaks of production in excess of the normal, but should utilize for this fuel-fired furnaces of lower initial cost.

On the other hand, the greater the number of electric furnaces which can be kept busy the lower the cost of power per ton.

Industrial power contracts usually have two factors, the demand charge and the energy charge. The first pays the power company for the equipment it must maintain to supply the maximum power needed, while the second depends on the total amount of power used.

Suppose we have a maximum demand of 300 kw. and that the average power consumption per ton of metal is 335 kw. hrs. per ton on 9-hr. operation, 275 on 18-hr. and 250 on 24-hr.; the total power used per day is then about 2000, 3565, or 5250 for the three cases. In a 25-day month this means 50,000, 91,000, 130,000 kw.-hrs. per month.

Assume that the plant, before it installed its electric furnace equipment, had a maximum demand in lights and motors of 200 kw., and used 20,000 kw.-hrs. per month for those purposes. Taking a concrete case where the power contract calls for a demand charge of \$1.80 per kw. per month for the first 50 kw. and \$1.00 per kw. per month for all over 50 kw., the energy charge schedule is: 2500 kw.-hrs. per month at 2.0 cents per kw.-hr. for the next 35,000 kw.-hrs. per month at 0.8 cent per kw.-hr.; for the next 310,000 kw.-hrs. per month at 0.5 cent per kw.-hr.; all over 347,500 kw.-hrs. per month at 0.4 cent per kw.-hr.

The 200 kw., 20,000 kw.-hrs. lighting and motor power cost as follows:

50 × \$1.50 = \$ 75.00	2500 × \$0.02 = \$ 50.00
150 × 1.00 = 150.00	17500 × 0.008 = 140.00
\$225.00 Demand	\$190.00 Energy Charge

Total \$415.00 or 2.07½ cents per kw.-hr. used.
The plant now has 500 kw. maximum demand, and 70,000, 111,000, 150,000 kw.-hr. used per month on the three assumptions

50 × \$1.50 = \$ 75.00	
450 × 1.00 = 450.00	
\$525.00 Demand	
Energy—Case 1— 2500 × \$0.02 = \$ 50.00	
35000 × 0.008 = 280.00	
32500 × 0.005 = 162.50	
70000	\$492.50 Energy
	\$25.00 Demand

\$1017.50 Total Charge
Less 415.00 Previous Charge for Lights and Motors

\$602.50 Total Charge for Electric Furnace Power

602.50
70000 = 1.205

The electric furnace power costs 1.205 cents per kw.-hr.

In Case 2 we have the same demand charge, but the energy charge is

2500 × \$0.02 = \$ 50.00	
35000 × 0.008 = 280.00	
73500 × 0.005 = 367.50	
€11000	\$ 697.50 Energy
	\$25.00 Demand

\$1222.50 Total
Less 415.00 Lights and Motors

\$ 807.50 Total Charge for Furnace Power

807.50
91000 = 0.89

The furnace power costs 0.89 cent per kw.-hr.

In Case 3 we have

2500 × \$0.02 = \$ 50.00	
35000 × 0.008 = 280.00	
112500 × 0.005 = 562.50	
	\$ 892.50 Energy
	\$25.00 Demand

\$1417.50 Total
Less 415.00 Lights and Motors

\$1002.50 Total Charge for Furnace Power

1002.50
130000 = 0.79

The furnace power costs 0.79 cent per kw.-hr.

And, if, in Case 4, the plant had three times the furnace installation figured above and used it 24 hrs. a day, or 900 kw. furnace demand (1100 kw. total); 450,000 kw.-hrs. per month furnace energy (470,000 total), the charge would figure

50 × \$1.50 = \$ 75.00	\$2370.00 Energy
1050 × 1.00 = 1050.00	1125.00
\$1125.00 Demand	\$3495.00 Total
2,500 × \$0.02 = \$ 50.00 Less	415.00 Lights and Motors
35,000 × \$0.008 = 280.00	
310,000 × 0.005 = 1550.00	\$3080.00 Total for Furnace Power
122,500 × 0.004 = 490.00	3080.00
	450000 = 0.685
	\$2370.00 Energy

The electric furnace power costs 0.685 cent per kw.-hr.

Tabulating these we get Table II

TABLE II

Case No.	1	2	3	4
Hours.....	9	18	24	24
No. furnaces.....	1	1	1	3
Kw.-hrs. per ton.....	335	275	250	250
Power price, cents per kw.-hr.....	1.205	0.89	0.79	0.685
Cost, dollars per ton for power.....	\$3.92	2.45	1.98	1.71

This table shows the advantage of continuous operation of electric furnaces, as well as that of large installations. The exact figures will vary in each particular case, but the ratios will remain approximately the same.

The cost of power is in most cases the largest single item in melting costs in electric furnace practice. Every effort must then be put forth to keep the cost down. The way to do this is to keep this furnace at work at its job, which is melting metal. This is important on 24-hr. operation but even more so on 8- to 10-hr. operation, for an extra heat per day on single-shift operation means that it is obtained at the end of the day when the furnace has recovered from cooling off through the night. Any furnace will illustrate this fact. Take an actual day's run of a small Rennerfelt on red brass, for example.

Heat	Charge Lbs.	Total Time Hrs. and Min.	Arc on Hrs. and Min.	Idle Time Hrs. and Min.	Kw.-Hrs. Used	Kw. per 100 Lbs.	Notes
1	497	2 : 45	2 : 05	40	211	42	Furnace at red heat from previous day's run
2	522	1 : 45	1 : 25	20	130	25	.....
3	527	2 : 55	1 : 10	1 : 45	105	20	Delay waiting for molds
4	523	1 : 25	1 : 05	20	106	20	.....
5	394	1 : 25	1 : 10	15	94	25	Waiting for molds —so held power input low
	2463	10 : 15	6 : 55	3 : 20	646	26	Av., or 520 kw.-hrs. per ton

This could have been run as follows, by eliminating all delays:

Heat	Charge Lbs.	Total Time Hrs. and Min.	Arc on Hrs. and Min.	Idle Time Charging and Pouring Hrs. and Min.	Kw.-Hrs. Used	Kw. per 100 Lbs.	Notes
1	525	2 : 10	1 : 95	15	215	41	
2	525	1 : 40	1 : 25	15	130	25	
3	525	1 : 25	1 : 10	15	105	20	
4	525	1 : 20	1 : 05	15	100	19	
5	525	1 : 20	1 : 05	15	100	19	
6	525	1 : 20	1 : 05	15	100	19	
	3150	9 : 15	7 : 45	1 : 30	750	24	Av., or 480 per ton

The elimination of delays thus gives a 25 per cent increase in output in an hour less time, and decreases the cost of power per ton by about 40 cents.

With the exception of the granular resistor type in which it is difficult to hold metal after it is once ready to pour because the response to changes in power input is so slow, it is possible to hold metal ready to pour as long as one likes in any of the electric furnaces. This is a convenience in an emergency, but it is very poor practice from the point of view of furnace efficiency.

The use of as large ladles as it is practical to discharge the furnace into, so that the furnace is idle the shortest possible time during pouring, combined with mechanical overhead charging (in such furnaces as the Snyder and the rocking type which readily allow it), allows the furnace to work at its job of melting the greatest possible

proportion of the time. On charges of all borings, especially in case of hand charging, briquetting would be desirable. Bundling of wire and similar scrap is almost essential. An electric furnace is like a motor truck in that the less time that is lost in loading and unloading, and the greater the number of hours per day it can be used, the lower the cost per ton melted in the one case and per ton mile in the other. Cutting down on waste time pays even better with the furnace than the truck, because the more power the furnace uses in 24 hrs., the lower the cost of the power per unit, while gasoline for the truck does not come much cheaper when bought in larger amounts. Another way that power can be saved in electric melting is to operate on a definite schedule of power used. The Ajax-Wyatt takes power at so steady a rate that a time schedule works just as well on that type, but the granular resistor furnace and the arc furnaces may vary considerably in rate of power input. After a few test runs, one can, for any particular alloy, particular proportion of ingot, scrap, and borings, and for any particular weight of charge, make out a perfectly definite schedule of kilowatt-hours needed on each heat. In 10 hrs. operation the kilowatt-hour per heat will be higher in the morning and approach or reach a lower constant figure at the end of the day.

By adhering to such a schedule and running on kilowatt-hour input instead of on a time schedule at a supposedly constant but actually variable kilowatt input, the heat can be brought out with astonishing regularity as to temperature. Each furnace should have its individual kilowatt-hour meter, and one readable to certainly not less than 5 kw.-hrs., and better 1 kw.-hr. With individual kilowatt-hour meters the performance of each furnace in a battery, and of each furnace tender can be watched. The kilowatt-hour meter is as important as the speedometer on a motor car or truck. Not all furnace makers supply them, but each furnace should have one.

Inasmuch as the heat losses through the walls and the electrodes are approximately constant even though the rate of power input may change, it is obvious that the higher the rate of power input, the more of it is usefully employed in melting. Suppose a furnace takes 100 kw. and loses 35 kw. through shell radiation and electrode losses, 65 kw. then do useful work. If the same furnace is given 125 kw. it may lose 37½ kw. in shell and electrode losses, but 87½ kw. do useful work. The furnace will do one-third more work in a given time at the higher rate. The upper limit of rate of input is that at which the local temperature is so high that refractories fail or that local overheating of the metal and consequent loss of volatile metals occur. It is quite probable that on the larger furnaces automatic control of power input would be desirable.

From the considerations noted above it is plain that the advantages of electric furnaces are most marked where a number of large furnaces or of small efficient furnaces can be used and especially where they can be used 24 hrs. a day. Rolling mills, smelting and refining plants, brass foundries of large manufacturing

plants and the larger jobbing foundries are the plants which can most obviously use electric brass furnaces at a saving in melting costs. Such plants should think twice before deciding to go on with fuel-fired furnaces.

The smaller plants and jobbing shops having a small output and a variable one, especially if they are so located that power will cost much over 1¼ cents per kw.-hr., should think twice before installing an electric furnace. Even this class of furnace users may often find that the electric furnace will save some money in the long run, although under normal peace conditions the amount saved will be small compared to what it was during the war or may be at present.

Whether electric brass melting has or has not as yet made much headway, it at least has a foothold and apparently a firm one. It will be surprising indeed if inside the next decade the ratio of brass melted electrically to that melted by fuel does not surpass the ratio of steel melted electrically to that melted by fuel. All metallurgists will agree that the electric steel furnace is here to stay. They will soon agree that the electric brass furnace is here to stay, too.

MORSE HALL, CORNELL UNIVERSITY,
ITHACA, NEW YORK

CORROSION TESTS ON COMMERCIAL CALCIUM CHLORIDE USED IN AUTOMOBILE "ANTI-FREEZE SOLUTIONS"¹

By PAUL RUDNICK
Received May 14, 1919

In view of the serious shortage and great increase in cost of glycerin and alcohol caused by the European war, the sale of calcium chloride solutions to prevent

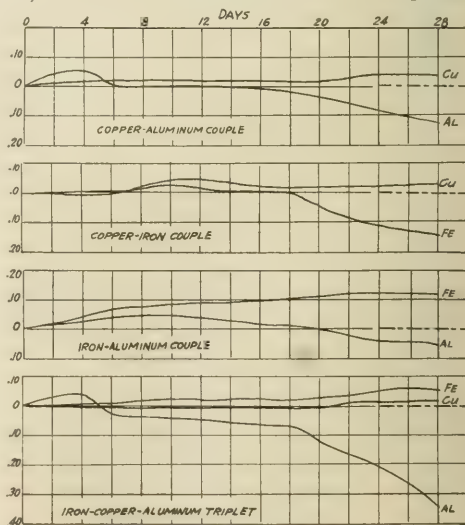


FIG. 1—CORROSION TESTS, SOLUTION A

freezing of the cooling solution in motor vehicles was vigorously pushed. Three proprietary products of this type were submitted for an opinion as to whether

¹ Read before the Division of Industrial Chemists and Chemical Engineers, 57th Meeting of the American Chemical Society, April 7 to 11, 1919.

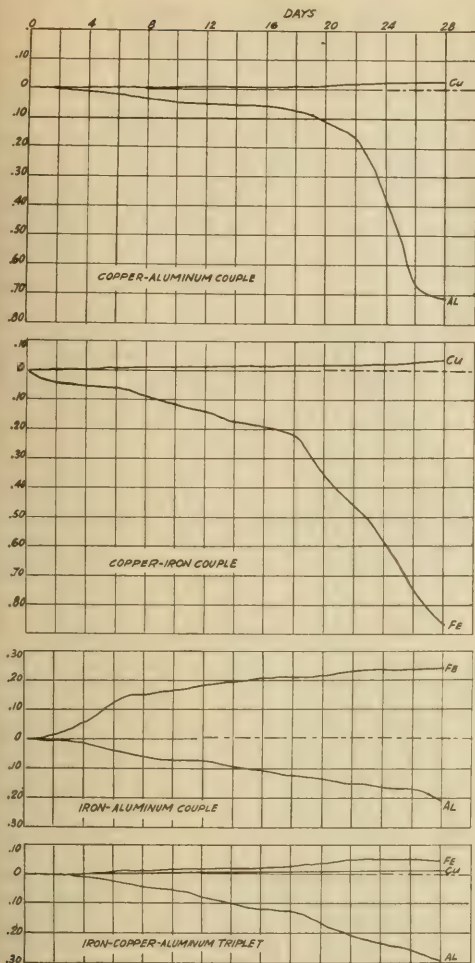


FIG. 2—CORROSION TESTS, SOLUTION J

such solutions might safely be used or whether harmful effects from corrosion might be expected.

These products were accordingly tested for their effect on aluminum, copper, and cast iron by suspending polished plates of these metals in solutions of the concentration directed or furnished by the manufacturers. The plates were suspended in pairs of copper and aluminum, copper and cast iron, and aluminum and cast iron, and also in sets of all three, by means of copper wire attached to the emergent ends of the respective plates. The solutions were continuously aerated during the test period, and were kept at a temperature of 30° to 40° C.

The tests were continued for 28 days, the loss or gain in weight of the plates being noted every other

day. The results are clearly shown in the curves obtained by plotting the loss or gain in weight¹ against the time of immersion.

The most striking points developed are:

1—Aluminum was attacked most severely, iron next, and copper least, as would be expected.

2—The rate of corrosion increased sharply on the eighteenth to twentieth day of immersion. This is of special interest in view of the terms under which one of these products was offered for sale.²

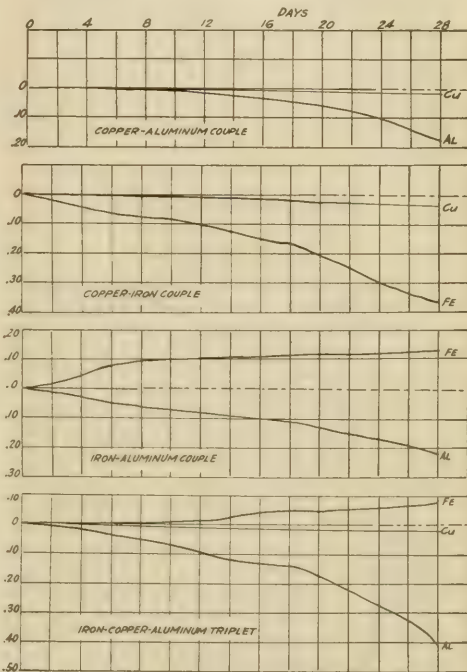


FIG. 3—CORROSION TESTS, SOLUTION T

The composition of the solutions varied from 28 to 30 per cent of calcium chloride and from 0.5 to 3.0 per cent of magnesium chloride. Solution T contained formaldehyde.³

The reaction of the solution was determined by measuring their hydrogen-ion concentration according to the well-known colorimetric method of Sörensen.⁴

¹ In each curve gain in weight in grams is plotted above zero on the ordinate, loss of weight in grams below the zero.

² The offer consisted of a 14-day trial. If at the end of this time no damage had been incurred, the product was to be paid for. If any damage had occurred, the seller agreed to have the necessary repairs made at his expense and to make no charge for the solution.

³ The formaldehyde was probably added to prevent corrosion in the hope that it would act in the same way as in the case of hydrochloric acid and iron, a fact which was first brought to my attention by Mr. A. V. H. Mory. The results show that formaldehyde does not prevent corrosion by calcium chloride.

⁴ *Biochem. Z.*, **21** (1909), 131.

Solution T was distinctly acid ($\text{Ph}=4.5$), solution J was practically neutral ($\text{Ph}=6.6$), while solution A was distinctly alkaline ($\text{Ph}=8.0$). The erratic behavior of solution A is probably due to its alkaline reaction.

Obviously calcium chloride is entirely unsuited for use in anti-freezing solutions in the cooling systems of motor vehicles in which aluminum or copper or both are in electrical contact with iron or steel. Rapid destruction, particularly of the aluminum parts, is to be expected. Actual experience has abundantly confirmed the results of the tests described.¹

The writer desires to acknowledge with thanks the assistance of Mary Hull, F. W. Waterman, and A. C. Haebich in carrying out the details of the work described in this paper.

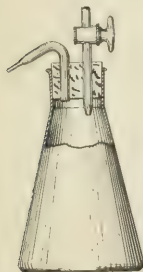
CHEMICAL LABORATORY
ARMOUR AND COMPANY
CHICAGO, ILLINOIS

A SIMPLE WEIGHING BURETTE

By DONALD W. MACARDLE

Received April 8, 1919

In many of the assays encountered in pharmaceutical work such as alkaloidal assay, a considerable degree of accuracy in titration is necessary. In order to avoid certain of the disadvantages of ordinary burettes, such as inaccuracy of bore, temperature variation, drainage, and difficulty of accurate reading, the writer has devised a simple weighing burette which obviates all corrections and allows nearly as rapid work as the ordinary style, with accuracy limited only by the sensitiveness of the end-point.



The sketch is practically self-explanatory. The glass stopcock was taken from a broken burette. To use the burette, turn up with the cock closed, so that the capillary is over the titrating vessel, and allow the heat of the hand to force the standard solution into the capillary. Then when the cock is opened the liquid will flow freely, and there will be no danger of loss through the cock. When near the end-point, the cock may be closed and the solution forced in drops by the heat of the hand.

A predetermined quantity of solution cannot be delivered without repeated weighings, but a little practice will enable the user to estimate the desired quantity within a few per cent.

A 100 cc. flask with rubber stopper, cock, and capillary, weighs about 40 g.

ANALYTICAL AND RESEARCH DEPARTMENT
UNITED DRUG COMPANY
BOSTON, MASSACHUSETTS

A NEW FORM OF DISTILLING BULB

By J. S. MCHARGUE

Received April 23, 1919

Fig. 1 represents a new form of distilling bulb and Fig. 2 indicates the method of constructing the bulb from sections of glass tubing of different sizes. The T is made by sealing a section of tubing 10 mm. inside diameter and 45 mm. long on to a section 16 mm. inside diameter and 120 mm. long. A drain hole 5 mm. in diameter is blown out on opposite sides of the stem of the T, 15 mm. from the arms and directly beneath them.

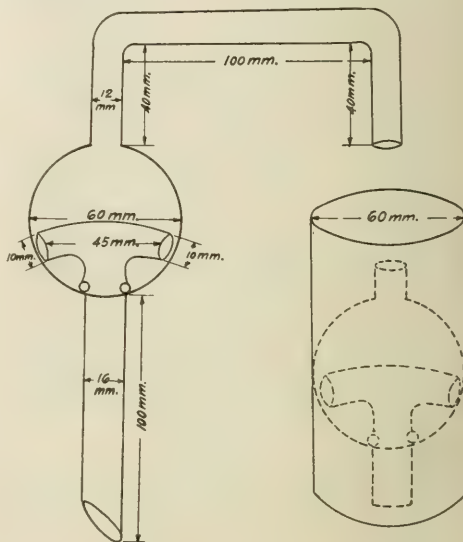


FIG. 1

FIG. 2

A section of glass tubing 60 mm. inside diameter and with walls 1.5 mm. thick is drawn off and blown out to a uniform thickness and in the shape of a symmetrical dome at one end. A hole of sufficient size to admit the stem of the T-tube is blown out at the apex of the dome. The stem of the T is inserted through this hole until the lower edges of the drain holes are opposite the rim of the hole in the large tube, and the two pieces sealed together at this point. The opposite end of the large tube is drawn off and blown out in such a way as to complete a symmetrical bulb of uniform thickness and 60 mm. in diameter. After blowing a hole of the proper size at a point on the bulb opposite the one made for the stem of the T, a tube of 12 mm. inside diameter is sealed on to make connection with a condenser tube. The form into which this tube is to be bent may vary, depending upon the most convenient manner of connecting a distilling flask to different types of condensers. In making the first bend in this tube above the bulb it is desirable that it be made in the direction that will preserve a right and left symmetry with respect to the arms of the T within the bulb.

¹ In addition to its corrosive nature, calcium chloride has another serious disadvantage, namely, the fairly good electrical conductivity of its solution. In the case of leaks or other accidents, short-circuiting of the ignition system may easily happen.

After making some distillation experiments with this type of bulb, in comparison with others of the form illustrated in the catalogue of dealers in chemical apparatus, it was found that the new bulb possessed the following advantages over the types with which it was compared:

The stem of the T that connects with the distilling flask is of sufficient size to allow the steam to pass into the bulb and the condensed water to flow back into the flask without the latter being caught in a column and held in this part of the tube by the escaping steam. The two small holes in the stem of the T within the bulb allow condensed water to return to the flask as fast as formed. The arms of the T diminish the possibility of any of the alkaline contents of the distilling flask being thrown into the condensing tube and

spoil a determination. If soap bubbles should be forced into the upper part of the T they are either broken up in the arms of the T or are forced out at the ends of the arms and broken up in spray against the walls of the bulb. Steam flowing out of the two ends of the T keeps the bulb at a more uniform temperature, which lessens condensation in the bulb and hastens distillation. The arms of the T slope downward and the openings at the ends are large enough to prevent water from being held in them by back pressure and interfering with the passage of steam.

This form of bulb was designed by the writer and two test bulbs were made for us by Messrs. Eimer & Amend.

DEPARTMENT OF CHEMISTRY,
KENTUCKY AGRICULTURAL EXPERIMENT STATION,
LEXINGTON, KENTUCKY

ADDRESSES AND CONTRIBUTED ARTICLES

THE UNIVERSITY OF NEBRASKA

DEDICATION OF THE NEW CHEMISTRY HALL

On May 23, 1919 the Department of Chemistry of the University of Nebraska dedicated its new Chemistry Hall with appropriate exercises. The presiding officer was Chancellor S. Avery and addresses were made by past and present heads of the department and representatives of the alumni and of the state.

[EDITOR.]

DEDICATORY ADDRESS

BY MAJ GEN WM L SIBERT, C W S, U S A

I accepted the invitation to deliver an address on the occasion of the dedication of the new chemical laboratory at the University of Nebraska with a twofold pleasure: first, because it gave me an opportunity to publicly pay a tribute that I have long felt like paying to the purely scientific man, the man who is impelled by a force that he cannot define to continually delve into the mysteries of nature with the hope that he can uncover some hidden principle that will find application in the advancement of the affairs of men, the man who is not actuated by any hope of reward, but is simply driven by a desire to discover. Nature works in wondrous ways its ends to accomplish, and human beings from infants up are forced to do her bidding. A child *will* play and do those things essential to its development and the man especially endowed for marked accomplishment in some particular field, if he be educated, is impelled as is the child. It can be truly said that the men whose work constitutes the milestones of the history of science were inspired.

My life has been occupied in applying the principles which the scientists have discovered. As life has progressed I have become more and more impressed with a feeling that the world has not recognized as it should the pure scientist. But times are changing. The managements of our large manufacturing concerns are appreciating more and more the value of the work of the research man on specified problems, and are establishing research branches of their own. This is comforting because it shows that capital, especially large capital, is becoming more and more willing to be guided in its application of science to industry, by those who have been especially educated for such work. Germany's initial success in the chemical world was due to an early appreciation of the importance of the relation of research to practical industry. Of course, institutions such as this prepare men not only for research, but for the development and manufacture of chemical products in general. It is therefore with especial pleasure that I assist in the dedication of this, the greatest institution of its kind west of the Mississippi, in which many young men will get their training and their inspi-

ration to do those great basic things that will assist in making this country take its proper place in the industrial world.

The public opinion of a nation should impel it to develop its full possibilities in every line where nature has provided the essential materials.

This country is now in one of its most crucial periods, in so far as its chemical industry is concerned. The war has just exposed its deficiencies, but at the same time, fortunately, has shown its possibilities. The fact that over 3,600,000 tons of nitrates passed through the Panama Canal during the 15 months prior to the armistice shows in what dire distress would have been the allied nations had they not controlled the seas, and had been forced to abandon the nitrate beds of Chile, and to rely upon their ability to take nitrogen from the air for their powder supply. Not only were deficiencies in indispensable war material shown, but deficiencies in things necessary in everyday life. Under the spur of necessity, and the high prices resulting from a deficient supply, the United States and private industries plunged into chemical manufacture, and tried to meet a situation that should have been prepared for in time of peace. More than \$100,000,000 were spent by the United States in nitrate plants alone, which plants had not reached the production stage when the war ceased. The production of explosives measured in dollars, under private control, increased in yearly production from 50,000,000 to 500,000,000 by April 1917, after



NEW CHEMISTRY HALL, UNIVERSITY OF NEBRASKA

which time the United States took control of the entire explosive manufacture. It was necessary to quadruple the chlorine supply of the nation, to plan to increase by ten times the phosphorus supply, and to make a material increase in the bromine supply, in order to meet the demands on the Chemical Warfare Service for lethal gases and smokes. The domestic production of coal-tar crudes, intermediates, and dyes, increased from \$3,000,000

a year before the war, to \$70,000,000 during the war. Drugs in some instances sold for 50 times their pre-war price. Similar increases, with great variation in prices, characterized other lines of chemical industry. Countries that had bought, prior to the war, all their chemicals from the central powers of Europe, suddenly called upon the United States for their supplies, which still further disturbed prices, and called for greater manufacturing effort.

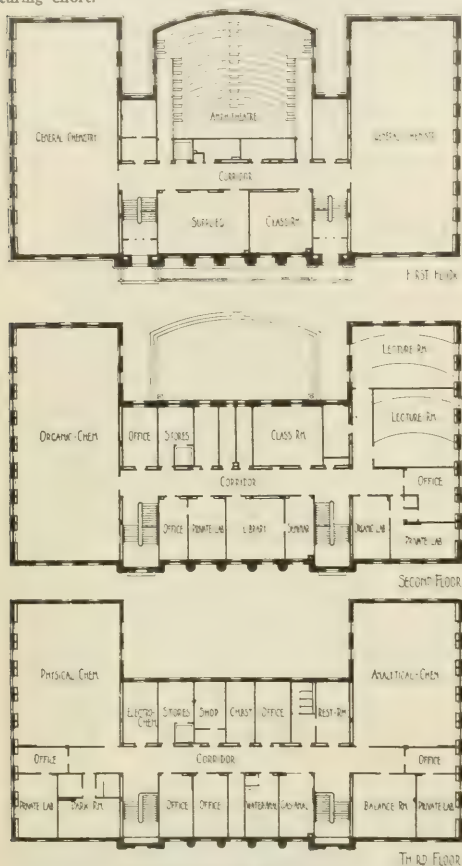
The fact that the University of Nebraska, west of the Mississippi, a section of the country handicapped by freight rates in many instances, is just completing a great laboratory to train young men for the coming struggle in chemical industry, is indicative of the determination of the nation to carry on a winning fight in that struggle. This constitutes the second great satisfaction connected with my visit here.

The work of the chemist and the chemical engineer during the war certainly shows that this country has technical ability in a marked degree. The raw materials are here, capital should have had its object lesson as to what can be done, and if there are other artificial obstacles in the way, or needed appliances not existent, the Government must assist in meeting the situation. It is the Government's business to know the needs of its people, and to see that they have an equal opportunity with their competitors in the world's trade.

Our young men who hope to succeed in chemical industry must know more than the chemistry or chemical engineering connected with their manufacturing establishment. They must know the benefits and abuses of tariffs. They must understand the relation of land and water transportation to the ultimate price of their product delivered in its market. They must be acquainted with all subsidies or other aids that their foreign competitors receive from their Governments.

As a basic proposition in this struggle, our land transportation problems must be settled on broad lines. The people of the nation are entitled to, and the development of the country depends upon, transportation at the lowest cost consistent with a fair return on the amount of money needed to build and maintain the railroad systems. Our nation has reached the stage when it must trade with other nations, must produce at a price that can compete in foreign markets, and the prime essential in this undertaking is cheap transportation, not only in gathering together the raw materials, but in delivering the finished product to its market. In the accomplishment of this delivery, the people of the United States must have their own merchant marine. I do not know how that last problem is to be solved, whether through United States ownership and operation or not, but I do know that a nation without its merchant marine is handicapped beyond hope in the race for international trade. The ships of no nation will carry freight for another nation if the merchants of the nation owning such ships can fill the demand.

Our chemical manufacturers before the war were handicapped in every direction, by land transportation, ocean transportation, and by the unfair and illegal competition of their foreign competitors, especially their German competitors. No one can grumble at a victory fairly won. Germany's early success in the chemical field was due to the appreciation on the part of her universities of the value to the industries of technical men, and especially the results following the availability of a large number of such men. The Germans appreciated the fact that if world markets were sought, transportation costs should be low. This resulted in the adoption of the higher grade products such as dyestuffs, medicines, etc., as specialties. This procedure also fitted in with the military aspirations of the nation, because many of the by-products in making dyes and medicines are used in the manufacture of explosives—all are derived from coal tar. If by competition or otherwise a nation can be prevented from making dyes and medicines, she is crippled in a military sense not only because the intermediates in dye manufacture can be used in making explosives, but because the dye processes, plants, and personnel can quickly be utilized in making explosives and other chemical substances that modern war has adopted. Germany, before the war, furnished more than $\frac{9}{10}$ of the dyestuffs of the world. There was, therefore, more than a desire to succeed industrially in Germany's determination to prevent by fair means or foul the development of American chemical



PLAN OF THE THREE MAIN FLOORS

Our war experience not only showed that our chemical industries were not so developed, in time of peace, as to meet our war needs, but also showed that such needs can not be provided in less than two years' time. In modern war no nation could repel the attacks of a prepared nation for that length of time. Fortunately we had in this war allies who furnished us guns and shells, and kept the seas open so that we could import the material needed for our powder. While we should draw from this a never-to-be-forgotten lesson on the subject of preparedness, we can at the same time take much satisfaction from the marvelous way in which the chemists and chemical engineers of the country were meeting the situation when the war closed. One of the greatest questions now before the country is: Can the advances in chemical industry made under the stress of war for war needs, for domestic needs, and for export, be held against foreign competition?

industries. Through taking out patents in this country on processes that she never intended to put into practice here, by dumping excess production into our markets at prices below cost of manufacture by means of fake companies in this country, whenever any new chemical industry tried to establish itself, and by bribing the actual dyers in the factories, she smothered chemical industry in this land. Fortunately, Germany's methods have been exposed by our Alien Property Custodian, her patents have been sold so that all American manufacturers can use them and no unfair illegal competition will be countenanced in this country in the future. France and England have even gone so far as to place an embargo against the importation of all dyestuffs. This country must be kept industrially free in the future.

Although not a chemist, it was my fortune to have charge of the Chemical Warfare Service of the Army during this war, and I have had my first peep into the possibilities of the chemical world, and have probably appreciated, on account of my responsibilities, more than the average man, what it means for a country not to be prepared in a chemical way for war. Modern war is a war of machinery and science. Man, of course, is as vulnerable as ever, and the same sized bullet that killed him in the Civil War will kill him now, and the object of most appliances is to destroy the enemy appliances so that man can go forward.

In no line of warfare is there the same possibilities for surprise and the gaining of decisive results by a single discovery as in the field of chemistry. There is no more humane method of warfare, if the word "humane" can be applied to the taking of life, which is of course what war means, than the use of gas and other chemicals. There is so much misconception on this point that I will quote from a report on medical observations, four months after the attack, on 2000 cases of men seriously gassed in this war:

1—That gas victims, irrespective of the type of gas and severity of attack sustained, show no marked predisposition towards active pulmonary tuberculosis, or towards the reactivation of a healed or quiescent pulmonary lesion.

2—That gas victims present little evidence of material destruction of lung tissue.

3—That gas victims with emphysema findings have a more protracted convalescence than have those of the bronchitic group.

While 30 per cent of all casualties in the American troops was due to gas, only 3 or 4 per cent of these casualties died. The above casualties result when an army is supplied with gas masks and other defensive appliances. If an army has no protection, as may be the case with a new chemical substance kept secret until the war, all the men exposed will become casualties unless they run away, from which fact the reason is clear that research, both from the offensive and defensive sides of chemical warfare, should be kept up to date at all times, so that our soldiers, if forced to go to war, will not be at the mercy of a prepared adversary.

The record of the Research and Production Divisions of the Chemical Warfare Service shows what our country can do. Although the last to enter the war, and commence the development of methods of making the standard gases as well as new ones, at the end of the war the United States was manufacturing gases at rates larger than all the other Allies and Germany combined. One of our chemists, accompanying the Army into Germany for the purpose of investigating the German method of making mustard gas, ascertained at a big gas plant there that the German method for making mustard gas had been abandoned and the American method adopted. I feared, when I first heard this, that German espionage had found some American secrets, but I later learned that the knowledge was acquired through the chemical analysis of the gas in one of our unexploded shells.

This analysis showed that it was not made in the German way, and indicated the American method. Germany was making this gas at about the rate of 10 tons a day. This country had actually made it at a rate of 40 tons a day, and had a plant ready to operate at a rate of 80 tons a day when the armistice came, and was prepared to more than double that rate. Our extreme unpreparedness immediately became apparent when we entered the war, and our ablest chemists and chemical engineers flocked to the colors and offered their services, and threw their hearts and souls into the undertaking. About 1000 chemists commenced on research, some of them on methods of producing in large quantities poison gases that had been made only in small quantities in the laboratory, others searching for new substances for offensive warfare, and others trying to find the best means of protecting our soldiers from gas. When all of these men, and the best chemical engineers, were welded together in one team, splendid results followed. In addition to the gases referred to above, more than 5,000,000 gas masks were made before the armistice.

Every American soldier had an American-made gas mask. The search for suitable materials for the gas masks reads almost like a romance. When it was found that charcoal from coconuts and other nuts gave best protection, men were sent to the Philippines, Central and South America to procure them. One of the most satisfactory responses of the war was that of the children of the country to the call to collect peach stones. When the war closed there were 5000 tons of such seeds in one pile at our charcoal works at Long Island City. There were 12,000 women working on gas masks at our Long Island plant alone, and it required no inspection to see that they were determined that every mask that went overseas was air-tight. Nearly all of them had some relative over there. Our chemical engineers did things in bigger ways than ever before. There was built in about 8 mo. a chlorine plant with a capacity of 100 tons a day. The biggest plant in the world previously was a 60-ton plant.

All of this is in keeping with the thought that the institutions in this country develop an initiative and individuality second to no nation. But this individuality in ordinary times tends to



H. H. NICHOLSON
1882-1905



S. AVERY
1905-1909



BENTON DALES
1909-1918



F. W. UPTON
1918-

THE DEPARTMENT HEADS

cause our people to lose sight of the nation's needs in time of stress, and consequently never make preparation for the storm of war. We need something that will temper this individualism with an ever-present national spirit that will always have in mind the nation's advancement and safety. What can all the people do that will permanently impress them with the thought that they have a country? I know of nothing that will do it to the same extent as will universal military training, and I know of nothing which at the same time will do more to create a spirit that will solve the serious industrial questions ahead of us, all on account of the democracy that comes from the association forced by such training. This training, however, should be coupled with a system of instruction extending from the kindergarten to the university, instilling into the youth of the land the precept that a nation must be just in order to play its predestined part in the world, and must be strong and ready to exert its strength in order to do its part in maintaining fairness and justice among the peoples of the earth. Modern science is too potent in the hands of selfish nature to permit of any other course, and selfishness will last until the millennium comes.

WAR DEPARTMENT
CHEMICAL WARFARE SERVICE, U. S. A.
WASHINGTON, D. C.

SHIPPING CONTAINERS¹

By C. P. BEISTLE

The Bureau of Explosives appreciates and welcomes the opportunity to join with you this evening in discussing the important question of shipping containers.

It seems advisable to devote a little time to an explanation of the origin and present status of the efforts of the Bureau of Explosives to promote safety in the transportation of dangerous articles through improvement of shipping containers. You are familiar with the old policy of the railroads in regard to shipping containers. The Traffic Department in prescribing freight rates stated in a very general way the type of containers that would be acceptable for different classes of freight. It

Statistics of Railways in the United States, prepared by the Interstate Commerce Commission (Division of Statistics and Accounts), show in their analysis of Operating Expenses under item "Loss and Damage, Freight," the figures given in the following table:

Year Ending June 30	Carrier	Loss and Damage Freight	Per cent of Total Operating Expenses
1916 (latest available)	Class I, II, III ¹	\$22,738,893	1.029
1915	I, II, III	29,942,828	1.461
1914	I, II	33,671,219	1.555
1913	I, II	30,883,454	1.451
1912	I, II	24,639,852	1.237

¹ Class I carriers are those having annual operating revenues above \$1,000,000. In 1916 Class I carriers operated over 230,500 miles and Class II operated over 18,000 miles of railroad in the United States.

The materials classed as dangerous by the regulations of the Interstate Commerce Commission, and causing the heaviest losses during the year 1918, as shown by Annual Report of the Chief Inspector of the Bureau of Explosives, were as follows:

Gasoline, causing 101 fires and a loss of.....	\$881,000
Alcohol, causing 39 fires and a loss of.....	145,000
Nitric Acid, causing 158 fires and a loss of.....	108,000
Matches, causing 39 fires and a loss of.....	51,000
Liquefied Petroleum Gas, causing 2 fires and a loss of.....	45,000
Nitrate of Soda, causing 5 fires and a loss of.....	28,000
Crude Oil, causing 11 fires and a loss of.....	26,000

POLICY OF BUREAU OF EXPLOSIVES

The foundation stone of this policy, established when the Bureau began its work in 1907, was to form a partnership with the shipper for the purpose of promoting safety in the transportation of his product. The principal object of this partnership was to impress upon the shipper his share of responsibility for this promotion of safety, and to give him corresponding opportunity to meet that responsibility. By this plan he had a voice in framing specifications to govern the design and construction of his shipping container, as well as the rules to govern both the carrier and the shipper in the marking, describing, and handling during transit of these shipments. On account of the greater danger involved, work was directed first toward the transportation of explosives. The containers used for this purpose were wooden boxes for high explosives and metal kegs



FIG 1



FIG 2

was not practicable to go into much detail in prescribing these containers. The absence of detailed specifications gave shippers who were anxious to economize on their transportation costs an opportunity to present their shipments and have them accepted at the freight stations, in almost any type of container that the shipper felt disposed to use. The active competition between railroads made it difficult, if not impossible, to apply restrictions whose enforcement meant the refusal of improperly packed freight. Loss and damage occurred as a natural result and the railroads bore the financial burden. What this burden amounts to at the present time is illustrated by the following statistics. The Annual Reports on the

for black powder. An exhaustive series of tests was planned and carried out at the Altoona yards of the Pennsylvania Railroad. These packages containing sand to represent the usual explosive contents were loaded in freight cars that were subjected to various degrees of rough treatment to represent the shocks liable to occur in railway operation. Special instruments were devised and constructed to furnish data concerning the stresses brought to bear upon these packages as a result of coupling shocks. When a freight car is allowed to strike at a speed of 5 miles per hr. a solid train of loaded freight cars at rest, the force tending to produce a movement of lading along the floor of the car amounts to not less than 5 lbs. for each lb. in the weight of the package. For example, 240 boxes of high explosives weighing 58 lbs. each develop under these

¹ Address before the New York Section of the Society of Chemical Industry, May 23, 1919.

SUMMARY OF REPORTED ACCIDENTS INVOLVING SHIPPING CONTAINER FAILURES CAUSING FIRES, PERSONAL INJURIES, OR PROPERTY LOSS, OCCURRING IN THE TRANSPORTATION OF DANGEROUS ARTICLES OTHER THAN EXPLOSIVES FOR A PERIOD OF 5 YEARS ENDING DEC. 31, 1918

NAME OF ARTICLES	Tank Cars				Metal Drums or Barrels				Carboys				Wooden Barrels & Kegs				Cylinders				Cans, Bottles, Jugs, etc., in Wooden Boxes or Barrels			
	No. Accidents	Persons Killed	Persons Injured	Property Loss	No. Accidents	Persons Killed	Persons Injured	Property Loss	No. Accidents	Persons Killed	Persons Injured	Property Loss	No. Accidents	Persons Killed	Persons Injured	Property Loss	No. Accidents	Persons Killed	Persons Injured	Property Loss	No. Accidents	Persons Killed	Persons Injured	Property Loss
Acetone.....	9	1	5	737	13	1	1	\$ 1,638	1	1	1	287	.....	.....	.....	.....	.....	.....	.....	.....	32	1	1	\$ 36 168 1
Acid, hydrochloric	.....	.....	.....	.....	.....	.....	.....	.....	674	1	1	13,007	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Acid, hydrofluoric	.....	.....	.....	.....	.....	.....	.....	.....	22	1	3	271	28	1	1	\$ 2,425	.....	.....	.....	.....	1	1	.....	.....
Acid, hydrofluosilicic.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14	.....	.....	477	.....	.....	.....	.....	.....	.....	.....	.....
Acid, nitric.....	.....	.....	.....	.....	.....	.....	.....	.....	468	13	384,491	.....	.....	.....	.....	.....	.....	.....	.....	.....	52	.....	.....	216,620
Acid, sulfuric.....	14	9	2,548	.....	39	1	11,289	.....	1016	30	27,261	.....	2	.....	13	1,169	64	11	.....	.....	.....	.....	.....	1,169
Alcohol.....	5	.....	32,660	.....	3	.....	5,670	.....	2	.....	33	.....	71	8	162,386	.....	47	.....	.....	.....	.....	.....	.....	2,538
Batteries, storage (charged with acid).....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15	.....	.....	1,180
Benzol.....	9	.....	8,029	.....	1	.....	38	.....	.....	.....	.....	.....	1	.....	4	.....	1	.....	.....	.....	1	.....	.....	.....
Bromine.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	26	.....	.....	.....	.....	.....	.....	21,613
Carbon bisulfide.....	.....	.....	.....	.....	3	.....	1,675	.....	.....	.....	.....	.....	.....	.....	.....	.....	14	.....	.....	.....	.....	.....	.....	88
Cologne spirits (alcohol).....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Electrolyte.....	.....	.....	.....	.....	.....	.....	.....	.....	98	1	2,635	.....	23	.....	13,250	.....	.....	.....	.....	.....	3	.....	.....	10
Ether.....	.....	.....	.....	.....	5	.....	81	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	.....	.....	13
Gas, compressed acetylene.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15	1	8	\$15,878	.....	.....	.....	43
Gas, compressed carbonic acid.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Gasoline.....	76	3	16	142,705	68	1	5,851	.....	.....	.....	.....	.....	5	3	1,246	.....	181	7	1,074	.....	33	.....	.....	207
Naptha.....	6	.....	2,514	.....	1	.....	1	.....	.....	.....	.....	.....	3	.....	1,514	.....	.....	.....	.....	.....	.....	.....	.....	.....
Paint.....	.....	.....	.....	.....	4	.....	105	.....	.....	.....	.....	.....	20	.....	464	.....	.....	.....	.....	.....	31	.....	.....	161
Shellac, Varnish.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	34	.....	.....	.....	.....	.....	15	.....	.....	57
Toluol.....	14	.....	14,068	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Varnish.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7	.....	6,493	.....	.....	.....	.....	.....	17	.....	.....	5,118
TOTALS.....	133	3	25	\$203,261	137	0	2	\$26,348	2281	0	48	\$427,985	176	0	12	\$188,306	196	1	15	\$16,952	363	0	12	\$249,043

Total No. Accidents = 3286, each involving from 1 to 130 individual containers (see nature of failures under each type of container).
Total No. Persons Killed = 4
Total No. Persons Injured = 114
Total Amount of Property Loss = \$1,111,895
Losses include fire, containers and contents, damages to other freight and property.

Tank car failures consist of leaking plates, seams, rivets, outlet valve, discharge pipe and outlet valve cap, not caused by collision or derailment; leaks resulting from the formation of ice in outlet valve discharge pipe or cap; leaks resulting from damage to outlet valve pipe or cap (due to collision, derailment, or rough handling).

Drum failures consist of leaking bungs, vent-holes, seams, and ruptures due to corrosion; bursting due to internal pressure; rough handling.

Carboy failures consist of inefficient stoppering, insufficient cushioning, improper loading, bracing, or blocking due to loose hoops, sprung staves, etc.; rough handling; or improper loading, blocking, or bracing.

Wooden barrel and keg failures consist of leaking staves, heads, bungs; bursting of heads; collapsing due to loose hoops, sprung staves, etc.; rough handling; or improper loading, blocking, or bracing.

Cylinder failures consist of broken valves, leaking valves, bursting of safety discs, explosions due to defective welding, dropping of cylinder, increase of internal pressure from exposure to direct sunlight, hot steam pipes, fire or dissociation of acetylene gas.

Failures of above-mentioned containers consist of inefficient stoppering or closure of interior packages; improper packing or cushioning; insufficient packing or cushioning; leaks due to improperly driven nails, rust spots, or defective seams (resulting from brittle or poor solder); improper loading, bracing, etc.

¹ This summary does not include the many listed dangerous articles which have been involved in less than 10 accidents each during the past 5 years.

circumstances a tendency towards relative movement which can be stopped only by a force equal to $5 \times 58 \times 240$, or 68,600 lbs.

After a careful study, plans for loading and bracing these explosive packages in cars were worked out in detail and published in our *B. E. Pamphlet*, No. 6A, which illustrates by drawings and photographs the best loading and bracing methods. The wooden boxes and metal kegs in use at that time for these shipments were subjected to careful test in static testing machines to develop their resistance to end and side pressures. These resistances were strengthened as much as was possible under the conditions that had to be met. As a final result of this standardization work we have been able to reduce the property loss due to the annual shipment during normal times of about 600,000,000 lbs. of explosives, to an average of about \$30,000 a year. This loss during 1907, the first year, covered by statistics, amounted to \$500,000. During the same year 52 people were killed and 80 injured by explosions in transit. These figures have been reduced so that it is now exceptional when a life is sacrificed by the transportation of explosives throughout the United States and Canada.

Our invitation to manufacturing shippers of dangerous articles throughout the United States to cooperate with us in this im-

portant work has met with most generous response. Where these shippers were already organized for other purposes into societies or associations, the full weight of the influence of these associations has been thrown into this work. In many cases organizations were effected where they had not previously existed, the principal object being to have representatives available to meet at any time representatives of the Bureau of Explosives, to discuss the problems requiring solution. In no case has this cooperation been more generous or effective than in the case of the Executive Committee of the Manufacturing Chemists' Association, under the chairmanship of Mr. Henry Howard, of Boston.

We have made very satisfactory progress in standardizing the shipment of explosives. The natural benefits to be expected from such standardization are referred to in the following quotation from the Annual Report of the Chief Inspector for the year 1918:

At this time it does not seem possible that the principal events of the year 1918 can ever be approximated in our national experience. For some time to come the one event, the winning of the war, will crowd all others into the background of our mental vision. When we are able to focus our minds on other events the services rendered by our railroads will stand out in bold relief and in the foreground of this picture will appear the

successful transportation of enormous quantities of such dangerous articles as explosives, poisonous liquids and gases, gasoline, and acids.

Our military program, adopted early in 1918, called for a production in one year of about 2,000,000,000 lbs. of explosives for military use, and for the production of poisonous liquids and gases at a maximum rate of about 200 tons per day. The actual production attained under this program cannot be stated at



FIG. 3

this time, but it is known that for most of the year preceding the signing of the armistice, the monthly production of military explosives exceeded 80,000,000 lbs., or more than 2000 carloads of 40,000 lbs. each per day. These explosives moved to the loading plants where each carload of explosives produced not less than 5 carloads of explosive projectiles. Allowing 10 days for the average movement to destination, and considering less-than-carload shipments as well as carload shipments, a conservative estimate shows that the railroads of the United States during the busy months of 1918 had at all times not less than 50,000 cars in transit on government business and bearing the explosive placard. This was in addition to the average of 5,000 cars in transit to meet the normal commercial demand, and our estimate does not include the cars bearing military explosives in Canada.

In meeting this abnormal demand only 11 accidents of all kinds occurred in the transportation of explosives during 1918, only 4 persons were injured, only one life was lost; and the total property loss was only \$33,238. Of these results the only one chargeable to war material was the loss of one life, which occurred in Canada.

This excellent record is due, primarily, to the general use of standard packages and of standard methods of loading, blocking, and bracing the packages in cars. Such standardization is secured more readily for explosives than for many of the other classes of dangerous articles on account of the relatively small number of shippers of explosives, and their very general appreciation of the necessity for strict compliance with the regulations. The record should be an object lesson to shippers of other dangerous articles and to operating officials of railroads. These other losses can and should be reduced by the same attention to construction of containers, loading of packages, and handling of cars. The efforts of the Bureau of Explosives must be reinforced, however, by stronger measures if progress in this direction is to be accelerated.

EFFICIENCY IN SHIPPING CONTAINERS A PROBLEM IN MECHANICAL AND CHEMICAL ENGINEERING

No argument is necessary to show the absurdity of concentrating the efforts of efficiency engineers on minimizing manufacturing costs and getting maximum yields in a manufacturing plant, without utilizing the same talent in the protection of these manufactured products from loss during transportation. The problem of securing safe transportation involves numerous factors. The nature of the material to be shipped must be considered with respect to the results liable to follow from leakage from shipping containers. In some cases only the loss of the material is involved, while in others disastrous fires involving the loss of much additional property may result, either by the effect of the exposure of leaking material to air and moisture, or by ignition of inflammable material.

In some cases the material shipped is liable to act chemically on the container. The nature of the material shipped and the design and construction of the container must be considered also from the standpoint of safe storage of the article, as well as safe transportation of it by rail. In many cases deterioration of containers during storage has a direct effect upon the safety of subsequent transportation of the package. The mechanical engineer who designs shipping containers must appreciate the stresses that are liable to act on his container during transit, and the loading and bracing of these containers in a freight car must be scientifically planned and executed. The amount of material packed in a container has an important influence also on the design of the container. Finally, the various factors calling for a maximum of strength and endurance must be analyzed against the permissible costs. In settling the permissible costs we must consider whether the package is designed for one journey or for continued use. In many cases the expensive package is the cheap one, the saving being due to its long life and continued service.

INTERSTATE COMMERCE COMMISSION CLASSIFICATION

Dangerous articles other than explosives are classified for transportation purposes by the Interstate Commerce Commission into Inflammable Liquids, Inflammable Solids, Oxidizing Materials, Corrosive Liquids, and Compressed Gases. Through the coöperation mentioned above, the Bureau of Explosives and the manufacturing shippers of these materials have during the last 11 or 12 years prepared transportation rules and shipping container specifications which have been adopted by the Interstate Commerce Commission, acting under legislative authority. The rules promulgated by the Commission describe the general types of shipping containers for these various classes of dangerous materials, and also the specific container and packing for many individual articles contained in these classifications. The specifications for shipping containers do not always represent ideal conditions from the safety standpoint, but as a rule they embody the best container commercially practicable and acceptable to the best class of shippers.

INFLAMMABLE LIQUIDS

The bulk of shipments of inflammable liquids are shipped in boxed cans, steel barrels or drums, or in tank cars. These liquids commonly have very slight corrosive effects on metal or other containers, and the principal requirement is to get the requisite strength in the construction of the container.



FIG. 4

The most dangerous of the inflammable liquids shipped in quantity are casinghead gasoline and liquefied petroleum gas. These liquids are produced by liquefying the condensable vapors in casinghead gas or natural gas, either by the compression or

absorption process. By the compression process, especially, a considerable amount of highly volatile material is condensed or dissolved in the liquid product. Some of the more volatile portions are eliminated by means of a "weathering" process, but the final product is far more volatile and dangerous than ordinary refinery gasoline. Such liquids produce internal pressure in their shipping containers. Owing to these pressures, very slight defects in the containers may produce large leakages. It was necessary to devise a test other than the flash test to show the varying degree of hazard involved in handling condensates of this nature. As the special hazard is the high vapor pressure, the test applied to the material is simply a determination of the vapor pressure in the liquid in a closed container filled to 90 per cent capacity at temperatures of 70° and 100° F., respectively, under standard conditions. Material that gives a pressure not exceeding 10 lbs. at 100° F. may be shipped in tank cars of the ordinary type, while condensates having pressures above 10 lbs., and not exceeding 15 lbs. in the summer or 20 lbs. in the winter, require a special type of tank which was developed especially for the transportation of this commodity.

TANK CARS

The ordinary tank car was originally designed for the transportation of comparatively less volatile liquids, such as crude oil and kerosene; and later, refinery gasolines were satisfactorily shipped in these cars, as comparatively little internal pressure was developed even in hot weather. These tank cars were not designed primarily to stand internal pressures. The shells are sufficiently strong, but the dome cover is not sufficiently tight, the safety vent valves are not of satisfactory design, and the presence of a bottom outlet valve is responsible for many expensive accidents.



FIG. 5

The insulated tank car used for the more volatile casinghead condensates is entirely covered with an insulating layer of magnesia or cork about 2 in. thick, which is in turn covered with sheet iron. The dome cover, instead of screwing directly into the dome ring, is bolted down over the dome opening with 10 or 12 bolts around the edges of the cover. By this means direct pressure is placed on the gasket instead of a twisting motion which is obtained with the dome covers which screw into the dome ring. Further, these bolted-on covers cannot be removed until a vent is opened by which all internal pressure is relieved before the dome cover is released. The insulation around the car prevents to a surprising degree the heating of the contents of the car by the heat of the sun and the atmosphere. For this reason the vapor pressures are kept low and there is less loss by evaporation than with the ordinary tank cars.

Very serious accidents have been caused by the use of the tank cars with screw dome covers. In several instances these covers

were removed while there was still high pressure in the car. As a result the cover was blown high in the air and a large volume of vapor and hundreds of gallons of liquid were forced up through the dome opening. The vapors were ignited by lights or fires several hundred feet away causing fires or explosions.

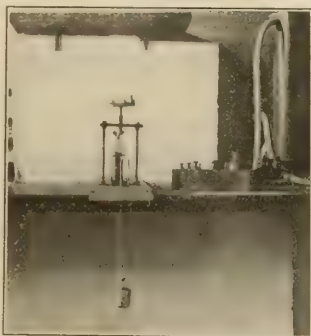


FIG. 6

Safety vent valves are necessary on the tank cars of both types, as otherwise, if the car were involved in a fire, it would most certainly explode and in that case throw burning gasoline over a wide area, causing rapid spread of fire and probable loss of life. The design of these valves is such that many permit escape of vapor at pressures far below the point at which they are set to operate. The gasoline vapors escaping under these conditions occasionally ignite from outside sources; however, the fires thus caused are comparatively small in extent as they burn only at the safety valve, and are usually extinguished without great difficulty and cause slight damage or loss. The bottom valves on tank cars used for inflammable liquids are a source of hazard, as the outside vent or boot is likely to be damaged or broken off in derailment or accidents, and at the same time the valve becomes unseated, allowing the rapid escape of the contents, which under these circumstances usually ignite almost immediately.

Gasoline frequently contains a small portion of water; this water settles to the bottom of the tank car and frequently works its way past the bottom valve into the outlet pipe. In cold weather this water will freeze. The expansion of freezing may burst the outlet pipe or unseat the valve. These conditions may be unnoticed until unloading the car is attempted or until the weather becomes warmer, when it frequently happens that a large portion of the contents escapes before the flow can be controlled. Aside from the loss of contents, severe fires and explosions have occurred from this cause. While from the standpoint of safety the bottom valves on tank cars are undesirable, it appears impracticable to eliminate them, owing to various commercial considerations.

Figs. 1 and 2 show fire in cars of gasoline owing to opening old style tank cars while there was considerable internal pressure. Figs. 3 and 4 show a tank car wreck which resulted in loss of much gasoline, but no fire. The absence of fire was due to the use of care and exceptionally good judgment in clearing up the wreck. In addition to care and judgment, good luck was present.

STEEL BARRELS AND DRUMS

The specification steel drum required for inflammable liquids serves the purpose admirably; failures in this container generally result from too long service, porous bungs, or improper gaskets. It is a fact not generally known, that ordinary cast-iron bungs in noticeable proportions are sufficiently porous or flawed to

permit leakage through the metal. This is more noticeable with light and volatile liquids, such as gasoline or ether. The remedy is to use steel bungs, or to subject all cast-iron ones to severe test for porosity before use.

Difficulties with these metal drums may be divided into three classes: first, poor welding; second, closing devices; and third, corrosion and rough handling.

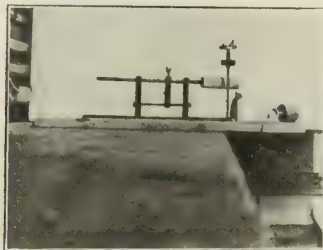


FIG. 7

Poor welding can ordinarily be controlled only by the most careful supervision of the manufacturer. An air test of 15 lbs. is prescribed for each package, but small holes may be covered with scale or closed by oxide so that leakage will develop after use. Such a test made before each shipment, especially if the package is hammered with a wooden mallet along the chime and side weld, would eliminate practically all chance of leakage due to defective welding. The apparatus and test would not be very expensive and would probably pay in the case of a large shipper, for the railroads are fast coming to the conclusion that claims on leaking packages should not be paid unless injury actually occurs in transit. A small shipper can get fair results by laying the package on its side after filling, and allowing it to remain for several hours and examining for leakage while hammering with a wooden mallet along the chime and side weld. Repairing of leaks by soldering does not pay in the long run and should not be allowed. They should be welded.

The efficiency of closing devices can be easily controlled by the purchaser, even if the manufacturer is careless. All that is necessary is a careful and intelligent inspection of packages upon receipt, and the use of a new gasket at each shipment. Bungs when screwed in about three-quarters of the distance should show a fairly close fit in the threads, otherwise they will soon strip. The thread in the bunghole should have at least 5 complete threads and that on the bung should be sufficiently long to engage in all of the 5 threads in the bunghole. Bungs should screw up to an even bearing when gaskets are removed. Gaskets should be at least $\frac{3}{16}$ in. thick by $\frac{3}{8}$ in. wide.

The use of a proper gasket is essential to tight closure of drums. The material from which the gaskets are made must be chosen with regard to the material to be shipped and also to the physical qualities, such as hardness, durability, and elasticity. Satisfactory gaskets may be made from numerous materials, such as hard fiber, leather, rubberized asbestos, etc. One of the principal causes of failures in gaskets is the fact that they are used too often. It would probably be a safe rule to require that no gasket should be used more than once.

WOODEN BARRELS

The transportation of dangerous articles in wooden barrels and kegs will always result in accidents as long as those packages are authorized. This is especially true in connection with the lighter of the inflammable liquids and the more dangerous inflammable solids. The troubles lie principally in the inherent liability to slow leakage of barrels of the tight variety and sifting of contents through cracks in slack barrels.

The shipment of alcohol in wooden barrels has resulted in comparatively large losses. In addition to the original weakness of the package these accidents are due to shippers using second-hand barrels without properly recoopering them, or barrels which do not actually come up to the standards prescribed. Faulty methods of loading may also contribute to the losses, since these packages are especially susceptible to damage through shock.

For new barrels the user is urged to require the manufacturer to certify to the fact that his product complies with the specifications and to mark them to show such compliance. This responsibility placed upon the manufacturer of the package will secure some improvement.

For second-hand barrels only the most careful recoopering should be allowed and care should also be taken that only those barrels actually complying with the specifications on original manufacture should be used for the dangerous articles.

The shipment of permanganate of potassium, the chlorates, and similar articles in slack barrels and kegs is also giving some trouble. If these accidents continue it will probably be necessary to limit these articles to metal containers. The present container, the slack barrel, is dangerous even after the contents are removed and some fires have been caused by their use as second-hand packages for other articles.

Failures of shipping containers for inflammable liquids have often been due to overloading the container and the expansion due to rise in temperature. To determine the proper outage it is necessary to know the coefficient of expansion of the liquid and the maximum temperature range to which it may be subjected in transit or storage. The maximum temperature to which shipments may be subjected in transit is probably about 110° F. in this section, while in the Southwest it is approximately 120° F. Generally the more volatile and lighter liquids have the higher expansion coefficient. Gasoline has a much higher coefficient of expansion than kerosene and heavier oils, and the outage sufficient for such shipments is quite inadequate for gasolines, especially those of higher Baumé gravity.

INFLAMMABLE SOLIDS

The principal requirement for shipping containers of inflammable solids is the exclusion of air or moisture. Contact with air causes spontaneous oxidation with many of these substances, and often with sufficient degree to cause ignition. The degree of activity varies with these materials and the attendant hazards of exposure to air is in proportion to this activity. Phosphorus, metallic sodium, fused sodium sulfide, cobalt resinates, and matches are included in the class of inflammable solids.



FIG. 8

The shipping containers for phosphorus commonly consists of sealed tin cans containing the phosphorus submerged in water; these cans are shipped in outside wooden boxes. This type of container has been satisfactory in direct shipment from factory to consumer. Where the material has been subjected

to long storage before shipment, trouble has been caused by the slow rusting of the tin cans, allowing the escape of the water, the entrance of air, and in some cases the actual ignition of the phosphorus. It will be necessary to modify the specification of this container either by having a much heavier coating of tin on the tin can, or by requiring that the outer wooden box be provided with an hermetically sealed metallic lining. The latter will probably be the safer, as no matter how secure the single inner package is, it is liable to be burst by the freezing of the water in cold weather.



Fig. 9

Metallic sodium, while highly active, has caused very little trouble in shipments, owing to the fact that the shipping container is practically satisfactory. Large shipments are commonly made in the form of bricks or ingots which are packed in heavy steel drums tightly closed. Smaller shipments are packed in hermetically sealed tin cans, packed in boxes, also immersed in oil in glass bottles surrounded by tin cans, the entire inner package being placed in a wooden box. Carload shipments are also made with the sodium cast solid in sheet-iron drums, such as are used for caustic soda. This package, while satisfactory for inter-plant shipments in solid carloads, is not permissible in L. C. L. shipments, or for general use.

Fused sodium sulfide is required to be shipped in tight iron drums, as when in wooden barrels it is liable to spontaneous heating and ignition, particularly in hot and damp weather. The crystallized sodium sulfide is more hazardous.

Strike-anywhere matches, while not liable to ignition by exposure to air, require a tight package for the reason that if the matches are accidentally ignited in a tight package, the fire is almost immediately smothered for lack of air. The present shipping containers for matches are wooden or fiber-board boxes. These containers quite generally smother any fire started in the matches. However, if the outer package is defective or is broken by rough handling, any fire started is likely to spread throughout the package and to adjacent packages.

The ordinary strike-anywhere match is extremely sensitive to friction. It is in fact more readily ignited by friction than any commercial or military explosive. Decrease of the losses in transportation may be sought either by the use of a shipping container more nearly air-tight, such as a metal-lined wooden box, or by noticeably decreasing the sensitiveness of the matches themselves. In order to determine the relative sensitiveness of the matches a special friction test apparatus has been designed and put into use.

In this apparatus an alundum cylinder, 3 in. long and $1\frac{1}{8}$

in. in diameter, is held in a horizontal position on a slide moving in a direction parallel to its axis. The slide and cylinder are moved forward 2 in. by a 500 g. weight after falling through a distance of 6 in. The match to be tested is held so that the match head touches the top surface of the cylinder, and the match stick is in a vertical position. The match is held in a socket which can give an adjustable pressure of from 10 to 200 g. on the match head. The test is made to determine the least pressure which will cause ignition of the match head during the 2 in. movement.

OXIDIZING MATERIALS

Materials classed as oxidizing materials for transportation purposes include sodium peroxide, barium peroxide, potassium permanganate, potassium chlorate, and others of less activity and hazard. Sodium peroxide is inherently the most hazardous of these compounds, but owing to the effectiveness of the containers—tight steel drums or tight tins packed in wooden barrels or boxes—very little difficulty has been experienced in shipments. Barium peroxide formerly caused numerous fires accompanied by heavy losses. At that time shipments were made in heavy and apparently tight wooden barrels. The barium peroxide was in the form of a fine but heavy powder. This powder in small quantities worked through the joints in the barrel, and it was found that friction of this powder between dry wooden surfaces readily produced fire. As a result of this investigation steel containers were required for shipments, and since this type of container has been used no fires have been reported in these shipments. The loss of the Steamer "Volturno" by fire some 6 years ago is believed to have been caused by the ignition of barium peroxide shipped in wooden barrels.



Fig. 10

Potassium permanganate and potassium chlorate are now shipped in wooden barrels or kegs. This practice is not entirely satisfactory, for there is a chance of fires being caused by friction if the contents escape from the package. Also if the chlorate gets into a fire it occasionally causes quite severe explosions. It will be recalled that there was a series of explosions of chlorate in connection with a warehouse fire in Jersey City about 18 months ago. An unexpected risk pertaining to wooden containers for chlorates has recently been noted. Fires have been caused by shipments of metal and hardware in second-hand chlorate kegs. The inner surface of these kegs was slightly crusted and impregnated with sodium chlorate. The friction

of the metal pieces against the chlorate-impregnated surface started the fires. Immediate discovery and control of two fires disclosed definitely the cause. It is quite possible that other fires have been caused in this manner and that the cause was never determined.



FIG. 11

CORROSIVE LIQUIDS

The shipping containers used for corrosive liquids consist principally of tank cars, steel drums, glass carboys, and glass bottles. For sulfuric acid and mixed nitrating acid the tank car is very satisfactory and the steel drum reasonably so. The glass carboy at its best is a fragile package. Sulfuric acid of 92 to 96 per cent strength has but slight effect on iron or steel, but the stronger acid, known as oleum, has a much more marked effect. This effect is not uniform over the surface, but causes irregular pitting. This effect may be due to local impurities in the metal, but it is quite pronounced in the grade of steel used in making steel drums. Owing to the proposed development of air, nitric acid plants, it is desired to ship strong nitric in tank cars with the minimum mixture of sulfuric acid which will serve to protect the steel from undue corrosion. So far as known, the least amount of sulfuric acid which has been successfully used for this purpose has been approximately 13 per cent by weight of the total mixed acid. The corrosion of the steel depends not only on the amount of sulfuric acid, but also on the amount of water in the mixture. Investigations on this subject are still incomplete. The shipment of nitric acid has been the cause of heavy losses, not only of acid but also of equipment. These shipments must necessarily be made in glass carboys.

While the glass is not affected by the acid, frequent fires have occurred owing to the breakage of the carboys. The glass carboy of the usual capacity, about 12 gal., is extremely fragile, and even with the best available packing there is considerable breakage due to the shocks caused by shifting and coupling of cars, or by train movement. The regulations require that no material, such as hay, straw, or similar combustible material should be used as packing for nitric acid carboys. The packings most used are mineral wool, and the so-called Stahl packing, which consists of four grooved, vertical wooden strips whose elasticity serves as the cushioning agent. While both of these packings are safer than hay for nitric acid carboys, nevertheless numerous fires have occurred in shipments in both types of these carboys. Figs. 8 and 9 show the result of fire in two different cars of nitric acid.

It is desirable that a carboy box for nitric acid should have a metal or other liner that will hold the acid after the carboy is broken, and not permit it to come in contact with the wooden boxes, or the wooden floor and lining of the car. As yet such a shipping container has not been developed to a commercial stage.

In the development of the carboy and its container it was necessary to determine accurately the resistance of the various combinations to severe stresses. In railroad transportation observation has shown that packages receive their greatest stresses in a direction parallel to the length of the car. These maximum stresses are due to coupling, switching, and sudden stops in train operation. The straight-sided carboy now in use is naturally more resistant to vertical stresses than to lateral ones, hence the freight car and the carboy make a combination in which the greatest stress comes on the weakest part of the carboy. As far as possible the packing serves to overcome this inherent weakness of the package.

Boxed carboys filled to the shoulder with water are tested to destruction by both vertical and lateral impact. The vertical impact is obtained by dropping the carboys on the bottom on a concrete floor. The lateral impact is obtained by suspending the carboy so as to act as the weight on a 14 ft. pendulum. The carboy strikes laterally against a vertical wall just beyond the bottom point of swing. The amount of impact is determined by the vertical component of the arc through which the carboy swings. In making this test it is necessary that the carboy be swung so that the face of the box is exactly parallel to the vertical wall, otherwise the box will not strike squarely and the test will be misleading.

Considerable difficulty has been caused at times by bursting of nitric acid carboys from internal pressure, due to expansion of the acid by heat or by decomposition of the acid by light. Experiments showed that with tightly closed bottles of nitric acid filled to 90 per cent of capacity, and exposed to direct sunlight, a pressure of 17 lbs. per sq. in. developed in 3 days.



FIG. 12

A considerably less pressure was produced by diffused daylight, and practically none in the absence of light. These tests showed the necessity of venting of nitric acid carboys, especially where ground glass stoppers were used for chemically pure acid. Work is also being carried on in the development of porous stoppers for commercial acids which will permit the escape of vapors produced in transit.

Until recently carboys were commonly closed by a loosely fitting earthen stopper held more or less securely in place by clay, plaster of Paris, and burlap. These stoppers were generally in fair condition when loaded in the car, but by the vibration and shocks of transportation they worked loose and in many cases jarred completely out of the necks of the carboys. This condition caused splashing of the acid from the carboys, which in some cases caused fire or injury to employees, and always caused rapid deterioration of the carboy boxes, the car floor, and lining.

Boxed carboys for the transportation of inflammable liquids and acids are a prolific source of trouble. Probably for nitric acid it will be necessary to adopt eventually a metal-lined box to retain the acid in case of accident. For ordinary acids, however, it is believed that careful attention to the following points will largely eliminate accidents due to the package: First, cushioning; second, closing device; third, repair.



FIG. 13

Poor and insufficient cushioning cannot be cheap in the long run. It will cause accidents and it will increase repair. The cushioning material should be $1\frac{1}{2}$ to 2 in. in thickness all around the carboy and should be carefully put in. A thin cushioning will give insufficient protection and will quickly wear through by the constant rubbing of the carboy, while one full of lumps will cause the pressures to be brought on small areas of the carboy and cause breakage. A 1 in. thickness does not give space for proper packing or sufficient cushioning.

The use of elastic wooden strips for cushioning decreases initial costs, but has not proved successful from the standpoint of safety and final costs. Great care must be taken in manufacture and assembly, the elasticity of the wood is liable to be quickly destroyed by acid or acid fumes, and finally the repair and readjustment costs are certain to be high unless efficiency is neglected. I believe that some improvement will be obtained if packages cushioned with elastic wooden strips are used only where reshipments will not occur.

The closing device appears to be simply a question of cost. If a stopper is well made, an efficient gasket applied, and a strong metal fastening used, there will be no leakage. Already the improvements along this line have been great, but there is room for more.

The lack of proper repair of packing is probably one of the greatest causes for breakage of carboys. The carboy is fundamentally an improper package and unduly subject to breakage, and when the outside box and the cushioning deteriorate, the resulting package is exceedingly inefficient. Periodical and efficient repacking should be required.

Fires have been occasionally caused by the use of organic packing, such as sawdust, around bottles and jugs of bromine.

This packing was improved later by saturation of the packing with the so-called bittern water, but still fires occurred at times, and it was finally required that bromine bottles or jugs should be packed in entirely incombustible packing.

Fires resulting in shipment of phosphorus trichloride necessitated the prohibition of any organic material as packing around the bottles or of any packing which will combine in any way with the phosphorus trichloride.

MISCELLANEOUS ARTICLES IN BOXES

The shipment of miscellaneous goods packed in boxes, and including dangerous articles, has always been difficult to regulate. A small amount of dangerous articles may start just as bad a fire as a large amount.

The greatest risk is noted in the transportation of nitric acid. The present regulations require all cushioning material to be incombustible. This does not seem to be sufficient as there are frequently in the same outside container other packages containing sufficient combustible matter to cause fire when attacked by the acid. Safety suggests that nitric acid should be absolutely prohibited from being packed with other goods.

The boxes in general use for these miscellaneous goods frequently merit severe criticism. Apparently many shippers fail to realize that in marking their boxes to show compliance with a certain specification they are giving the word of their company to the effect that they actually do comply. The required marking is supplied by some of these shippers, not because the package is correct, but because the railways will not take the package without it.

The shippers should purchase their boxes under a guarantee from the manufacturer that they comply with the proper specification, and they should require him to mark the boxes to show such compliance and to stand back of this marking.

COMPRESSED GASES

The specifications for shipping containers for compressed or liquefied gases have been exceptionally successful in preventing losses and accidents. This is due to the fact that the pressure in cylinders of compressed or liquefied gases can be accurately determined and controlled. The cylinders can be made of a metal selected to have the proper chemical composition and the required tensile strength, elastic limit, and working qualities. Further, each cylinder, after being designed and made with a view to meeting these requirements, is subjected to a hydrostatic pressure test at a pressure sufficiently above any reasonable working pressure to ensure a proper factor of safety. It is required that when subjected to this pressure test, the permanent expansion must not exceed 10 per cent of the temporary expansion. A test of this nature assures that the actual bursting pressure will considerably exceed the test pressures, and at the same time the metal will not be overstrained, weakened, or hardened by the test. In the manufacture of compressed gas cylinders there is the advantage that the cylinders last for a long time, and hence the expense is distributed over a long series of shipments. Carbon dioxide cylinders have been in general use in this country for a longer period than any other type of compressed gas cylinders. Many cylinders have been in use for more than 20 years. Many of the earlier cylinders were made according to specifications which would not at present be approved, yet there have been relatively few failures. Where cylinders of this type have failed it has generally been due not so much to excess pressure, but to brittleness of the metal. In most cases the bursting of the cylinders was caused by a shock such as is produced by a cylinder falling over, or dropping from a car or wagon.

Fig. 13 shows a carbon dioxide cylinder which burst in service. This cylinder was of sufficient strength, but the metal was brittle.

Acetylene cylinders have presented a peculiarly different problem in design and construction, because of the property of acetylene which causes it under certain conditions to dissociate with explosive violence when compressed to a pressure above 2 atmospheres. It can readily be liquefied, but in this condition is almost as dangerous as nitroglycerin. Experience has shown that the only safe way to store and ship compressed acetylene is in solution in acetone, which in turn is held in a porous filling mass in a steel cylinder. Asbestos blocks or other porous materials are used for this mass. This mass must have a porosity of not greater than 80 per cent and must have no large voids in which an explosive reaction may start. The mass must be of sufficiently fine texture to be safe, and sufficiently rigid and durable to prevent sagging away from the walls of cylinder, even after long use and severe handling.

Aside from the tests of the cylinder by the usual hydrostatic tests, the filled and charged cylinders are tested as to liability to explosive dissociation of contents and bursting of the cylinders. The tests commonly applied are, first, placing charged cylinder in fire and observing whether gas escapes quietly by the safety

vents or bursts cylinder; second, placing a charge of dynamite on cylinder sufficiently heavy to make deep dent in side wall, and yet not sufficient to break wall; third, burning a hole through wall of cylinder with a charge of thermit.

Shipping container specifications, as has been indicated, have been gradually developed to their present state. They are neither completed nor perfected, they do not always represent the best possible container because they must be made within certain limiting costs to be available for commercial use. They represent the joint results of the experience of shippers of the commodities, manufacturers of the shipping containers, and of the carriers, plus thorough study of all the conditions. Additional specifications are being prepared from time to time as needed, and modifications and improvements are made in those previously drawn up. Further knowledge of the materials to be shipped, improvements in materials and manufacturing processes, will suggest future developments and improvements in shipping containers.

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BIBLIOGRAPHY OF HELIUM LITERATURE

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INTRODUCTION

It is particularly appropriate at this time to issue a bibliography of the scientific literature relating to helium. The development, during the war, of great fractionating plants capable of separating from natural gas a sufficient quantity of helium to supply a fleet of airships has aroused the keen interest, not only of engineers and scientists, but also of the general public in the unique properties of this gas.

The year 1918 certainly marks the beginning of a new era in the history and use of helium. Before that time only a few liters of the gas had ever been collected, and the cost per liter was enormous. The separation of millions of liters of the gas at a very moderate cost, therefore, makes the gas at once available for many purposes which formerly seemed impossible of accomplishment.

Helium has probably been the most interesting of all the elements to the theoretical scientist on account of the romantic history of its discovery, its occurrence in a remarkable condition of solid solution in many minerals, its formation as a product of the disintegration of the radioactive elements, its liquefaction after a decade of unsuccessful attempts by some of the world's greatest experimenters, the attainment by its use of temperatures below those at which the resistances of pure metals vanish, its many unique physical properties, and the many important theoretical conclusions which have been drawn from its behavior.

All of these points of interest have been the subjects of very thorough investigation. The important developments of the future will probably be along the line of the applications of helium, many of which have already been suggested; but in order to make the most of these possible applications it is necessary to know the properties on which they are based. It is as a guide to these properties that, it is hoped, this bibliography will find its chief usefulness.

This bibliography was first prepared at the beginning of the development of helium for balloon gas purposes and was intended as an aid in that enterprise. It has since been brought up to a later date and is thought to include practically everything of scientific value published up to January 1, 1919, except reviews and other articles containing no original work, which were published in inaccessible foreign journals, when the same ma-

terial was available in English or American publications. Such articles have been purposely omitted.

The arrangement of material under each subhead has, in general, been such that closely related articles occur together in their chronological order. The bibliography is thus, in effect, a brief outline history of the subject. An exception to this arrangement is made in the case of articles on the occurrence of helium, which have been arranged alphabetically according to the author's names. This was done because the papers by different authors are usually but slightly related to each other, and the chronological development seems of less importance than the bringing together of the papers, often numerous, of each author.

A—DISCOVERY AND IDENTIFICATION

I—DISCOVERY

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BUREAU OF STANDARDS
WASHINGTON, D. C.

FOREIGN INDUSTRIAL NEWS

By A. McMILLAN, 24 Westend Park St., Glasgow, Scotland

DETERMINATION OF ACETONE, ALCOHOL, AND BENZENE

A method for the determination of small quantities of acetone, alcohol, and benzene in the air was described by S. Elliot and J. Dalton at a meeting of the Society of Public Analysts in London. A measured quantity of the air is drawn through suitable apparatus, the vapors being absorbed as follows: The acetone in alkaline iodine solution, the excess of iodine being estimated by thiosulfate; the alcohol in dilute chromic acid solution, and after oxidation to acetic acid, the excess of chromic acid is estimated by iodine; the benzene in a mixture of concentrated sulfuric and fuming nitric acids, which convert the benzene into dinitrobenzene, and this is extracted and estimated by stannous chloride solution.

GERMAN POTASH FOR ALLIES

According to a Berlin telegram quoted by Reuter's correspondent in Denmark, an agreement was signed recently for the delivery of potash in England. It is not impossible that there will be a further agreement for the delivery of potash to America. England is to get 30,000 tons, the proceeds of which will be credited to the German government in payment for food supplies. Of this amount 10,000 tons will be forwarded via Hamburg or Bremen and 20,000 tons via Rotterdam.

HYDRAULIC MAINS OF REINFORCED CONCRETE

A communication to the *Société Technique du Gas* by Mr. Martineau describes the successful result which followed the emergency measure of constructing ten hydraulic mains in reinforced concrete undertaken as the only possible course during the war in consequence of the high price of cast iron, and the delay in getting such work completed. The metallic reinforcement consists of a network of $\frac{1}{4}$ -in. round iron wire formed in squares 4 in. \times 4 in. The concrete walls had a thickness of $2\frac{3}{8}$ in. The walls of the main rest on iron running the length of the retort bench. The valve of the tar outlet is let into the cement. A rebate along the upper part of the main receives the cover, formed of a slab of cement, into which are set the inspection and cleaning boxes. Before being taken into use all the interior surface of the main, as also the lower side of

the cover, were given three coats of hot tar. This was done to close up the capillary passages in the cement and thus prevent any action of ammonia on the metallic part, the continuous flow of the tar during the working maintaining this protective coating. The main was brought into use without any mishap in the way of expansion or leakage. Test pieces of cement placed in it at the time of starting operations and 6 months afterwards showed no signs of any action on the cement by the gas liquor. The ten mains were constructed in 6 weeks and the cost of each (\$200) was much less than the quotation (\$500) for the work in cast iron at the prices ruling.

ELECTRIC STEEL-HARDENING FURNACE

A Wild-Barfield electric steel-hardening furnace which has been supplied to the metallurgical department of Sheffield University by Automatic and Electric Furnaces (Limited) of 6, Old Queen Street, Westminster, measures 8 in. by 15 in. over all and has a heating chamber 4 in. in bore by 13 in. in depth. The power consumption (200 volts alternating current) is 1,400 watts at full load and the maximum temperature attainable is 850° C. The furnace has an output of 10 lbs. of tools per hr., the maximum weight of article it can take being 2 lbs. and the maximum length 8 in. An electrically-heated quenching and tempering bath, taking 600 watts, measures 12 in. by 15 in. over all. The inner pot is 8 in. in bore and 13 in. in depth, and can take articles up to 4 lbs. in weight and 10 in. in length. The maximum temperature that can be reached is 350° to 400° C.

PLATINUM

Following upon some prospecting work undertaken at the initiative of the Spanish government after three years research in various directions, it has been found that platinum exists in Serrana de Rhonda to an extent of 2 to 3 g. per meter. Serrana forms a chain of volcanic mountains extending over a distance of 1400 sq. km., hence the beds surpass the platinum found in the Ural mountains, where the beds cover an area of only 50 sq. km. It may also be mentioned, says *Engineering*, **127** (1919), 303, that the deposits in the Urals never yielded more than $\frac{1}{4}$ g. per meter and, in addition, the beds there are getting exhausted.

EDIBLE OIL REFINING

A new industry, says the *Chem. Trade J.*, 64 (1919), 258, has been started at Sunderland, England, by the opening of an edible oil refinery. The new venture is an attempt to capture a highly profitable trade formerly enjoyed by Germany and has already despatched its first consignment in the form of salad oil to margarine works. The present output of refined oils is about 50 tons which will be increased on the introduction of new machinery at an early date. Not the least important branch in the undertaking is the department for dealing with the residue which finds a ready sale in the soap-making industry.

LINSEED OIL SUPPLY

Business men in England in the oil trade are puzzled to account for the shortage in linseed oil which first made itself felt before Easter. Three causes, according to the *Liverpool Daily Post*, are suggested for the shortage. One is that the government is holding up supplies in order to compel the trade to use up the surplus linseed oil fatty acids of which there are large stocks in hand. Another cause given is that holders are refraining from selling in the expectation of firmer prices, while a third suggestion is that the government had temporarily oversold to the continent which has long been hungry for linseed oil. There is a temptation to do this since the price for export is \$375 per ton as against \$290 for home consumption. It is at present not possible to say what is the correct cause.

GERMAN SOAP AND ALLIED INDUSTRIES

Quoting from a German contemporary, *Chem. Trade J.*, 64 (1919), 367, discusses Germany's after-war prospects of obtaining oil and fats with special reference to the soap and margarine industries. The German stearin, soap, and candle industries were on a large scale before the war. About 250,000 tons of fat were used for soap-making and from 6,000 to 8,000 tons for candles. There were 34 large, 85 medium, and 549 small soap factories with a total capital of \$75,000,000. Not more than 18,000 tons of fat per annum were available during the war for soap-making. Of the 120 margarine factories previously existing and producing 250,000 tons, only 24 are now working. Before the war, Germany's consumption of oils and fats was estimated at 1,900,000 tons, comprising 600,000 tons of vegetable oils and fats, and 1,300,000 tons animal fats. 1,500,000 tons were used for food and 400,000 tons for industrial and technical purposes. Only about 20,000 tons of oils and fats were obtained from home-grown oilseeds and the balance of 580,000 tons were milled in Germany from 1,700,000 tons of imported oilseeds and nuts. A considerable amount of oil was, of course, exported. Germany views with concern the enormous extension of the oil-milling industry in other countries, especially in England and America, and feels that her chances of competing on equal grounds for the world's supplies of oilseeds and nuts are remote as many of her large mills have had to close down. Bone fat extraction was increased but most of this fat is inedible. The article discusses the merits of crushing oilseeds or expressing as compared with benzene extraction. The latter gives a higher yield of oil but necessitates, as a rule, more refining than when the oil is cold-expressed.

SILICA FROM RICE HUSKS

Some experiments have recently been carried out in Burmah, says *Engineer*, 127 (1919), 403, with a view to utilizing the silica content of rice-husks, in the manufacture of glass. On burning the husk about 18 per cent of white ash is obtained and, although this ash contains small quantities of iron, it has been proved suitable for the manufacture of glass having a pale green or yellow color. In burning the husks, sufficient heat is generated to carry out the various processes.

OXYGEN IN SODIUM PEROXIDE

The methods generally available for the estimation of oxygen in sodium peroxide, depending on the liberation of hydrogen peroxide by water and titration with permanganate and on the treatment with potassium iodide and bicarbonate with titration of iodine with sodium arsenite, are said to give low results, while the method of measuring the oxygen liberated by water in the presence of cobalt nitrate gives high results. The following methods described by J. Milbauer in *Prakt. Chem.* are said to give accurate results. (1) Water (100 cc.) is mixed with concentrated sulfuric acid (5 cc.) and chemically pure boric acid (5 g.), sodium peroxide (0.5 g.) is added gradually to the mixture, which is shaken briskly, and the liberated hydrogen peroxide is treated with permanganate. The low results given by the older method are attributed to the catalytic decomposition of a portion of the hydrogen peroxide by the manganese sulfate formed during the titrations. (2) Sodium peroxide is introduced gradually into a solution of potassium iodide (2 g.) in dilute sulfuric acid, 1 in 20 (200 cc.), and the iodine then titrated with standard thiosulfate. The results agree with the first method. (3) Sodium peroxide (0.2 to 0.3 g.) is mixed with about 10 cc. copper sulfate solution (0.05 per cent) in a small flask connected with a nitrometer, the flask shaken and decomposition is complete in a minute. The oxygen is then measured. The gas evolved contains 0.32 per cent carbon dioxide and 0.08 per cent hydrogen. With cobalt nitrate as catalyst the results are invariably high. The author considers that this may indicate the presence of an oxide higher than the peroxide. The action of the atmosphere on sodium peroxide has also been investigated. Moisture appears to be more active than carbon dioxide in causing decomposition.

MAGNESIUM AND ITS ALLOYS

A very interesting account of the production of magnesium and its uses as an alloying agent is given in a somewhat long article published in *Engineer*, 127 (1919), 402. Before the war, it would seem that Germany was the sole producer of magnesium on a commercial scale, but factories have now been set up in Canada, the United States, France, and England. The technical difficulties involved in the manufacture, which were considerable, have been mastered and many new processes have been introduced which reduced the cost of production and lead to wider uses of the metal. The usual methods of extraction are (1) action of sodium on fused magnesium chloride, (2) electrolysis of a fused double chloride. The magnesium chloride was formerly obtained exclusively from Stassfurt, Germany, but it is now recovered as a by-product at various salt works. Among the new methods of manufacture is the reduction by carbon which yields a black powder at a very low cost. Another method giving an alloy of magnesium and aluminum directly consists in electrolyzing a fused bath of magnesium chloride and fluoride. The anode is carbon; the cathode consists of aluminum so that the magnesium formed at the cathode forms an alloy which can be used as stock in making up alloys of any desired composition. The chief advantages of magnesium alloys are their lightness, strength, and toughness, and their ability to resist shock and vibrations, very important properties when used in aircraft construction. Alloys of magnesium and aluminum containing 5 to 30 per cent magnesium have approximately the same mechanical properties as brass and are used for making screws, nuts, wire, tubes, and sheets. The hardness increases with magnesium content. With 70 per cent magnesium, the alloy is as hard as mild steel. The tensile strength of alloys containing 2 to 10 per cent magnesium is considerably improved by quenching from about 500° C. It would seem that the cheapness of production will have a large influence in the wide introduction of alloys of magnesium and aluminum.

REFRIGERATION

Mr. B. Rothwell, describing the Seay ammonia absorption refrigerating plant at a meeting of the Liverpool Engineering Society, said that this plant has been proved capable of making 25 tons of ice per ton of coal burned, with an estimated evaporation of 9 lbs. of steam per pound of coal. In this system of refrigeration, the absorbing medium used is ammonium nitrate, normally a crystalline salt. In absorbing ammonia it changes to a sticky viscous liquid form. It is stated that 3 lbs. of this salt absorbs 1 lb. of pure ammonia. Thus in the absorber the salt takes up ammonia gas as it comes from a refrigerator or ice-making tank at low pressure and temperature, the crystalline changing into the thick liquid form. In the generator this liquid is treated again by steam coils until the ammonia is driven off and passes into an ammonia condenser of an ordinary type, the salt reverting to its solid form in the process. In connection with the generator, it is claimed that much economy in heating is obtained over what can be secured in the older water and ammonia absorption plant. This is because the change of state of the salt from liquid to solid liberates its latent heat of liquefaction which goes towards the heat required for vaporizing the ammonia and thus, of the approximately 520 B. t. u. required to vaporize each pound of ammonia, only about 200 B. t. u. have to be provided by steam heating coils.

PROTECTION OF IRON FROM RUST

A method of protecting iron from rust for which very durable results are claimed has recently been described by Prof. Barff and is referred to in the *Schweizer Elektrotech. Ztg.* The iron is treated at red heat with superheated steam, thus receiving a superficial coating of black iron oxide that offers complete protection against rust. The coating is of a very hard nature and adheres firmly. In some circumstances the coating formed will resist the action of emery paper for a considerable time while if the temperature is raised to 650° C. and the time of treatment to 6 or 7 hrs. it will resist the action of a file. Exposure in the open air to rain or moisture for 6 wks. did not produce any appearance of rust.

SUBSTITUTE FOR LUBRICANTS

Electrician, 81 (1919), 986, quoting from the *Weser Zeitung*, reports that a new undertaking—the Potash Mineral Fat Undertaking—with headquarters at Essen is being founded. It is proposed to manufacture a heavy lubricant for traction cars and carts, etc., by the treatment of potash, other essential ingredients being obtained as by-products from coal. It is surely one of the most curious anomalies of the past few years that the exigencies of war should have led to the development of coarse lubricants from potash, a material which outside Germany has been very scarce and whose manufacture has called forth great expenditure of effort and ingenuity.

LUBRICANTS FOR LOCOMOTIVES

According to a report by Mr. Esser, of Luxemburg, published in *Glaser's Annalen*, a mixture of mineral oil and tar oil has given satisfaction as a lubricant for high-speed traction machinery and carriages while tar oil alone is only serviceable for low speeds. It is not claimed that this mixture comes up to the quality of the best lubricants available for such purposes in peace time. The parts should not be mixed in the cold lest heavy hydrocarbons of the anthracene series be deposited which would bind the parts. When the tar is mixed hot a sediment is at first formed but there is said to be no further trouble. For the summer service 80 parts tar may be mixed with 20 parts mineral oil; for winter months the two constituents should be used in equal proportions, and in very cold days up to 15 per cent of petroleum should further be added to keep the lubricant limpid.

QUEENSLAND COPPER

There is abundance of copper, says *Engineering*, in Queensland. It is hard to say where copper cannot be found in more or less large deposits, and all the copper deposits are not worked and the bulk of the yearly output has been derived from a few favored mines, which always contain gold and silver in considerable quantities. The celebrated Mont Morgan mine is a proof of this but the extensive district of Cloncurry produces more than half of the output of copper for the whole state. Several years ago it was confidently stated that the production of copper would be vastly increased as would also the output of other valuable metals in the north by the construction of certain railways. These railways are now completed and afford connection between the distant mines and the eastern seaports. The vast copper-mining district of Cloncurry has an area equal to that of Tasmania.

SALVING FRENCH HOSEPIPE

An interesting side line of war salvage is being carried on at Hayes, Middlesex, England, where some hundreds of miles of trench hosepipe are being disintegrated and the various products recovered for sale. This type of hose contains a large amount of iron wire and canvas impregnated with a small proportion of rubber. A special machine has been designed for treating the hose, and the stripped wire is stated to be worth about \$60 a ton at present prices. The rubber is being reclaimed, and the canvas ultimately finds an application as cellulose. The work is being done on a part of the premises of a detinning works, where considerable quantities of scrap tin are now being treated by the electrolytic process with satisfactory results. Tin metal of a particularly high standard of purity containing as much as 99.8 per cent of pure tin is being obtained from the scrap.

ROSELLA FIBER

The British Commissioner at Asuncion states, according to *Paper Maker*, 57 (1919), 426, that conditions of labor in Paraguay will not admit of the rosella fiber (*Hibiscus sapdarifa*) competing with jute, but it is expected that it might be used locally as a substitute. There are six other fibers that are promising, one of which is the "natural wool." This fiber, sometimes called "vegetable wool," is obtained from the leaf of the common palm which grows wild in profusion in Paraguay, but as in the case of the kernels from the same palm, it may be doubted if the fiber can be obtained in sufficient quantities upon a commercial basis. The removal of the fiber from the plant is exceedingly simple. The plant is left to soak in water for four days and the fiber comes off as a glove. The pulp of the plant serves for paper making. The paper factory at Buenos Aires has given an order for the pulp, which cannot be fulfilled owing to the bulky nature of the cargo which makes the freight prohibitive.

POROSITY IN BRICKS

Some figures bearing on the effect of porosity on the heat-conducting properties of bricks were given in a recent paper to the English Ceramic Society by Dr. J. W. Mellor. He found by calculation that with pores 0.1 cm. across at a temperature of 1400° C. the amount of heat carried across the air space per second was equal to the amount carried through the solid. With smaller pores the same would be the case at higher temperatures and with larger pores at a lower temperature. Thus, for pores 0.01 cm. across the temperature would be 3000° C., and for pores 0.5 cm. the temperature would be only about 730° C. The latter would be rather large pores, but pores of 0.01 cm. would scarcely give a porous structure. In the calculations the conductivity of air and possible changes in conductivity due to increases of temperature were not taken into account and convection by current of air was also ignored.

SCIENTIFIC SOCIETIES

INTERALLIED CHEMICAL CONFERENCE IN PARIS

On the initiative of the Société de Chimie Industrielle, an interallied meeting of delegates of chemical societies has just been held in Paris.

Representatives of the Société Chimique de France, the oldest of all French chemical societies, the Société de Chimie Industrielle, the Association des Chimistes de Sucrerie et Distillerie, the Société de Chimie Physique, the Société de Chimie Biologique, the Société des Experts Chimistes, and the Association des Chimistes de l'Industrie Textile made up the French delegation.

Belgium was represented by Mr. Chavanne, president of the Société Chimique de Belgique; the United States by Mr. Wigglesworth, president of the American delegation, Dr. F. G. Cottrell, delegate from the National Research Council and from the American Electrochemical Society, Lt. Col. Bartow of the American Institute of Chemical Engineers, Messrs. John Pennie and Charles MacDowell, delegates to the Peace Conference, Lt. Col. Zanetti, Lt. Col. Norris, Maj. Colin MacKall, Lt. Sidney Kirkpatrick, Lt. Commander Donald Riley, delegates from the AMERICAN CHEMICAL SOCIETY; the United Kingdom of Great Britain and Ireland by Sir William Pope, president of the British Federal Council and former president of the Chemical Society, Prof. Henry Louis, president of the Society of Chemical Industry, Mr. Chapmann, former president of the Society of Public Analysts, Mr. Reed, former president of the Society of Chemical Industry, and Messrs. Stephen Miall and Edwin Thompson; Italy by Prof. Emmanuel Paterno, vice president of the Italian Senate and president of the Italian Chemical Society, Messrs. Guiseppe Paterno, Umberto Pomilio, and Francesco Giordani, delegates of the Società Chimica Italiana, and Messrs. Parodi Delfini and Eugenio Barbier of the Società du Chimica Italiana.

The delegates held several private conferences. These conferences, presided over by Prof. Charles Moureu, a member of the Institute and president of the Fédération Française des Associations de Chimie, prepared a plan for an interallied confederation, the object of which is an intimate coöperation between France, England, Belgium, the United States, and Italy.

There existed before the war an International Chemical Council which included representatives of the Central Empires. It has just been dissolved. The Interallied Confederation will take its place. German science will continue to function, but the barbarous aid which it gave to the enemy armies during the war is sufficient to debar it forever from a confederation where science is to serve the progress of humanity.

The Conference outlined the relations that should exist between the different chemical associations of the allied countries and allowed also the chemical societies of neutral countries an equal right to take part in the Confederation. At the close of the discussions an Interallied Council was constituted. Each nation represented appointed two delegates to take part in it. This Council, which meets in London, July 15 to 18, 1919, is composed as follows:

BELGIUM—Messrs. Chavanne and Crismer
UNITED STATES—Dr. Cottrell and Lt. Col. Zanetti
FRANCE—Messrs. Moureu and Paul Kestner
UNITED KINGDOM OF GREAT BRITAIN AND IRELAND—Sir William Pope and Mr. Henry Louis
ITALY—Senator Paterno and Mr. Parodi Delfini
General Secretary—Mr. Jean Gerard, 49 Rue des Mathurins, Paris, France

During the public meetings held April 14 and 15, many communications of great interest were presented. Professor Louis, president of the Society of Chemical Industry, addressed

the audience on the processes of the concentration of iron minerals by magnetic separation. It is not necessary to point out the importance of this problem when one remembers that France will soon become one of the first iron producers of the world.

Dr. Cottrell described the developments in the United States toward procuring the helium desired for filling balloons and dirigibles. Although this problem is not now of such immediate interest, it illustrates one of the most interesting instances of progress in chemistry during the war, a result which will supply in industrial quantity a gas which before has been only a laboratory curiosity.

Professor Moureu, the first to show the existence of helium resources in France, and Mr. George Claude, inventor of the Claude process for the liquefaction of air, made a few remarks with the object of drawing the attention of the scientific world to the possible consequences of this discovery as much from a theoretical as from a practical view.

The meeting closed with a communication from Mr. MacDowell on the potash industry in the United States. This industry, originating with war needs, is now flourishing. It furnishes to agriculture a part of the necessary potash required in America. However, the production is still insufficient, and Mr. MacDowell made a request for the surplus Alsatian potash to replace in the United States the German potash from Stassfurt.

At the April 15th meeting, one of the American delegates to the Peace Conference, Mr. John C. Pennie, discussed patent legislation in the United States. This legislation, the result of an idea inscribed in the fundamental constitution of the United States, is carried out in an extremely liberal spirit as compared to that existing in European countries.

Mr. Barbet suggested the creation of an interallied patent, and the meeting closed with an extremely interesting communication by Mr. Olet, Directeur de l'Office International de Bibliographie, on the organization of international publications and the function of the chemical associations.

Two of the most important industrial establishments in France, the Kuhlmann Company and Solvay & Company, invited the members to luncheon. The luncheons were served at the Laurent Restaurant, presided over by Mr. Donat Agache, representing the Kuhlmann Company, and at the Marguery Restaurant presided over by Mr. Talvard, director of the Solvay Company.

A farewell banquet brought the members together at the Palais d'Orsay. The members of the Conference were present, together with many influential men of the scientific and industrial chemical world. The banquet was presided over by Mr. Loucheur, Ministre de la Reconstitution Industrielle, assisted by Mr. Boret, Ministre de l'Agriculture et du Ravitaillement.

At the guest table were present: Lord Moulton, Sir William Pope, Prof. Henry Louis, Mr. Levinstein, Mr. Wigglesworth, Maj. Frederick Keyes, Mr. John C. Pennie, Professor Chavanne, Prof. Emmanuel Paterno, Prof. Moureu, Mr. Paul Kestner, president of the Société de Chimie Industrielle, Messrs. Haller, Le Chatelier, and Adolphe Carnot, members of l'Institut, Mr. Cahill, Commercial Attaché to the English Embassy, Mr. Poulenc, president of the Société Chimique de France, Mr. Duchemin, president of the Syndicat Général des Produits Chimique, Mr. Renard, Deputy and former Minister, Mr. Gaston Menier, Senator, Mr. Fleurent, Directeur de l'Office des Produits Chimiques et Pharmaceutiques au Ministère du Commerce, Mr. Roux, Directeur des Service Scientifiques au Ministère de l'Agriculture, Mr. Lheure, Directeur Général du Service des Poudres, Mr. Behal, member of l'Académie de

Médecine, and Mr. Dordes, Directeur des Services Scientifiques au Ministère des Finances.

By the generosity of the Compagnie des Produits Chimiques d'Alais et de la Camargue, the Société de Chimie Industrielle was enabled to invite to the banquet the many representatives of the Chemical War Service, including Belgian, American, English, Italian, and French, and to thus pay respect to the very important coöperation carried on during the war by the allied chemists. After a concert given by the band of the Republican Guard, Mr. Kestner gave a brief history of the Society of Chemical Industry, of which Mr. Henry Louis is president. It was founded 37 years ago, has 14 sections and 5,000 members. It is a fine example. If we wish to develop economically, to supply our needs, to become exporters, these are examples of combination which we should follow. Then speaking of the ruined industries:

If you come to see our ruins, our destroyed factories, our tools mutilated or stolen, our soil rendered barren, the horrible sight will remain forever with you to confirm the necessity of complete reparation.

Prof. Henry Louis then spoke as follows:

There is no doubt that we have carried off a complete and glorious victory on the field of battle, serving with true and loyal means against the ignoble arms that the enemy has employed; in the same manner, we will win a victory not less pronounced in the economic war for which our enemy has long since been prepared, and all her industrial preparations will be destroyed by our allied technic as surely as her military preparations were crushed by the heroism of our soldiers.

During the course of a talk by Sir William Pope, the following words were much applauded:

I would like to express to you the pleasure with which we have seen the return to France of the right bank of the Rhine which gives back to her the raw materials indispensable for her industrial rebirth.

At these declarations the authorized representatives of the United States, Italy, and Belgium were unanimous in their enthusiasm.

And Mr. Loucheur, having the final word, said with charming simplicity and good humor that after having held chemistry in abomination—it had hindered him in entering Polytechnique—he had recognized its power and had determined to learn it. He stated that with aviation and the tanks it had won the final victory for us and that it enjoys the preference for its effort at coöperation. The effort must be effective, for Germany has not diminished her chemical industry; on the contrary, she has developed it considerably. She is a very formidable adversary whom we are going to meet in the economic struggles of tomorrow. In order to conquer her on this ground we must treat chemists as they deserve, encourage them, and stimulate their willingness, for, as an English proverb says, "Where there's a will, there's a way."

Before separating, the members of the Interallied Conference visited the devastated region of Chauny on Wednesday, April 16.

They were received by Mr. Gerard, President du Conseil d'Administration de la Société de St. Gobain, and observed the methods adopted by the Germans in their efforts to completely crush this industrial city where no battle took place.

Very much impressed by the visit to this place of destruction, the members of the Conference separated at the end of the journey.

The next Conference will be held in London in July.

AMERICAN CHEMICAL SOCIETY DYE SECTION

The initial meeting of the newly organized Dye Section of the AMERICAN CHEMICAL SOCIETY will be held at Philadelphia, beginning Wednesday, September 3, 1919, under the chairmanship of Dr. C. L. Reese. Everyone interested in the chemistry of dyes is invited to be present.

The Secretary of the Section asks all workers in the field of dyes to present the results of their scientific work at this and following meetings of the Dye Section. To this end the Secretary of the Section requests any one who has ready for publication any work on the chemistry of dyes to communicate with him at once, giving subject and time necessary for presentation.

Any information on the chemistry or engineering of the manufacture of dyes would be particularly pertinent to the present conditions of the dye industry in the United States. It is to be hoped that all engaged in the dye industry will realize the mutual help that will result from a liberal presentation of their discoveries and experiences.

Full details as to exact place of meeting and list of papers will be in the final program of the September meeting of the AMERICAN CHEMICAL SOCIETY. This program will be mailed to those requesting it by either Dr. C. L. Parsons, Box 1505, Washington, D. C., or the undersigned.

R. NORRIS SHREVE, *Secretary*

43 FIFTH AVE., NEW YORK CITY
June 11, 1919

NATIONAL RESEARCH FELLOWSHIPS IN CHEMISTRY

The National Research Council has made the following appointments to National Research Fellowships in Chemistry:

F. R. BICHOWSKY, of Washington, D. C., A.B. (Pomona, '12), Ph.D. (California, '16), physical chemist at the Geophysical Laboratory of the Carnegie Institute of Washington since 1916, who plans to conduct researches at the University of California.

EMMETT K. CARVER, of New York City, A.B. (Harvard, '14), Ph.D. (Harvard, '17), formerly assistant to the director of the Wolkott Gibbs Memorial Laboratory at Harvard and recently Captain, Chemical Warfare Service, U. S. A.

W. H. RODEBUSH, Ph.D. (California, '17), research chemist for the United States Industrial Alcohol Company of Baltimore, who will conduct researches at the University of California on specific heats and other properties of substances at low temperatures.

WARREN C. VOSBURGH, of New York City, B.S. (Union College, '14), A.M. (Union College, '16), Ph.D. (Columbia University, '19), research assistant to the professor of chemistry at Columbia University for the past six months.

GEORGE SCATHARD, of New York City, A.B. (Amherst College, '13), Ph.D. (Columbia University, '17), formerly research assistant to the professor of chemistry at Columbia University and instructor in organic chemistry, and recently First Lieutenant, Sanitary Corps, U. S. A.

FIFTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES, CHICAGO, ILLINOIS, WEEK OF SEPTEMBER 22 TO 27, 1919

The week of September 22, 1919, when the greatest exposition of the chemical industries in the world holds forth in the Coliseum and First Regiment Armory, will be one of convocation of many societies in Chicago with the Exposition.

The American Institute of Mining Engineers will occupy the stage for the first part of the week, the American Ceramic Society meets on Wednesday, September 24, the American Electrochemical Society on Thursday, Friday, and Saturday, September 25, 26, and 27. The dates of the Technical Association of Pulp and Paper Industry were not announced at the time of going to press.

Among the interesting features of the Exposition program will be a symposium upon "Safety in the Plant and Mine" with speakers of authority in this work under the chairmanship of M. L. Leopold, safety engineer of the U. S. Bureau of Mines, and in the evening after this meeting—which will occupy an entire afternoon—there will be shown a series of motion pictures which are now being made in industrial plants all over the country under the supervision of government agents, of safety work in plant, field, and mine.

Even in motion pictures, as in all important improvements in plant machinery and products, the Exposition is outstanding as the place of introduction to the public of the newest and most recent developments. Each improvement of the projectoscope in motion picture projection has been reserved for first public demonstration at the Exposition which again this year will have the latest developments in this field of endeavor.

There have been many developments in the way of new exhibits that are engaged for the Exposition: of these, it is not circumspect to list them all, but mention may be made of the group of electric furnace exhibits which will be there, and in operation. These will give men of science, probably for the first time, an opportunity to see and compare the various designs and judge them for the different lines of work to which they are applicable.

A glance at the roster of exhibitors causes one to look forward with interest to the opening of the Exposition and its exhibits.

A BUILDING FOR THE AMERICAN CHEMICAL SOCIETY

Editor of the Journal of Industrial and Engineering Chemistry:

At the recent Council Meeting of the SOCIETY held in Buffalo, a brief reference was made to the growing need for a building to serve as the permanent administrative headquarters of the SOCIETY and to provide accommodations for the editing of *Chemical Abstracts*, the compilation of compendia of chemical literature, and possibly other activities of the SOCIETY.

There were far too many matters requiring the immediate attention of the Council to permit discussion of this proposal and it was simply mentioned in order that the officers of the SOCIETY might keep it in mind for future careful consideration. The purpose of the present note is to bring the matter to the attention of a larger number of our members in the hope that the advantages of a building for the SOCIETY may become more generally recognized.

The arguments in favor of a permanent home address of the AMERICAN CHEMICAL SOCIETY as compared with a post office box number for the Secretary's office need hardly be mentioned. The determining consideration, so far, has undoubtedly been the question of cost. While we were a struggling young SOCIETY, it certainly would have been unwise to divert funds so urgently needed for our publications to providing a home office for the SOCIETY. We have, undoubtedly, been exceptionally fortunate so far, in not having to pay rent for offices; and, although there appears to be no immediate apprehension that this subsidy to the SOCIETY will be terminated, nevertheless, it should not be counted on indefinitely. It is conceivable that even in spite of the great contributions American chemists have recently made to the Government's conduct of the war, a question may sooner or later be raised in regard to the propriety of the continued use of government offices for the business of our SOCIETY. Furthermore, in the case of *Chemical Abstracts* we cannot be sure that the present institution will continue to furnish free quarters and we may have difficulty in finding free accommodations elsewhere.

Even though the apprehensions expressed above may be ill founded, a very real argument in favor of having our own home lies in the possibility of a more economical and efficient organization of our activities. The advantages in this respect appear to have been realized by organization similar to ours both here and abroad. As examples, may be mentioned the engineering societies of the United States, the American Medical Association, and the English and German chemical societies. The building of the German Chemical Society in Berlin contains in addition to the administrative headquarters, the editorial office of *Chemische Zentralblatt, Berichte, Beilstein, and Landolt-Börnstein*, as well as a library and large lecture hall.

There is little doubt that the work involved in the compilation of physical-chemical constants and data of inorganic and organic chemistry can be most economically done in connection with the search of the literature required for our *Chemical Abstracts*. The intimate coordination of these projects, and provision for their permanent organization and continued expansion, is perhaps the strongest argument for a building for our SOCIETY.

The possibilities of utilizing such a building for many other purposes in connection with the advancement of chemistry in America are unlimited. A bureau of chemical intelligence, as recently suggested by Dr. A. M. Patterson,¹ would naturally find its logical place in such a building. Many other projects will quickly suggest themselves, such as: (1) The collection of very rare journals and other publications abstracted in *Chemical Abstracts*, but usually not available in libraries; (2) the collection of relics and data of historical interest to chemistry in America; (3) a repository for rarer compounds, dyes, and other chemical products; (4) a section devoted to patents; (5) possibly a bureau of employment.

If such a building, devoted to the needs of American chemists, were located in Washington, it would, in addition to eliciting the pride of our own members, be an object of interest to many of the visitors who annually come to the nation's capital. Can we overestimate the value of such a building to us when we consider what we might gain thereby in the way of publicity and the general public's knowledge of and interest in our activities?

There is hardly a doubt that if a suitable building were presented to the AMERICAN CHEMICAL SOCIETY, it would be accepted and used to great advantage by several branches of our organization. If this is granted, the question arises whether the matter is not of enough importance for us to exert ourselves actively to secure a building. The point then is, how great an effort would be required, that is, how costly a building is needed? On the basis of conditions as they exist in Washington it would appear that an initial outlay of about \$25,000 would secure a building which would serve our purpose for some years at least. This would mean the purchase of a centrally located building which could be remodeled for our use and enlarged from time to time as required, or eventually replaced by an entirely new and commodious structure. Taking this estimate as a minimum, the upper limits of the undertaking would be governed only by the amount of money which could be collected for the purpose.

The question of securing the relatively small sum suggested should certainly not be a serious matter. There is little doubt that many of our members would be willing to contribute to this object and funds from public-spirited individuals outside the SOCIETY might also be expected. Whatever amount is thus secured and invested in a building becomes a part of the permanent assets of the SOCIETY which constitute the surest possible provision for the future.

ATHERTON SEIDELL

President, Chemical Society of Washington

WASHINGTON, D. C.

May 15, 1919

THE CANADIAN INSTITUTE OF CHEMISTRY

The Chemists' Organization Committee, appointed at the convention of Canadian Chemists held in Ottawa, May 1918, submitted to the second convention held at Montreal, May 16 and 17, 1919, a report, the main recommendations of which were, briefly, as follows: The task of organizing chemists in Canada should be carried out by an entirely new and separate organization, to be known as the Canadian Institute of Chemistry, the membership to consist of Fellows and Associates. The qualifications for the Fellowship should be: (1) Graduation at a

¹ THIS JOURNAL, 11 (1919), 487.

university after a four-year course with chemistry as chief subject; or (2) graduation at a university after a three-year course with chemistry as main subject, followed either by a further year's university training in chemistry, or by two years' experience in an approved laboratory; or (3) five years' active experience—with a responsible position—in either pure or applied chemistry, and the passing of an examination before a board appointed by the Institute. This examination may be waived in the case of chemists already practicing at the date of incorporation of the Institute. The minimum age of Fellows is to be 25 years; below that age the same qualifications are to apply for the Associateship. An Associate is to become Fellow on reaching 25 years of age on the recommendation of five Fellows, provided he has practiced chemistry for at least two years. All candidates must satisfy the examiners that they have had a good general education.

The objects of the new organization are to raise the status of the profession and so attract the best intellects; to have available an organization that can be consulted by the government in times of crisis; to protect the public; and to assist chemists by establishing registration and employment bureaus, a library, and centers for social and scientific intercourse.

The results of elections at a meeting held on May 21 were:

President: Prof. J. Watson Bain, of the University of Toronto.

Vice Presidents: Dr. George Baril, Laval University, Montreal; Dr. A. McGill, Chief Analyst, Department of Trade and Commerce, Ottawa; Dr. R. D. MacLaurin, University of Saskatchewan, Saskatoon, Sask.

Secretary-Treasurer: Harold J. Roast, F. I. C., Montreal.

Executive Members: Prof. E. G. R. Ardagh, University of Toronto; Dr. J. S. Bates, Kenogami, P. Q.; Dr. T. E. Bigelow, Mount Allison University, Sackville, N. B.; S. J. Cook, Department of Trade and Commerce, Ottawa; J. A. Dawson, Department of Trade and Commerce, Vancouver; I. Grageroff, Montreal, Que.; Dr. L. F. Goodwin, Queen's University, Kingston; Prof. A. Lehman, University of Alberta, Edmonton; Prof. E. MacKay, Dalhousie University, Halifax, N. S.; Prof. M. A. Parker, University of Manitoba, Winnipeg.

It was decided that the fees for Fellows in the Institute should be an entrance fee of \$10.00 and an annual fee of \$5.00. For Associates, the entrance fee will be made \$5.00 and the annual fee \$2.50. The secretary announced the first subscription to the Foundation Fund of the Institute, namely, a check for five hundred (\$500) dollars from the James Robertson Co., Ltd., Montreal.

The office of The Canadian Institute of Chemistry is in the Kingdom Building, Beaver Hall Hill, Montreal, Quebec.

MEETINGS OF THE EXECUTIVE COMMITTEE OF THE DIVISION OF CHEMISTRY AND CHEMICAL TECHNOLOGY, NATIONAL RESEARCH COUNCIL

At the meeting held in Washington on April 21, 1919, there were present Messrs. Alsberg, Bancroft, Lamb and Washburn.

It was voted that a special committee on the chemistry of colloids be appointed to undertake the following specific projects:

(1) To arrange a series of lectures on different aspects of colloid chemistry by competent specialists and to make public the fact that such lectures have been arranged for and can be given at any institution or before a meeting of any interested body which will make the necessary financial arrangements with the committee.

(2) To secure the preparation and publication of a textbook and laboratory manual on colloid chemistry suitable for use in university courses in this field, both books to be prepared under the auspices of the committee and subject to the criticism of its full membership and any other experts whom the committee may desire to consult.

(3) To make a research census of investigations and investigators in the field of colloid chemistry.

The committee on colloid chemistry selected is made up as follows:

H. N. HOLMES, Oberlin College, Oberlin, Ohio, *Chairman*
JEROME ALEXANDER, 59th St. & 11th Ave., New York, N. Y.
W. D. BANCROFT, National Research Council, Washington, D. C.
G. H. A. CLOWES, Eli Lilly Co., Indianapolis, Ind.
W. A. PATRICK, Johns Hopkins University, Baltimore, Md.
J. A. WILSON, 203 Juneau Ave., Milwaukee, Wis.

The following questionnaire relating to the economic and educational conditions affecting opportunities for research in universities was approved:

ECONOMIC AND EDUCATIONAL CONDITIONS AFFECTING OPPORTUNITIES FOR RESEARCH IN UNIVERSITIES

The Division of Chemistry and Chemical Technology of the National Research Council is making a study of the research conditions in the departments of chemistry in the universities of the country in so far as these conditions are affected by the economic status of the members of the staff and the time available for carrying on research. Each member of the staff above the rank of assistant is requested to supply the Division with the information requested below. All such information will be treated as confidential and to this end it is requested that the name of the professor or instructor not appear upon this blank, but be placed upon the back of the inclosed return envelope in order that the completeness of the replies may be checked.

Age
Married
Number of dependents
University title
Degrees received, with dates
University salary
About how many hours per week (averaged throughout the school year) are you required to spend in
(a) The class room (lectures, quizzes, etc.)
(b) Laboratory teaching, exclusive of research courses
(c) Preparation for (a) and (b)
(d) Other university duties
(e) Outside work to supplement income
Do you find it difficult to conduct research because of lack of equipment?
Does your institution (a) encourage, (b) discourage, or (c) adopt an indifferent attitude toward the prosecution of research by its professors?
Name and address of institution

A letter from Edward F. Harrison, of Philadelphia, with reference to a proposed chemo-mechanical method for extracting organic matter from sewage was presented, and it was recommended that Mr. G. C. Whipple, sanitary engineer, be consulted with regard to what action, if any, the Council might take with reference thereto.

A letter from Mr. H. J. Wheeler, chairman of the former Committee on the Chemistry of Soils and Fertilizers, recommending the continuation of such a committee, was presented, but no action was taken.

A letter from Dr. Charles E. Munroe, chairman of the Committee on Explosives Investigations, relating to the appointment of a committee to arrange for a series of cooperative investigations dealing with the specific heats of explosive materials, was presented.

It was voted that a committee of three members, to consist of the chairman of the Division, the chairman of the Explosives Investigations Committee, and one additional member (to be selected by them) of recognized standing as an expert in calorimetry, be appointed.

It was voted, however, to suggest to that committee the advisability of arranging to have the desired investigations all done, if possible, by one person, for example, as a master's thesis, instead of distributing the work among a larger number of less qualified students.

A letter from Dr. Edwin A. Hill, of the United States Patent Office, dealing with the status of the card index of chemical literature and making certain recommendations concerning the desirability of expanding it into a Bureau of Chemical Intelligence, was presented, and it was voted to transmit this letter to the Research Information Service for consideration and report.

A revised statement of the recommendations of the Division with respect to the formation of an International Chemical Council was presented and approved. The recommendations in their final approved form are as follows:

1—That an International Chemical Council be constituted; and that, if possible, arrangements be made for transferring the funds originally given to the International Association of Chemical Societies to this International Chemical Council.

2—That the object of the International Chemical Council be to initiate and promote international cooperation in chemistry; for example, by arranging:

(a) For international cooperation in the preparation and publication of chemical literature.

(b) For the appointment of international commissions to deal with special chemical questions of standardization (such as atomic weights, nomenclature, etc.).

(c) For international cooperation in the prosecution of special research projects.

(d) For the calling of international chemical conferences for various purposes; and also for the organization of an International Chemical Congress with meetings at stated intervals, and including all of the scientific and technological branches of chemistry.

3—That the International Chemical Council be constituted of delegates representing the leading chemical societies and other chemical research organizations of the several allied and neutral countries, these delegates to be selected as described in Paragraph 5.

4—That the International Chemical Council be affiliated with the International Research Council; and that the National Research Council of each country or its National Academy when no Research Council has been created, act as the intermediary in communications between the International Chemical Council and the chemical organizations of that country, and arrange for the proper representation of those organizations in accordance with Paragraph 5.

5—That the delegates from each country shall in general be chosen by the major chemical societies in that country, but that the number and distribution of such delegates and their voting strength within the delegation be determined initially by the National Research Council of that country, with the understanding that in countries where a National Research Council shall not have been organized the National Academy itself shall fulfill this function until the National Research Council is organized.

6—That upon all questions voted upon by the International Chemical Council the number of votes cast by the various countries be determined by their population as follows:

- Countries of less than 5 million inhabitants have 1 vote
- Countries between 5 and 10 million inhabitants have 2 votes
- Countries between 10 and 15 million inhabitants have 3 votes
- Countries between 15 and 20 million inhabitants have 4 votes
- Countries over 20 million inhabitants have 5 votes

The inhabitants of colonies and possessions are included in the population of the country to which they belong, according to the indications of its government. Each self-governing dominion has the same number of votes as an independent country according to the above scale.

7—That the International Chemical Council, as soon as it shall be organized, shall elect an executive committee of seven members, which shall exercise such functions as may be assigned to it by the Council. The executive committee shall appoint an executive secretary, who shall have charge of correspondence and of the central office of the Council.

8—That until the International Chemical Council shall be organized and its executive committee appointed, the Committee on International Cooperation in Chemistry appointed by the Paris Conference shall act as a provisional executive committee for purposes of organization. Its membership shall, however, be increased by the addition of four members representing industrial chemistry, to be appointed, respectively, by the Royal Society of London, the Académie des Sciences de France, the Accademia dei Lincei, and the National Research Council of the United States. This committee shall elect a chairman and a secretary, but the latter need not be a member of the committee.

A detailed statement of the resolutions adopted by the Council of the AMERICAN CHEMICAL SOCIETY at the Buffalo meeting, with reference to the publication of chemical compendia and critical tables of physical and chemical constants [THIS JOURNAL, 11 (1919), 415] was presented.

It was voted that in the opinion of the Division the plan proposed in those resolutions should be amended so as to strike out

the one-year limitation on the terms of office of the trustees and committees provided for therein, it being the opinion of the Division that all such appointments should be made for an indefinite period, the understanding being that the appointees would in so far as possible continue until the completion of the work undertaken. (See minutes of meeting of April 29, 1919.)

Messrs. Bancroft and Washburn were appointed a committee to act for the Division on all questions relating to the organization of the machinery for inaugurating the proposed compilation and publication of critical tables of physical and chemical constants.

A verbal suggestion from Dr. Munroe, concerning the advisability of creating a committee to look into the question of the use of explosives as fertilizing materials, was presented, and Dr. Alsberg was appointed a special committee to look into the matter and make recommendations at the next meeting of the Executive Committee.

At the meeting on April 29, 1919, there were present Messrs. Alsberg, Bancroft, Lamb, Stieglitz and Washburn, and by invitation, Messrs. Hillebrand, Parsons, and Moore, members of the Division, and Livingston, liaison member from the Division of Biology and Agriculture.

The appointment of Dr. W. P. White as a member of the Committee on Specific Heats of Explosive Materials was approved.

It was voted that the action taken at the previous meeting regarding the term of appointment of trustees and committees in connection with the preparation of chemical compendia and critical tables be amended to read as follows:

That in the opinion of the Division the committee of seven charged with the scientific control of the undertaking should be appointed for such terms as the appointing powers shall decide.

It was voted that the Committee on Scientific Control of the Tables on Physical and Chemical Constants be requested to take up at an early date the question of what particular physical properties of organic compounds are of most importance to the organic chemists, with the idea that standard methods for determining such properties might be worked out with the cooperation of the Bureau of Standards and such methods published and be made generally available for the use of organic chemists.

A letter from Dr. Marie, editor of the Annual Tables of Physical and Chemical Constants, addressed to Dr. Stieglitz and recommending that the International Commission in charge of those tables should take up at once the matter of preparing a set of critically digested tables, was presented, together with Dr. Stieglitz' reply thereto. Dr. Stieglitz' reply was to the effect that in his opinion the International Commission in charge of the Annual Tables was not in a position to handle such an undertaking under present conditions for a variety of reasons which he mentioned, and that such tables could better be prepared by this country in accordance with the program adopted by the AMERICAN CHEMICAL SOCIETY.

The Division voted concurrence in the views expressed by Dr. Stieglitz in his reply to Dr. Marie.

The Division approved the addition of the American Society of Biological Chemists to the list of societies which elect delegates to the International Chemical Council, this Society to elect one such delegate.

Dr. Parsons requested that members of the Division send to him suggestions regarding the personnel of the two control committees to be charged with the preparation of the series of technological and scientific monographs, to be published by the AMERICAN CHEMICAL SOCIETY, and also suggestions as to subjects for such monographs and suitable persons to undertake their preparation. He also informed the Division that the AMERICAN CHEMICAL SOCIETY had named E. G. Love and C. L. Parsons as trustees in charge of the monograph series, and Julius Stieglitz as trustee for the "Table."

A letter from Dr. C. E. Munroe, chairman of the Explosives Investigations Committee, concerning the investigation of explosives as fertilizer materials, was presented, and after extended discussion it was voted that Dr. B. E. Livingston be requested to present the matter to the Division of Biology and Agriculture for consideration and report, with the understanding that if that Division should decide that a committee to deal with the matter ought to be appointed, the Division of Chemistry and Chemical Technology would concur therein and would act with the Division of Biology and Agriculture in the formation of a joint committee.

Dr. Alsberg was appointed by the Division as its liaison member with the Division of Biology and Agriculture.

The proposed questionnaire with regard to economic and educational conditions affecting opportunities for research in universities was amended to include a question to the following effect:

Do you desire to have brought to your attention, from time to time, research problems which need investigating and which would make suitable thesis subjects for advanced students? If so, state field of chemistry preferred.

.....

At the meeting on May 15, 1919, those present were Messrs. Alsberg, Bancroft, Lamb, Washburn and Leuschner, liaison member from the Division of Physical Sciences.

It was voted, first, that the Division recommend the appointment of Lt. Col. A. B. Lamb, C. W. S., Dr. F. G. Cottrell, Chief Metallurgist, Bureau of Mines, and Lt. Col. J. E. Zanetti, C. W. S. as three of the American delegates to the meeting of the International Chemical Council to be held in London next July; second, that the chairman of the Division be named as alternate for Mr. Lamb in case he should be unable to go; third, that the chairman of the Division be instructed to ascertain the names of prominent American chemists who may possibly plan to be in Europe at the time of the July meeting of the International Chemical Council and to arrange, if possible, to secure the attendance of such men at the meeting of the Council as additional American delegates.

It was voted that the name of Professor Gellert Alleman, Swarthmore College, Swarthmore, Pa., be placed before the chairman of the National Research Council as nominee of this Division for appointment by the Council as one of the three trustees in charge of the series of monographs to be published by the AMERICAN CHEMICAL SOCIETY.

It was voted that the names of Dr. Arthur L. Day, Geophysical Laboratory, Washington, D. C., and Mr. Elihu Thomson, Lynn, Mass., be transmitted to the Division of Physical Sciences with the recommendation that it concur in the nomination of one of these gentlemen as chairman of the Board of Trustees in charge of the business control of the critical volumes on physical and chemical constants, the appointment of this position to be made by the chairman of the National Research Council.

It was voted that a Committee on Sewage Disposal be formed to undertake the following projects:

1—To prepare a research survey of the field with special reference to possible methods of sewage disposal which will recover the valuable oils, fats, and fertilizer constituents of the sewage; this survey to include statistical data and a discussion of the economic aspects of the subject as well as the scientific ones.

2—To outline a series of basic research problems necessary to the further extension of our knowledge of the possibilities of recovering and utilizing the valuable constituents of sewage.

3—To ascertain what researches are already in progress in the country in connection with this problem and, if it seems desirable, to prepare a list of sewage experiment stations or similar organizations whose equipment and staffs may possibly be utilized in connection with any project of cooperative research which it seems wise to undertake.

4—To prepare general plans and estimates of cost of establishing a sewage experiment station to study new methods of treating sewage for the recovery of its valuable constituents and to

work in close cooperation with investigators now engaged or who in the future may be interested in undertaking physical, chemical, or biochemical investigations on various aspects of the problems which present themselves.

5—To investigate particularly the Rice process and the Miles process of sewage treatment and to make recommendations to the Division as to what action, if any, the Council might take with reference to research or development in connection with one or both of these processes.

It was voted that the Committee on Sewage Disposal be constituted with the following personnel:

PROF. G. C. WHIPPLE, Professor of sanitary engineering, Harvard University, *Chairman*

MAJ. C. G. HYDE, Surgeon General's Office, War Department, Washington, D. C. (professor of sanitary engineering, University of California)

LT. COL. EDWARD BARTOW, Sanitary Corps, U. S. A., A. E. F., Water Analysis Laboratory, U. S. A. P. O. No. 702(?) (Chief of the Illinois State Water Survey and professor of sanitary chemistry, University of Illinois)

LT. COL. W. D. BANCROFT, C. W. S., American University Experiment Station, Washington, D. C. (Chairman, Division of Chemistry and Chemical Technology, National Research Council, representing colloid chemistry)

PROF. E. B. PHELPS, Cr. Dr. Charles North, 30 Church St., New York City

MR. MARTIN H. ITTNER, 105 Hudson St., Jersey City, N. J., an organic chemist, who is a specialist in the chemistry of oils and fats

DR. W. W. GARNER, Physiologist, Bureau of Plant Industry, United States Department of Agriculture, Washington, D. C., expert on the chemistry and use of organic fertilizer materials

The Committee on the Chemistry of Colloids was authorized to proceed with the preparation and publication of a suggestive bibliography of literature on colloids of a brief and elementary nature to serve as a guide to chemists wishing to take up the study of this subject.

The title of the Committee on Specific Heats of Explosive Materials, authorized at the meeting of April 21, was changed to the Committee on the Thermal Properties of Explosive Materials.

The following personnel was approved for the Committee on Synthetic Drugs:

JULIUS STROGLITZ, University of Chicago, Chicago, Ill., *Chairman*

MOSES GOMBBERG, University of Michigan, Ann Arbor, Mich.

G. W. MCCOY, Director of Hygienic Lab., United States Public Health Service, Washington, D. C.

FRANCIS M. PHELPS, Pacific Building, Washington, D. C.

W. A. PUCKNER, Chief, American Medical Association Chemical Laboratory, Chicago, Ill.

EDWARD S. ROGERS, People's Gas Building, Chicago, Ill.

The following extracts from the minutes of the meeting of the Division of Physical Sciences on May 1 were brought to the attention of the Committee:

Moved: That the Division of Physical Sciences approve in principle the plan for the publication of critical tables of physical and chemical constants, as outlined in the "Report by the Committee on Publication of Compendia of Chemical Literature, etc.," and that the acting chairman be authorized to appoint two members to represent the Division of Physical Sciences on the Committee to be formed in accordance with the following motion passed at the meeting of the Executive Board of the Council, April 15:

Moved: That a copy of the Report on Publication of Compendia of Chemical Literature, etc., be sent to the members of the Executive Board prior to the next meeting, and that a committee consisting of two members of the Division of Chemistry and Chemical Technology, two members of the Division of Physical Sciences, one member from the Bureau of Standards, and one member from the Smithsonian Institution, be appointed to report on the proposed project at the next meeting of the Executive Board. Adopted.

In response to a request of the Chemical Division for the appointment of a liaison officer to act with them, the following motion was made:

Moved: That the appointment of a liaison officer from this Division to act with the Chemical Division be referred to the Executive Committee with power. *Adopted.*

Moved: That the Division does not concur in the method proposed by the Division of Chemistry for making a research survey. *Adopted.*

Moved: That the Division on Educational Relations be requested to cooperate with the Executive Committee of this Division and that of Chemistry and Chemical Technology in formulating proper plans whereby a research survey might be made and report back to the Division. *Adopted.*

SCIENTIFIC SECTION AMERICAN PHARMACEUTICAL ASSOCIATION

During the annual convention of the A. Ph. A. to be held in New York the week beginning August 25, 1919, the Scientific Section will hold meetings on Thursday and Friday, August 28 and 29. Those desiring to read papers before this section

should submit them to the Secretary, Dr. A. G. Du Mez, Hygienic Laboratory, U. S. P. H. S., Washington, D. C., not later than August 10, 1919.

CALENDAR OF MEETINGS

Society of Chemical Industry—Annual Meeting, London, July 15 to 18, 1919.

American Chemical Society—Fifty-eighth (Annual) Meeting, Philadelphia, Pa., September 2 to 6, 1919.

American Institute of Mining and Metallurgical Engineers—Chicago, Ill., September 22 to 26, 1919.

National Exposition of Chemical Industries (Fifth)—Coliseum, Chicago, Ill., September 22 to 27, 1919.

American Electrochemical Society—Fall Meeting, Chicago, Ill., September 23 to 25, 1919.

NOTES AND CORRESPONDENCE

SHALL WE HAVE ANNUAL PATENT RENEWAL FEES?

Editor of the Journal of Industrial and Engineering Chemistry:

Our patent system is founded on the constitutional provision that "The Congress shall have power * * * to promote the progress of science and useful arts, by securing for limited times to authors and inventors, the exclusive right to their respective writings and discoveries. * * *." Note the "promote the progress." It seems to me only fair to assume, therefore, that Congress is *not* to grant these exclusive rights if by so doing "progress of science and useful arts" is avoidably or needlessly obstructed or impeded.

In the following a partial remedy is suggested for the cure of such cases where there is avoidable obstruction or impediment to such progress through the grant of such exclusive rights.

Fundamentally, our patent system is the most generous and liberal patent system in the world and more patents have been taken out in this country than anywhere else. Nevertheless, I think this very generosity and liberality has in some substantial respects seriously disadvantaged us. I believe that can be cured without diminishing the generosity and liberality of the system as a whole.

Because I was then personally satisfactorily convinced that many of our patents avoidably and needlessly obstructed progress, I stated in a paper read before the New York Section of the AMERICAN CHEMICAL SOCIETY, ten years ago, on January 8, 1909 (see *Electrochemical and Metallurgical Industry*, Feb. 1909, p. 78), "that an inventor who allows his patent to lie idle transgresses the spirit underlying the patent system. He is reserving to himself a field of endeavor which he has agreed to exploit and is not exploiting and by his reservation he prevents its exploitation by others and thus retards progress.

"A partial remedy for this might be a low annual tax, say \$15 or \$25 or some other sum, not high enough to stand in the way of any inventions giving any reasonable promise of remuneration, yet high enough to make it appear unprofitable to retain reservation in fields which they are either unwilling, unable, or incompetent to develop."

Revenue was and is only an incidental result of that suggestion; its sole purpose is to correct that abuse and the income is wholly secondary and for my purposes entirely beside the point.

The discussion that followed will long be a most vivid recollection for me. Everybody (so it seemed) jumped on me and so hard that I thought I hadn't a friend in the room.

Among the things that convinced me then that I was right in the above suggestion was the large number of forfeitures for

non-payment of renewal fees or taxes regularly published in England and in Germany and also that about three-fourths of a long string of British patents cited as anticipatory references in the recent patent litigation had turned out to be so "valuable" that their owners (and among them Henry Deacon) had forfeited them rather than pay \$25 for the fifth year of the monopoly grant.

The reasons advanced by those who ten years ago opposed this suggestion were, on the one hand, that the poor inventor would be discriminated against and invention by him discouraged, and on the other hand, rich corporations would not be deterred by any such fees.

It must be remembered that the United States is the only major country that does *not* have an annual fee system; that in and of itself does not by any means make the tax system right. But there is an obvious discrimination against United States inventors through the absence of such a fee system in this country because, when a German inventor forfeits his German patent, he thereby throws that field open to development and exploitation by Germans in Germany but because he does not also and at the same time relinquish his corresponding rights in the United States we are barred by our own laws and by our own acts from enjoying a liberty of action and a freedom of motion that the Germans enjoy. A dead German patent, therefore, still lives and rules in the United States.

Supposing we had had in force the following fee system modeled after that of England, Germany, and other European countries:

First year, to and including the seventh year, no fee			
8th year.....	\$10	13th year.....	\$60
9th year.....	\$20	14th year.....	\$70
10th year.....	\$30	15th year.....	\$80
11th year.....	\$40	16th year.....	\$90
12th year.....	\$50	17th year.....	\$100
TOTAL, \$550			

How many of the 1200 Bayer patents recently sold by our Alien Property Custodian would have been in force at the time of sale? To keep them alive for their full statutory term would have cost \$660,000, or an average of \$66,000 per year. It is unreasonable to assume that there are no "dead horses" among 1200 patents and no one wants to pay for a "dead horse" although no one, in such a case, would mind having him so long as he costs nothing.

In order to present an idea of how the German tax system operates in Germany on German patents in Class 12: chemical processes and apparatus; Class 22: dyes, varnishes, lacquers, paints and adhesives; and Class 23: oils and fats collectively, consider the following table constructed for me from official German documents:

	Total No. of Patents Granted during Each Year from 1900 to 1914 in These Classes	Total No. of Patents Still in Force on March 1, 1915 in These Classes	Percentage of Patents Still in Force on March 1, 1915
1914.....	852	852	100% (1st yr.)
1913.....	870	811	93% (2nd yr.)
1912.....	863	684	79% (3rd yr.)
1911.....	656	504	77% (4th yr.)
1910.....	702	351	50% (5th yr.)
1909.....	567	286	50% (6th yr.)
1908.....	620	253	41% (7th yr.)
1907.....	621	237	38% (8th yr.)
1906.....	542	233	43% (9th yr.)
1905.....	545	124	23% (10th yr.)
1904.....	420	80	19% (11th yr.)
1903.....	618	85	16% (12th yr.)
1902.....	685	80	12% (13th yr.)
1901.....	627	37	6% (14th yr.)
1900.....	417	1	0.5% (15th yr.)
TOTAL.....	9505	4619	49%

Life of grant of German patent, 14 years.

Average effective life of German patent less than 7 years.

Invention and "the progress of science and useful arts" may very well have been impeded rather than promoted thereby in Germany; and that, even though the exact contrary has been very strenuously maintained in this country and in the very recent past for the German patent system by some who, by no stretch of imagination, could be termed, that present-day *rara avis*, "Germany's friend."

To get at material capable of answering that question would call for determination of ownership of each of the 9505 German patents in the preceding table and that would be a long, tedious, and expensive job. In order to get a complete picture the same operations should be gone through for Austria, England, France, Italy, Japan, Switzerland, and any other relevant countries. Then we might have material for an answer to the question so far as the chemical and allied industries are concerned. Then the whole job would have to be gone over again for the other industries. Rather a tall order!

For seven of the leading chemical countries the following table of renewal fees has been compiled from Fairweather's "Foreign and Colonial Patents" published in 1910. In this the Austrian crown, the French and Swiss francs, and the Italian lire have been taken at 20 cents each, the German mark at 25 cents, the English pound at \$5, and the Japanese yen at 50 cents.

	Austria	England	France	Germany	Italy	Japan	Switzerland
1	..	..	..	..	\$ 8	....	..
2	\$ 10	..	\$ 20	\$ 12.50	8	....	\$ 6
3	12	..	20	25.00	8	....	8
4	16	..	20	37.50	13	\$ 5.00	10
5	20	\$ 25	20	50.00	13	5.00	12
6	24	30	20	62.50	13	5.00	14
7	32	35	20	75.00	18	7.50	16
8	40	40	20	87.50	18	7.50	18
9	48	45	20	100.00	18	7.50	20
10	56	50	20	112.50	23	10.00	22
11	72	55	20	125.00	23	10.00	24
12	88	60	20	137.50	23	10.00	26
13	104	65	20	150.00	28	12.50	28
14	120	70	20	162.50	28	12.50	30
15	136	..	20	175.00	28	12.50	32
	\$778	\$475	\$280	\$1312.50	\$270	\$105.00	\$266

The above suggestion of a total fee of \$550 may appear high and reduction to one-half or to \$275 by starting from a \$5 fee and an increase of \$5 may seem desirable.

Men for whose sound judgment I have very willingly great respect tell me that for the United States to adopt a fee system like the one above outlined would stifle invention and impede progress. Men for whose sound judgment I am bound to have equal respect tell me the exact opposite! Which group is right? I am free to confess I am more than ever convinced that the second group is.

To be sure, the Committee on Patent and Related Legislation of the AMERICAN CHEMICAL SOCIETY, of which I happen to be a member, might go ahead and examine the question thoroughly. But, as above shown, that is a colossal job if it is to be well done and will run into money quite handsomely. This is, therefore, a question on which the membership should express itself because there are so many angles to it that no one man

or any small group of men can reasonably hope to tackle them conclusively.

I am of the opinion that such a tax system would effectively remove much of the grip which foreign—and especially German—inventors have on our domestic industry and would also relieve use of the congestion due to patents to our own citizens which are not exploited, or serve no useful purpose, and to some extent, at any rate, of that class of domestic patentees designated, more or less unjustly perhaps, as patent sharks, trailers, or pirates. In other words, the dead wood would be cleared out. Therefore, I express the hope that our members will seriously look into this matter from all angles and particularly those that affect themselves, by conference with counsel, executive, operating, financial and sales officers, if need be, in order that this may grow into a tangible result I suggest that at the Philadelphia meeting next September our Industrial Division devote a part of its program to a constructive, systematic discussion and exploration of this subject to the end that our Committee on Patents may be in a position intelligently to deal with the question and for the greatest benefit to the greatest number. Here is surely a case where in a multitude of counsel lies wisdom.

There is little likelihood that any legislation creating such a tax system (if that is to be done) could be of much effect until after the eighth year of its existence because it would not apply to issued patents or to the pending patent applications; such legislation could only affect applications filed when and after it became effective.

25 BROAD STREET
NEW YORK CITY, N. Y.
June 4, 1919

BERNHARD C. HESSE

Editor of the Journal of Industrial and Engineering Chemistry:

Upon reading Dr. Hesse's communication, I am convinced that a discussion on the patent question at the September meeting of the SOCIETY would be both profitable and timely. A symposium is therefore being arranged for that meeting when the Pharmaceutical Division and the newly formed Dye Division will unite with the Division of Industrial Chemists and Chemical Engineers, it being thought that the members of these three divisions will be particularly interested in this matter. This symposium will be under the direction of the Patent and Related Legislation Committee with Mr. Edwin J. Prindle as presiding officer.

Having the active coöperation of these three Divisions, every phase of the subject should be considered and some definite conclusions reached. It is hoped, therefore, that papers may be prepared covering the various points of view, and that the members of the SOCIETY will come with the anticipation of actively participating in the discussion.

HARLAN S. MINER
Chairman, Division of Industrial
Chemists and Chemical Engineers

GLOUCESTER CITY, N. J.
June 13, 1919

SCIENTIFIC AND TECHNICAL EMPLOYEES OF THE GOVERNMENT ORGANIZE

On Thursday, May 8, 1919, the scientific and technical employees of the Government met in a mass meeting at the New National Museum, pursuant to a call sent out by a committee representative of governmental activities. The question of an organization of scientific and technical workers which has been widely discussed during the last year was brought acutely to the fore by the work of the Joint Congressional Reclassification Commission, as the Commission wishes to deal with the employees only through an organization and not as individuals. The

purpose of this meeting was to determine whether the scientific and technical workers in the federal employ wish to organize, and if so, what sort of organization they desire. Three plans were submitted which were as follows: Plan No. 1, To work through existing scientific organizations; Plan No. 2, To form an independent organization of employees doing scientific or technical work; Plan No. 3, To form a scientific or technical branch of the Federal Employees' Union. The auditorium of the Museum was well filled. Dr. Rodney H. True, of the Bureau of Plant Industry, presided. After a rather full discussion of the merits of the several plans submitted, it was finally decided by a vote of 185 to 132 to adopt Plan No. 3. The determining factor in this action seemed to be the practical one of adopting the plan most likely to yield the results desired. The temporary committee appointed at the meeting of May 8, with Dr. True as chairman, has been actively at work on drawing up plans for the permanent organization.

The point of view of the organizers is as broad as can be desired by those most independently inclined. Their purpose is purely a constructive one, being directed by the facts that properly conducted scientific research has to have sufficient appropriations to insure satisfactory progress, and that affiliating with numerous and well-organized bodies which are in close touch with voters enables scientific workers to approach the appropriating powers (congressmen) through their most powerful argument, namely, their constituency. Activities will also be directed to securing for us greater freedom and improved status, reasonable salaries, effective coöperation, and better public recognition of the aims and purposes of research. Aside from these matters of direct and vital necessity are those broader questions of presenting scientific and technological ideals before the public by other means than through the exigencies of warfare.

THE BLOEDE AND THE HOFFMANN SCHOLARSHIPS OF THE CHEMISTS' CLUB

The announcement is made by the Scholarships Committee of the Chemists' Club of New York, that the Bloede and the Hoffmann Scholarships will be awarded for the academic year 1919-1920. These scholarships were founded by Dr. Victor G. Bloede, of Baltimore, and Mr. Wm. F. Hoffmann, of Newark, with the object of giving financial assistance to deserving young men, to obtain an education in the field of industrial or chemical engineering.

These scholarships will be open to properly qualified applicants without restriction as to residence, and may be effective at any institution in the United States, which may be designated or approved by the Scholarships Committee.

Applicants must, as a minimum qualification, have completed a satisfactory high school training involving substantial work in elementary chemistry, physics, and mathematics, and present a certificate showing that they have passed the entrance examination requirements of the College Entrance Examination Board or its equivalent. Preference will be given to young men who have supplemented these minimum qualifications with additional academic work, especially in subjects which will form a suitable groundwork for the more advanced study of applied chemistry and chemical engineering.

All applications should be in the hands of the Scholarships Committee of the Chemists' Club, 52 East 41st Street, New York City, on or before July 15, 1919.

TECHNOLOGICAL FELLOWSHIPS IN SWEDEN

The American-Scandinavian Foundation announces that ten fellowships have been established, of the value of \$1,000 per year each, to be awarded technically trained young men, between twenty and thirty years of age, who will study in technical

institutions in Sweden. The subjects are those in which Sweden offers unusual advantages: four fellowships in physics and chemistry, two in hydroelectric engineering, two in metallurgy, and two in forestry and lumbering. Further information and application forms may be obtained from the Secretary of the Foundation, Henry Goddard Leach, 25 West 45th Street, New York City.

A GRANT FOR RESEARCH

The American Pharmaceutical Association has available a sum amounting to about \$240 which will be expended during 1919-1920 for encouragement of research. This amount, either in full or in fractions, will be awarded in such manner as will, in the judgment of the A. Ph. A. Research Committee, produce the greatest good to American pharmaceutical research.

Investigators desiring financial aid in their work will communicate, before August 1, 1919, with H. V. Arny, chairman A. Ph. A. Research Committee, 155 West 68th Street, New York City, giving their past record and outlining the particular line of work for which the grant is desired.

The committee will give each application its careful attention and will make recommendations to the American Pharmaceutical Association at its meeting in New York, August 25 to 29, 1919, when the award or awards will be made.

MOTION PICTURES IN THE TRAINING OF THE CHEMIST

Editor of the Journal of Industrial and Engineering Chemistry:

The results of the correspondence of the chairman of the committee of the Society on the Relation of Industries and Universities with the chief chemists of the leading commercial organizations of the United States¹ show such a startling unanimity of opinion regarding the inability of the student to apply his knowledge to the commercial phases of chemistry, that a statement of a method by which it is believed this deficiency in the training of the chemist will be overcome seems opportune at this time.

To quote Dr. Ellery, "Every practical working chemist knows that educational institutions can give only to a very limited extent practice in actual chemical processes that are commercial. Most laboratories in our educational institutions cannot equip themselves with what might be called industrial chemical apparatus, and even if they could, it is to be questioned whether the result of the use of such apparatus in a school laboratory would give the practical ideas which employers want * * * every teacher realizes the deficiency and deplores it all the more because he knows that he is quite unable to correct it."

But is he unable to correct it? Has he forgotten the educational value of motion pictures? Can it not be seen that the adequate and logical presentation of our chemical industries through the medium of the motion picture would be of inestimable value to the educator as well as the manufacturer. This is not a new idea. It is not an experiment, for many of our leading manufacturers have already taken films for the education of their own employees. Can they not go a step further and educate their future employees by the same method?

It is proposed by the committee that an effort be made to consult with the industries that may be located within convenient reach of the educational institutions, in order to persuade the managers of the industries and the authorities of the schools to enter into an arrangement by which chemistry students may get actual industrial experience during their years of training. But what of our institutions which are not so conveniently located? Are they to be entirely neglected? Our schools are not and cannot be situated near industrial centers and even

¹ THIS JOURNAL, 11 (1919), 375.

in the case of those so fortunately situated it is not always the wish of the student to specialize in any particular industry during his period of training, and it is admittedly poor educational practice to have him do so.

Factory inspection trips form a part of the curriculum of some of our larger institutions. These are helpful as far as they go, but it is evident that they must be hurried and superficial at best. Very often the student is led through in a desultory manner and the entire continuity of the particular process viewed is lost, with the inevitable result—confusion. He gets a somewhat hazy idea of the magnitude of the process but the details are lost and he has no means of retracing his steps to view them again, so that even this method is open to considerable criticism and also it is adaptable only to the privileged few, those who are conveniently situated. Many manufacturers are unwilling to grant this privilege, for the reasons that the running of their plants is disorganized on the days these visits take place and they do not want the responsibility for any accident that may happen to a careless visitor. In a large number of cases these privileges have actually been withdrawn.

It seems, then, that the logical solution of this problem lies in the motion picture. If the student cannot go to the plant, bring the plant to the student. It is within the reach of all and for the use of all. The smaller school will be benefited as well as the larger one. There will be no privileged few. The industries of California will be shown to Maine and those of Maine to California. The entire scope of the chemical industry will then be shown. There need be no specialization on the part of the student during his course of training. There will be no lost motion, no hurried steps, or superficial observation. The student can study the processes at his leisure and in direct conjunction with his theoretical work. The manufacturer need be troubled only once and then by one person only instead of a group, and in place of advertising his wares to a limited few he has his products shown throughout the country to those who are most vitally interested in seeing and using them. At the same time he is educating his future employees and is directly serving and helping to build up the entire chemical industry, which we know has now become a permanent institution in this country, unfettered by any German myth.

Now what essentials must the film possess in order to be of value in a technical institution?

The films must be specially prepared for the purpose, and with a full recognition of educational requirements. They must comply with the fundamental requirements that, where industrial operations are shown, the whole of the process shall be displayed in a manner that will make clear to the student the exact nature of the technical operation.

The pictures must be supplemented by a technical description given by a person expert in the subject that is being illustrated. They must be shown under conditions that will allow of the film being stopped when required, so that where the subject calls for a fuller explanation this can be given.

The view must have a serious scientific or technical interest. A film which has been prepared solely to entertain or amuse would be quite unsuitable for use in a technical institution.

How may these requirements be met? How may these essentials be fulfilled in every detail?

Realizing the importance of the situation and sensing the profound duty which lies before it, the Community Motion Picture Bureau, the largest company in America dealing exclusively with educational motion pictures, is now proceeding to fulfil the necessary requirements. It has on its staff men who are particularly expert in each field of endeavor, educational and industrial. This makes the proper planning, producing, and presentation of each picture an assured fact. No picture will be considered complete until it has received the unqualified

approval of the representative of each industry shown, thereby guaranteeing an accurate, logical, and truthful portrayal of that industry in every respect. In addition to the regular titles each picture will be accompanied by a booklet containing a short description or scenario explaining the processes chemically and mechanically, so that the educator may thoroughly familiarize himself with the subject that is to be viewed.

That the exact nature of the technical operations may be adequately shown, all important features of the process and such views as do not permit of direct photography will be presented diagrammatically, that is, by means of animated drawings. It can readily be seen how important this feature is to the student. He will be able to see what transpires inside of the vessel as well as outside, and the exact operation of any particular apparatus or mechanism can be shown in principle as well as in detail. There can be no doubt regarding the immense advantage of this method of presentation over factory inspection trips or the casual perusal of trade catalogues and blueprints. The machine works before one's eyes and one sees why and how it works.

There are projection machines now available which meet all the necessary requirements for the schools and lecture tables. The film can be stopped, making each individual picture a lantern slide, while the instructor explains any point that may appear to be hazy to the student, and if for any reason a point has been missed by the student, the machine can be automatically reversed and any part of the film run over again. The cost of these machines is easily within reach of even the smallest of schools.

Thus all the conditions have been met and it only remains for the manufacturer to do his part. What greater service can he perform for the advancement of the chemical industry in America than this one, and at the same time derive that type of advertising which is of greatest advantage to himself? But, it has been asked, "What of the manufacturer with the secret process? Will he permit that to be shown?" Many of the so-called "secrets" are not secrets at all. They are secrets merely in the imagination. And those that are truly considered secrets or "stocks in trade" usually consist of minor operating details, the showing of which could very easily be omitted without destroying the fundamental ideas or the continuity of the process. There can be no disclosures of plant secrets for, as stated before, each picture and also the scenario is to be approved by the manufacturer himself before it is released to the outside world.

The Bureau is establishing a complete library of motion pictures embodying all of the fundamental chemical industries of America and will distribute them in such a way that they may be available to every school in the country according to its individual requirements. With the aid of the industries a comprehensive library will be completed by next fall for the opening session of the schools.

That this project is a sound one, and one that will supply a crying need, was manifested by the universal acclaim with which it was received by both educators and industrial managers at the recent Victory Meeting of the AMERICAN CHEMICAL SOCIETY at Buffalo. The chemical industry of America must remain a permanent institution, but its permanence is entirely dependent upon the proper education of its chemists. The success of American enterprise is due to its superior educational methods. Shall we not be superior in motion picture education also?

ARTHUR C. NEISH

Associate Professor of Chemistry, Columbia University

OSCAR BYRON

Chemical Engineer, Columbia '14

46 WEST 24TH STREET
NEW YORK CITY
May 2, 1919

LIBRARIANS FOR SPECIAL LIBRARIES

Editor of the Journal of Industrial and Engineering Chemistry:

In reply to Mr. Smith's letter published in your June issue, I might suggest that the extent to which women have been employed as librarians of industrial and business libraries is a direct result of a special need for persons trained and experienced in library science, indexing, cataloging, and filing. Whether or not it is more important for the librarian of an industrial library to be trained in the science of his own library or in library science is still a much-disputed question, but since so large a part of the work of any industrial library has to do with library methods, there can be no doubt but that library training is essential for an efficiently organized library of any kind.

The ideal condition, of course, would be a training and experience both in library methods, and in the special science with which the library deals. It is usually impossible, however, to persuade a chemist, mechanical engineer, or accountant to enter library work, where the range of salaries is lower, and the possibilities much less than in his own special line of work, and yet where he is expected to be experienced both in library work and in some other science.

Whenever an industrial company desires a chemist, mechanical engineer, or accountant, they quite logically secure a person educated or trained in chemistry, engineering, or accountancy. Why, therefore, should there not be in charge of the library a person who is primarily library trained? Most trained librarians are now college graduates, who either have specialized in library economy or have supplemented their college degree by two years' graduate work in a library school.

ARTHUR D. LITTLE, INC.,
CAMBRIDGE, MASS., June 6, 1919

E. D. GREENMAN

CHEMICAL WARFARE SERVICE EMPLOYMENT SECTION

The Employment Section of the Chemical Warfare Service, Seventh and B Streets, N. W., Washington, D. C., at the present time has more applications from colleges for men to teach chemistry commencing next fall than it is able to supply.

The Section also has on its lists a number of excellent scholarships and fellowships available in ten or twelve colleges where men can take up work for the master's and doctor's degrees. In some instances, the holder of the fellowship^{*} is required to teach a few hours a week.

WORKS AND LABORATORY ACCIDENTS

EXPLOSION IN THE DYE PLANT OF THE CALIFORNIA INK COMPANY

Drug and Chemical Markets for April 16 reported that an explosion in the dye plant of the California Ink Company, Berkeley, Cal., had caused damage amounting to more than \$25,000. The following account of the accident was sent in response to our request for such information as might prove of interest to other workers in this field.—[EDITOR.]

Editor of the Journal of Industrial and Engineering Chemistry:

The explosion that occurred was caused by a weakness in the metal forming the bottom of a steel autoclave 36 in. in diameter and about 9 ft. long, having a cast steel top that is very heavy, almost 3 in. thick. When the bottom let go it went up straight in the air just like a skyrocket, probably 75 to 100 ft. high, broke through the joists of the second story which were 6 by 10 in., went on up through the roof, which was of galvanized iron and heavy rafters, turned a somersault, and came down in another building through the roof and landed in the second story, some 50 ft. away. It naturally wrecked everything within a radius of some 35 to 40 ft. from the original position.

The most fortunate thing was that everybody was safely out of range of the explosion and no one was seriously hurt. Some of our men were considerably overcome and shocked from the gases. They were quickly revived and we are thankful to say that no one was injured permanently.

We feel quite confident that by having the autoclave built properly, with a new shell and a new one-half inch bottom, the holes properly drilled instead of punched, a repetition of this can be readily avoided.

The last pressure that anyone noticed on the pressure gauge was 125 lbs., which is our working pressure. We intend to subject both our autoclaves to hydrostatic pressure of about 25 per cent more than the working pressure, at least once a week, in order to discover any possible weakness, as we do not want a repetition of this kind of excitement with its possibility of resulting very seriously to some of our employees.

WEST BERKELEY, CAL.
April 24, 1919

L. H. LEWARS

CHEMICAL FIRE HAZARDS

Editor of the Journal of Industrial and Engineering Chemistry:

The report on a fire in a cotton bleach and dye works has come

to our attention and owing to the nature of the fire we believe that the following brief description of it may be of interest to readers of the *Journal of Industrial and Engineering Chemistry*.

A barrel of sulfur black dye was stored in the drug room of the plant. At midnight a watchman detected a slight odor given off by the material in this barrel and found that the dyestuff was smoldering. The watchman summoned assistance and the barrel of material was removed to the yard and damage to the building was prevented. The manufacturers of the dye are understood to have replaced the material free of charge and to have stated that the trouble was due to the dye containing too much sulfur.

While the pure dyes of this character may be free from danger, it would seem that irregularities in the manufacture are likely to lead to trouble and that material of this sort should be so stored that large values of other materials are not exposed to the hazard, and the danger of a fire spreading from it should be avoided. The use of metal barrels for this material appears to be advisable.

The writer is not sufficiently informed as to the nature of this material to feel sure of the exact cause of fires of this sort and would be interested in an explanation of the chemical actions involved.

BOSTON, MASS.
May 3, 1919

W. D. MILNE
Superintendent of Surveys

\$100,000 FIRE

Editor of the Journal of Industrial and Engineering Chemistry:

On March 22, a disastrous fire occurred in the establishment of A. Daigger & Co., Laboratory Supplies and Chemicals, 54 West Kinzie Street, Chicago, Ill. The second, third, and fourth floors of the building were almost completely destroyed and the loss has been estimated at about \$100,000.

It has been impossible to determine exactly the cause of the conflagration, but it was apparently due to crossed wires or faulty insulation in connection with an electric elevator.

The building has been rebuilt and the stock replenished, so that business has just about returned to a normal basis.

A. DAIGGER AND COMPANY
CHICAGO, ILL.
May 5, 1919

R. J. QUINN

WASHINGTON LETTER

By PAUL WOORON, Union Trust Building, Washington, D. C.

Substantial governmental aid for the domestic potash industry cannot be regarded as promising. Tungsten and magnesite have a better chance to secure some tariff aid. Optical glass and chemical glassware and porcelain are practically certain of removal from the free list, but a reduction from the amount of duty asked may be expected. The dyestuffs industry will be maintained but much difficulty is certain in the devising of the method by which protection will be afforded.

These are deductions by disinterested persons who have analyzed the attitude of the Ways and Means Committee of the House of Representatives, as displayed since the opening of the tariff hearings.

Under existing conditions, the Republicans are very anxious not to run to extremes of protection. The Democrats, pledged in advance by the President, are going to coöperate in safeguarding the industries which grew up during the war. While the Congress in Republican hands, but with nothing like enough votes to pass a tariff measure over the President's veto, results of an intermediate character may be expected. Both Republicans and Democrats are showing the keenest interest in competitive conditions among domestic producers and manufacturers. It is safe to predict that the domestic industries will have to prove beyond doubt that *bona fide* competition exists.

The licensing plan for potash, which found favor with the Senate Committee on Mines and Mining at the last session of Congress, has not appealed to either the Republican or the Democratic members of the Ways and Means Committee. It is regarded as being impracticable of administration and as possessing few advantages over a tariff. The domestic producers admitted before the committee that they prefer a tariff, but had put forward the licensing plan on the theory that it would be more acceptable to the Democratic administration. Some are convinced that the low-cost producers of potash in the United States will be able to compete without a tariff. The advisability of trying to maintain the high-cost producers is doubted very generally in Congress, especially in face of the desirability of absorbing as much as possible of the German product. The very potent influence of the farmer is being exerted against any material increase of prices over the cost of the duty-free imports.

On the other hand, the producers made a good case in showing the strides which have been taken during the war. The committee evidently was convinced that new attainments are within reach, but some members think they will be reached, duty or no duty, and few are willing to take any step which will aid materially to the cost of fertilizer.

Dr. E. C. Sullivan, of the Corning Glassware Works at Corning, N. Y., was one of the witnesses called in connection with the chemical glassware hearing. He pointed out the superiority of the American product, showing that it will stand five or six times the drop of German glassware, and has a greater resistance to solvent action. His concern, as was the case with practically all those who testified, was more with Japanese than with German competition. Increasing costs in Germany, particularly in the wage which doubtless will have to be paid in the future, led practically every witness to regard Japan as a much more formidable competitor. It was pointed out by Dr. Sullivan and others that the Japanese competition is an actuality. Glassware made in Japan already is on the American market in large volume.

Frank J. Sheridan, of the Tariff Commission, discussed wages of the Japanese workmen and while he did not deny that their year contains 283 working days and the average daily period of work is 11½ hours, he called attention to the fact that our speed and capacity of manufacture are so great that the difference in wages is reduced considerably. He pointed out that chemical and scientific glassware making is a key industry, in that it supplies the research departments of many industries.

Wm. P. Clarke, of Toledo, president of the American Flint Glassworkers' Union, emphasized the danger from Japanese competition. He said a 60 per cent duty would remedy but would not entirely meet the situation.

Dr. Charles L. Parsons, the secretary of the AMERICAN CHEMICAL SOCIETY, told the committee that educational institutions will gain in the long run by sacrificing the advantages they have enjoyed in securing chemical glassware free of duty. He declared that he regards the chemical glassware industry as essential to the chemical independence of the country. He

said that the American manufacturers are making the best glassware in the world and that there should be a tariff to protect the industry. He expressed the belief that glassware never again will be obtained as cheaply as before the war, because the price of labor is greater and the value of the dollar is less. He predicted, however, that prices will fall somewhat from the present level.

Mr. Warren S. Hood, of the Vineland Scientific Glass Company, said that a duty always will be necessary to safeguard the industry and does not think that an embargo for five years will be sufficient to enable the American industry to compete unaided with foreign producers.

F. F. Shetterly, of the Corning Glass Works, declared that a 45 per cent duty would be inadequate to protect the industry.

Dr. Charles H. Herty, the editor of the *Journal of Industrial and Engineering Chemistry*, in his statement to the committee, emphasized the fact that we know now what it means to be dependent on other countries and realize the need of a self-contained chemical industry in the United States. He said that he regards as vicious the law which gives educational institutions the duty-free privilege in scientific supplies. He called particular attention to the influence on the American student working continually over apparatus marked "Becker—Made In Germany." He suggested to the committee that it would be better to make the duty on scientific supplies a little too high rather than a little too low. "My doctrine is," he said, "economic independence for America so far as the chemical industry can make it."

H. S. Coors appeared in behalf of manufacturers of chemical and scientific porcelain. The annual consumption of these products, he said, is around \$500,000.

Walter R. Eimer, representing dealers and makers of scientific apparatus, said the duty should be at least 60 per cent. He said opinion has changed since the Tariff Commission hearing, at which manufacturers said they would be satisfied with 45 per cent duty.

Col. H. K. Rutherford, of the Bureau of Ordnance, told of the difficulties the Army had in securing the \$30,000,000 worth of fire control apparatus, which was bought during the war. He recommended a tariff and declared there is real competition among domestic manufacturers. Col. M. A. Reasoner, who bought \$3,000,000 worth of scientific supplies for the Government during the war, urged a duty which would allow the continuance of the home industry.

Chester G. Fisher, of the Scientific Materials Company of Pittsburgh, pointed out that the scientific instrument industry is classed as a "master key" industry in England. He said that 90 per cent of the total cost of scientific instruments is represented by the labor. He left with the committee a copy of the Scientific Material Bluebook calling attention to the fact that in its 700 pages may be found the greatest reason why the industry should be protected, since the book contains practically every scientific instrument used—all made in America.

Harvey M. Ott asked that an addition be made to the bill so as to cover half-finished products or instruments, as he fears chicanery on the part of Germany or Austria. C. H. Stoelting, of Chicago, told of many unsuccessful attempts to compete in the manufacture of instruments without protection.

The United States Tariff Commission is furnishing the Committee on Ways and Means with special reports on the commodity under consideration. Extracts from the report on optical glass and chemical glassware are as follows:

The advantages possessed by Germany and other countries are such that this new American industry is unequal to successful competition with the countries named on the basis of continued free importation of the foreign product.

It was not until after five years of scientific research and experiment that the Jena works, of Germany, developed 28 new kinds of optical glass. This firm had the advantage of 25 years' experience in producing optical glass and in this field was practically without a competitor. It is not reasonable to expect that American manufacturers and scientists could, in less than three years, attain the required standards of knowledge and efficiency to meet the demands of domestic consumption and the inroads of foreign competition.

During the war the optical industries of Germany, France, and England have been driven to a high state of industrial activity and the scientific precision essential in the production of perfect optical glass. Under the Tariff Act of 1913 optical glass is admitted free of duty into the United

States. The new American industry under such conditions is unequal to the task of engaging in successful competition with the output of the highly developed industry and the experienced scientists and manufacturers of the countries named.

Many of our most important industries requiring research work—the testing of processes and the analyses of their materials and products—are dependent upon chemical and scientific glassware for their successful continuance. Laboratory tests and analyses by means of this ware are essential in the chemical control of such varied industries as iron and steel, raw and refined sugar, packing-house products, fertilizers, rubber manufacture, Portland cement, soap, oil refining, waterworks, textiles, and in chemical plants in the manufacture of explosives, dyes, soda, and other products.

With regard to dyes and related coal-tar chemicals, the Tariff Commission's report to the committee contains the following:

Several different methods of rendering aid and protection have been proposed, and the degree to which Congress may see fit to use the tariff will doubtless depend in large measure on whether or not the other methods are adopted and successfully administered. The more important of the proposals that have been made include (1) direct financial aid by the Government, (2) the limitation of imports through the control of patents, (3) the exclusion of foreign products except under license, (4) a revision upward of the present tariff rates, and (5) the prevention of unfair competition on the part of foreigners in the domestic market.

Having said that the present rates of the tariff would probably suffice to maintain important branches of the industry, and that every increase in these rates would insure the safety of additional branches, we are finally faced with the question: What rate of duty would protect all branches that now show any growth and will guarantee the development of those that are missing? To this the Tariff Commission is bound to answer that this end apparently cannot be accomplished by any rate of duty familiar in American tariff legislation. This conclusion is inevitable when a comparison is made of what is known of domestic costs with the pre-war prices of German dyes or even with the very recent prices at which those dyes were offered in exchange for food. Many of those interested in the industry naturally wish to see the rates pitched very high. The advocates of such rates, however, overlook the effect of such a policy on other industries. If the manufacturers of textiles, leather goods, and many other commodities cannot procure, or can procure, only at an exorbitant price, the dyes which they need, not only will they be rendered unable to compete in international trade, but also will they find themselves at a serious disadvantage in the domestic market.

A law that would be effective against German dumping of dyestuffs will be difficult to draw, for the usual test of dumping can hardly be applied.

A comparison of their export with their domestic prices will have little meaning, because both are fixed by a monopoly and may be adjusted at will, and because private contract prices may easily be made to vary widely from published quotations. A comparison of prices with costs would be still more futile, for the obvious reason that their costs are known only to themselves, and there is little likelihood of their being disclosed.

For the prevention of dumping in the case of dyestuffs it is well worth considering whether the United States might not adopt to advantage a practice not uncommon in other countries of fixing a minimum valuation for the assessment of duties, regardless of what the market price may be or what the invoice price may show.

The Eli Lilly Company, drug and pharmaceutical manufacturers, Indianapolis, has agreed to issuance of an order by the Federal Trade Commission requiring it to relinquish all attempts to influence its 248 selected wholesale distributing druggists throughout the United States to maintain standard resale prices fixed by the Lilly Company on Lilly products.

The text of the order against the concern which has total annual gross sales of several million dollars, follows:

Now, therefore, it is ordered that respondent, The Eli Lilly and Company, and its officers, directors, agents, servants, and employees, cease and desist from directly or indirectly recommending, requiring, or by any means whatsoever bringing about the resale by its wholesale distributors of the drugs, pharmaceuticals, and similar products manufactured by it according to any system of prices fixed or established by respondent, and more particularly by any or all of the following means:

1—Entering into contracts, agreements, or understandings with such distributors to the effect that such distributors in reselling such products will adhere to any system of resale prices fixed or established by respondent.

2—Securing from such distributors contracts, agreements, or understandings that they will adhere to any such system of resale prices.

3—Refusing to sell to any such distributors because of their failure to adhere to any such system of resale prices.

4—Discriminating in prices against such distributors because of their failure to adhere to any such system of resale prices.

5—Discriminating in prices in favor of such distributors because of their adherence to any such system of resale prices.

6—Carrying out or causing others to carry out a price maintenance policy by any other means.

Provided, that nothing herein contained shall prohibit respondent from issuing price lists or printed prices in its advertising matter, or upon containers, of its said products, so long as respondent shall refrain from directly or indirectly recommending, requiring, or by any means whatsoever bringing about the resale of such products at such resale prices.

INDUSTRIAL NOTES

The Industrial Bill passed this session by the British Columbia legislature provides for a new Department of Industries whose powers will be to provide for industrial research, to acquire and utilize existent knowledge in arts and manufactures, to carry out an economic survey of natural resources, to furnish advice regarding industrial problems, to publish technical, scientific and statistical information, and generally promote the economic development of the province.

The Virginia-Carolina Chemical Company will begin at once the construction of a \$200,000 fertilizer plant at Jacksonville, Fla., which will care for the company's business in Florida, as well as that in the Latin-American countries.

The Armour Fertilizing Works, the third largest manufacturers of fertilizers in the United States, has purchased all of the interests of Howard F. Chappell and the United States Smelting, Refining & Mining Company in the Mineral Products Corporation, for \$1,000,000. The plant produces potash from alunite.

The British Photographic Research Association plans to carry out a program of research work. This body was formed in May of last year, under the government scheme of financial aid through the Department of Scientific and Industrial Research, to carry out research work in photography, photochemistry, and other related subjects. Dr. R. E. Slade has been appointed director of research, and temporary laboratories have been obtained at University College, London. Professor J. J. Thomson, O. M., P. R. S., is president of the Association, and the leading firms of photographic chemical manufacturers are represented on the council.

The trade-mark "Pebeco," together with such German interests as may exist in a contract between Lehn & Fink, of New York, and P. Beiersdorf & Co., of Hamburg, Germany, was sold to Lehn & Fink on April 22 at the office of the Alien Property Custodian, for \$1,000,000.

Exports of dyes during the month of February totaled over \$2,000,000, according to statistics from the Department of Commerce. Exports of aniline dyes totaled \$1,231,355; those of logwood extracts, \$170,237; and all other dyes, \$617,050. During the month, our imports of dyes amounted to a little more than \$500,000.

The American Chamber of Commerce in London, numbering over 800 of the principal Anglo-American interests, is now forming a chemical and drug section. American concerns of good standing who wish to be represented in the chamber can get full particulars, application forms, etc., through the Keene Company, 335 Broadway, New York.

The Bureau of Standards has just issued Technologic Paper No. 125, entitled "The Viscosity of Gasoline." The instruments ordinarily employed for finding the viscosity of lubricating oils are not suitable for gasoline, but it was found that the Ubbelohde viscosimeter, designed primarily for use with kerosene, served to determine the viscosity of gasoline accurately enough for commercial purposes. The usual method of estimating the volatility of gasoline from the specific gravity is a rough approximation, and the volatility depends somewhat on the viscosity. Those interested may obtain a copy by addressing a request to the Bureau.

A paper mill, with a daily capacity of 165 tons, is being erected at Olaa (Hawaii) for the manufacture of all kinds of paper. This production will utilize only one-tenth of the available supplies of bagasse of the sugar factories of Olaa. The mill has been planned with a view to being gradually expanded, so as to ultimately utilize all the available supplies of bagasse, should the venture prove successful, in which case the output could reach 165 tons a day, and even more, should the factories in the other islands follow this good example. The mill cannot start for another year, as the required machinery could not be obtained during the war.

LIST OF APPLICATIONS MADE TO THE FEDERAL TRADE COMMISSION FOR LICENSES UNDER ENEMY-CONTROLLED PATENTS PURSUANT TO THE "TRADING WITH THE ENEMY" ACT

YEAR 1945	PAT. NO. 748,375	PATENTEE Hepp and Hartmann	ASSIGNEE	PATENT	APPLICANT
			Farwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Blue anthraquinone dye and process of making	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1904	778,036	Hepp and Uhlenhuth	Farwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Anthraquinone dye and process of making	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1907	871,507	Homolka and Erba	Farwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Anthrachrynone derivatives	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1909	943,717	Uhlenhuth	Farwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Brown anthraquinone dye and process of making	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1910	975,863	Hepp and Hartmann	Farwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Anthraquinone derivatives and process of making same	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1911	989,602	Henle	Farwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Manufacture of amino-aryl-acidyl-amino-anthraquinone and their acidyl derivatives	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1911	998,772	Hessenland	Farwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Blue dyestuff and process of making same	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1911	999,785	Hessenland	Farwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Vat dyestuff	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1911	1,002,270	Hessenland	Farwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Vat dyestuff of the anthraquinone series and process	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1911	1,007,104	Hessenland	Farwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Vat dyestuff of the anthraquinone series and process	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1912	1,023,847	Hessenland	Farwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Alizarin-red vat dyestuff and process of	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1912	1,025,174	Welde and Homolka	Farwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Blue vat dyestuff and process of making same	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1912	1,025,195	Kränzlein	Farwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Salmon-colored vat dyestuff and process	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1912	1,028,139	Schmidt	Farwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Manufacture of azo dyestuff of the anthraquinone series and process	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1912	1,038,003	Schmidt and Kränzlein	Farwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Pure anthraquinonylurea chloride and process	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1912	1,046,498	Schmidt and Kränzlein	Farwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Halogenized condensation product of the anthracene series and process of making	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1912	1,047,940	Hessenland	Farwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Vat dyestuffs of the anthraquinone series and process of making	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1913	1,052,480	Hepp, Uhlenhuth and Roemer	Farwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Dyestuffs of the anthraquinone series and process of making same	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1913	1,052,520	Schmidt	Farwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Condensation products of the anthracene series and process of making same	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1915	1,123,390	Schirmacher and Voss	Farwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Vat dyestuffs and process of making same	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1915	1,138,670	Kränzlein, Hagenbach and Gily	Farwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Arylaminoanthraquinone dyestuffs and process	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1915	1,139,540	Kränzlein	Farwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Arylaminoanthraquinone dyestuffs	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1910	961,047	Ullman	Actien-Gesellschaft für Anilin Fabrikation, Berlin, Germany	Anthraquinone acridones	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1911	993,915	Ullman	Actien-Gesellschaft für Anilin Fabrikation, Berlin, Germany	Halogenized carboxylic acid of the phenylaminoanthraquinone series	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1911	993,992	Herzberg and Bruck	Actien-Gesellschaft für Anilin Fabrikation, Berlin, Germany	Vat dye of the anthraquinone series	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1911	996,485	Herzberg and Bruck	Actien-Gesellschaft für Anilin Fabrikation, Berlin, Germany	Sulfurized vat dye of the anthraquinone series	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1911	1,001,325	Ullmann	Actien-Gesellschaft für Anilin Fabrikation, Berlin, Germany	Product of the anthraquinone series and process	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1911	1,008,906	Herzberg and Bruck	Actien-Gesellschaft für Anilin Fabrikation, Berlin, Germany	Vat dyes of the anthraquinone series	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1913	1,078,505	Herzberg and Hoppe	Actien-Gesellschaft für Anilin Fabrikation, Berlin, Germany	Blue dyes of the anthraquinone series	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1911	1,008,908	Herzberg and Bruck	Actien-Gesellschaft für Anilin Fabrikation, Berlin, Germany	Vat dyes of the anthraquinone series	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1913	1,050,829	Herzberg and Bruck	Actien-Gesellschaft für Anilin Fabrikation, Berlin, Germany	Anthraquinone vat dye	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1915	1,131,516	Herzberg and Hoppe	Actien-Gesellschaft für Anilin Fabrikation, Berlin, Germany	Greenish blue dyes of the anthraquinone series	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1911	999,045	Laska	Chemische Fabrik Griesheim-Elektron, Frankfurt-on-the-Main, Germany	Manufacture of brown sulfurized vat dyestuffs	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1911	999,680	Singer	Chemische Fabrik Griesheim-Elektron, Frankfurt-on-the-Main, Germany	Vat dyestuffs of the anthracene series	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1912	1,016,638	Laska	Chemische Fabrik Griesheim-Elektron, Frankfurt-on-the-Main, Germany	Vat dye and process of making same	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1912	1,028,521	Zitscher and Rath	Chemische Fabrik Griesheim-Elektron, Frankfurt-on-the-Main, Germany	Anthracene derivatives and process of making	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.
1912	1,042,931	Laska, Zitscher and Rath	Chemische Fabrik Griesheim-Elektron, Frankfurt-on-the-Main, Germany	Vat dyestuffs of the anthracene series and process of making same	National Aniline Co., Inc., 21 New York City & Chemical Burling Slip.

LIST OF APPLICATIONS MADE TO THE FEDERAL TRADE COMMISSION FOR LICENSES UNDER ENEMY-CONTROLLED PATENTS PURSUANT TO THE "TRADING WITH THE ENEMY" ACT (Continued)					
YEAR	PAT. NO.	PATENTEE	ASSIGNEE	PATENT	APPLICANT
1912	1,044,933	Singer	Chemische Fabrik Griesheim-Elektron, Frankfurt-on-the-Main, Germany	Process of making vat dyes of the anthracene series	National Aniline & Chemical Co., Inc., 21 New York City
1913	1,066,777	Zitscher and Rath	Chemische Fabrik Griesheim-Elektron, Frankfurt-on-the-Main, Germany	Process of making nitro-amino derivatives of the anthraquinone series	National Aniline & Chemical Co., Inc., 21 New York City
1913	1,070,196	Singer	Chemische Fabrik Griesheim-Elektron, Frankfurt-on-the-Main, Germany	Vat dyes and process of making same	National Aniline & Chemical Co., Inc., 21 New York City
1913	1,079,368	Laska and Rath	Chemische Fabrik Griesheim-Elektron, Frankfurt-on-the-Main, Germany	Vat dyestuff	National Aniline & Chemical Co., Inc., 21 New York City
1915	1,162,496	Laska and Rath	Chemische Fabrik Griesheim-Elektron, Frankfurt-on-the-Main, Germany	Vat dyes of the anthraquinone series and process	National Aniline & Chemical Co., Inc., 21 New York City
1906	825,509	Iljinsky	R. Wedekind & Co.	Alizarin sulfo-acid and process	National Aniline & Chemical Co., Inc., 21 New York City
1906	826,510	Iljinsky	R. Wedekind & Co.	Anthraflavin disulfonic acid and process	National Aniline & Chemical Co., Inc., 21 New York City
1907	847,078	Iljinsky	R. Wedekind & Co.	Production of organic sulfonic acid	National Aniline & Chemical Co., Inc., 21 New York City
1907	851,423	Iljinsky	R. Wedekind & Co.	Anthraquinone disulfonic acid	National Aniline & Chemical Co., Inc., 21 New York City
1911	996,487	Iljinsky	R. Wedekind & Co.	Process of making acid dyes of the anthracene series	National Aniline & Chemical Co., Inc., 21 New York City
1914	1,087,293	Iljinsky	R. Wedekind & Co.	Process of making acid dyes of the anthracene series	National Aniline & Chemical Co., Inc., 21 New York City
1918	1,261,394	Iljinsky	R. Wedekind & Co.	Vat dyestuffs and process for their formation	National Aniline & Chemical Co., Inc., 21 New York City
1910	965,804	Franke	R. Wedekind & Co.	Alizarin preparation and process	National Aniline & Chemical Co., Inc., 21 New York City
1911	999,439	Karl Elbel and Edward Wray, Biebrich, Germany	Kalle & Company, Aktiengesellschaft, Biebrich, Germany	Vat-dyeing coloring matter	Consolidated Color & Chemical Co., 122 Hudson Street, New York City
1907	867,305	Karl Schirmacher and Bernhard Deicke, Höchst-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Vat dyestuff	Consolidated Color & Chemical Co., 122 Hudson Street, New York City
1912	1,025,174	Robert Welde, Höchst-on-the-Main, and Benno Homolka, Frankfurt-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Blue vat dyestuffs and process of making same	Consolidated Color & Chemical Co., 122 Hudson Street, New York City
1909	916,029	Albrecht Schmidt and Ernst Bryk, Höchst-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Red-violet dye and process of making same	Consolidated Color & Chemical Co., 122 Hudson Street, New York City
1908	892,897	Karl Schirmacher and Hermann Landers, Höchst-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Red vat dye	Consolidated Color & Chemical Co., 122 Hudson Street, New York City
1910	968,697	Albrecht Schmidt, Ernst Bryk, and Robert Voss, Höchst-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Vat dye and process of making same	Consolidated Color & Chemical Co., 122 Hudson Street, New York City
1912	1,025,138	Erwin Hoffa, Höchst-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Violet-blue vat dyestuffs	Consolidated Color & Chemical Co., 122 Hudson Street, New York City
1908	876,679	Bally & Wolf	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Nitrobenzanthrone compounds and process of making same	National Aniline & Chemical Co., Inc., 21 New York City
1908	893,384	Schlegel	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Dyeing	National Aniline & Chemical Co., Inc., 21 New York City
1913	1,062,975	Isler	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Coloring-matter of the anthraquinone series	National Aniline & Chemical Co., Inc., 21 New York City
1913	1,062,988	Muller and Isler	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthraquinone dyes	National Aniline & Chemical Co., Inc., 21 New York City
1913	1,066,987	Bohn and Nawiasky	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Gray-to-black shades on vegetable fiber and process of producing them	National Aniline & Chemical Co., Inc., 21 New York City
1913	1,067,046	Luttinghaus and Braren	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthraquinone acridones	National Aniline & Chemical Co., Inc., 21 New York City
1913	1,077,115	Bally	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Green anthraquinone dyes and process of making	National Aniline & Chemical Co., Inc., 21 New York City
1913	1,083,051	Boner	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Producing anthraquinone compounds	National Aniline & Chemical Co., Inc., 21 New York City
1914	1,089,221	Isler	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthraquinone coloring-matters and process of making them	National Aniline & Chemical Co., Inc., 21 New York City
1914	1,090,123	Bohn and Immerheiser	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Chromium compounds of oxy-anthraquinone sulfonic acids and process of making same	National Aniline & Chemical Co., Inc., 21 New York City
1914	1,090,636	Luttinghaus, Lohse and Sapper	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Brown vat dye	National Aniline & Chemical Co., Inc., 21 New York City
1914	1,095,780	Bally and Wolf	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Reddish brown vat dyes	National Aniline & Chemical Co., Inc., 21 New York City
1914	1,106,970	Reinking and Stiegelmann	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Compounds of leuco vat dyes with aralkyl compounds and process of making same	National Aniline & Chemical Co., Inc., 21 New York City
1916	1,207,981	Neresheimer	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthraquinone dyes and process of making same	National Aniline & Chemical Co., Inc., 21 New York City
1916	1,207,982	Neresheimer	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthraquinone dyes and process of making same	National Aniline & Chemical Co., Inc., 21 New York City
1917	1,216,921	Bally and Wolf	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Yellow-brown vat dye	National Aniline & Chemical Co., Inc., 21 New York City
1917	1,238,932	Nawiasky	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthraquinone compounds	National Aniline & Chemical Co., Inc., 21 New York City

According to *Commerce Reports* there is immediate need of approximately 12,000 tons of chemical fertilizers in the Canary Islands for the restoration of the banana plantations, which form the principal industry of the archipelago. The amount and kinds of fertilizers needed are: Sulfate of ammonia, 3,500 tons (24 to 25 per cent); superphosphate of lime, 3,500 tons (36 to 38 per cent); dried blood, 1,500 tons; and potash, 3,500 tons (97 to 98 per cent). The leading fruit houses are making every effort to obtain these fertilizers and are prepared to pay cash f. o. b. in any American port where they can be delivered, or even to arrange for the shipment thereof in case such a plan should be preferred by the seller.

A large deposit of silica sand has been located near Monroe, La., convenient to railway, water and gas. It is estimated that the pit contains about 18,000,000 yards of sand, gravel, and road-building material underlaid by a very large strata of silica or glass sand.

A topographic and geodetic survey of Pennsylvania for the location of chemical deposits is proposed in a bill introduced into the state senate. The essential provisions of the bill are: "The survey shall disclose such chemical analysis and location of ores, coals, oils, clays, soils, fertilizing and other useful minerals, and of waters as shall be necessary to afford the agricultural, mining, metallurgical, and other interests of the state a clear insight into the character of its resources."

The Aluminum Potash Company has filed articles of incorporation at Salt Lake City. Its capitalization is \$3,000,000, with 10,000 shares of \$100, 7 per cent preferred stock and 20,000 shares of common stock. The company was formed to take over potash and other mineral deposits in Piute County, Utah, near the town of Belknap.

Mr. B. E. Reuter and Mr. J. E. Wrenn, who were, respectively, chief and assistant chief of the Fats and Oils Division of the Food Administration during the war, have organized a corporation called the Fats and Oils Service Company with main offices in New York City and branch offices in Atlanta, Chicago, and San Francisco. This company aims to give to the fats and oils and allied industries information and service such as was given under the Food Administration and also has inaugurated a brokerage and commission department.

With more than 1,250,000 tons of reserve stock of sulfur above ground at the large plants in Louisiana and Texas, there is a growing belief in the trade and among technical and chemical experts that the domestic sulfur producers will invade the sulfuric acid field in competition against pyrites. The Texas Gulf Sulfur Company, since starting operations about the middle of March, has placed in production additional wells, and the present output is reported as 1,000 to 1,500 tons of sulfur per day.

A number of new uses for woodpulp have been developed during the war, many of them through the efforts of the Forest Products Laboratory of the United States Forest Service. One of the more important of these uses was in the manufacture of propulsive explosives which, incidentally, developed the fact that woodpulp was suitable for a number of other commodities. When a shortage of cotton from which to make explosives was threatened before the signing of the armistice, the laboratory entered a practically new field of investigation—studying the practicability of using woodpulp as a source of explosives. Methods for the production of acid sulfite and sulfate pulp suitable for nitrating were developed, and tests at a government arsenal proved conclusively their suitability for nitration purposes. These results have other applications, particularly in the manufacture of lacquers and pyroxylin products, and the laboratory is continuing its work along these lines.

The potash producers of the United States intend to make an aggressive fight, as soon as Congress meets, to secure some sort of protection for their industry, in which \$50,000,000 has been invested since the beginning of the war. There has been too little organization behind the efforts in this direction in the past, but the recently organized United States Potash Producers' Association represents the entire industry, including not only the Nebraska and California producers, but also the sugar company producers, the producers of first sorts potash from wood ashes, and all other potash producers in this country. The association has opened an office in Washington in charge of Mr. Frederick W. Brown, executive secretary, and will urge upon Congress the necessity of licensing the importation of foreign potash.

The Davis Manufacturing Co., Jellico, Tenn., manufacturers of chemicals, have completed negotiations for the leasing of a building at Knoxville, Tenn., comprising approximately 45,000 sq. ft. floor area, and will install new machinery for the manufacture of its specialties.

Fritzsche Bros., New York, dealers in and importers of essential oils, aromatic chemical preparations, essences, and fine drugs, have incorporated with \$1,000,000 capital under the laws of the state of New York.

The California Potash Co., Sacramento, Cal., is conducting extensive experiments in the pine woods near Alta, Cal., with the view of extracting creosote and tar products from mountain pine.

The Heyden Chemical Co. of America has been incorporated by Allan F. Ryan, broker, 111 Broadway, who bought the stock of the Heyden Chemical Works from the Alien Property Custodian. The company is incorporated for \$2,500,000, active capital, under the laws of New York State and is distinct from the Heyden Chemical Works which was incorporated on November 2, 1900, under the laws of New Jersey.

The McKenna Corporation of 49 Wall Street, New York, was the successful bidder for the 8,000 shares of the capital stock of Merck & Company, which were sold at auction by the Alien Property Custodian for \$3,750,000, on May 9, at the offices of the company, 45 Park Place, New York. The sale of the stock must be confirmed by a committee from the Custodian's office, which must be satisfied that the purchasers are American citizens. The 8,000 German-owned shares of the Merck stock represent the greater portion of the total outstanding stock of the company, 10,000 shares all told. George Merck, president of the American company, is the owner of the other two thousand shares. Merck & Company was incorporated under the laws of New York State in 1908, being recapitalized in 1917. Prior to the outbreak of the war the annual business of the company averaged between \$3,000,000 and \$4,000,000 a year. In 1915 the earnings increased to \$6,913,637 and for the first 8 months of 1918 reached \$8,030,474. The 8,000 shares of stock which were sold, were delivered to the Alien Property Custodian voluntarily by George Merck in order that the disposal of them by the Government might be facilitated. Mr. Merck also furnished a full statement of the business relations between himself and E. Merck, of Darmstadt, Germany, who furnished credit amounting to \$800,000 prior to the time of the incorporation of Merck & Company in the United States in 1908.

The American stockholders of the Roessler and Hasslacher Chemical Company and its allied concerns have filed ten equity suits in the United States District Courts of New York, Buffalo, and Newark against Francis P. Garvan, Enemy Alien Property Custodian, and the Columbia Trust Company, the present holders of the stock. The purpose is to prevent the Alien Property Custodian from gaining control of the company, which is one of the largest in the country. In these suits the stockholders seek to enjoin Mr. Garvan from exercising control over 80 shares of stock of the Perth Amboy Chemical Works, 240 shares of the Niagara Electrochemical Company, and 3,800 shares of the Roessler & Hasslacher Company, for which the custodian made a demand on April 1 last, claiming their sale to American stockholders in February 1917 was not *bona fide*, but that the stock was still being held for the Deutsche Gold and Silver Scheide Anstalt of Frankfurt.

The United States Civil Service Commission announces the following competitive examinations: Catalytic chemist (male), \$3,000 to \$4,000 a year; Assistant Catalytic Chemist (male), \$2,000 to \$3,000 a year; Junior Catalytic Chemist (male), \$1,600 to \$2,000 a year. These three positions are for vacancies in the Ordnance Office and in the Ordnance Department at Large, War Department. There is also an examination for assistant in charge of soil chemical investigations (male), at \$3,500 a year or lower or higher salaries, for a vacancy in the Bureau of Soils, Department of Agriculture, Washington, D. C., and an examination for an assistant petroleum chemist (male) at \$1,620 to \$1,920 a year, for a vacancy in the Bureau of Mines, Department of the Interior, for duty at Pittsburgh, Pa. Applicants should at once apply for Form 1312, stating the title of the examination desired, to the Civil Service Commission, Washington, D. C., or at the branch offices in the principal cities in the United States.

The foreign trade committee of the Chemical Alliance, Inc., has submitted a report recommending the organization of a \$15,000,000 chemical corporation under the Webb-Pomerene law. The capital will be divided into \$10,000,000 common stock and \$5,000,000 preferred shares. The common stock is to be subscribed by manufacturers participating fully in the plan, and the preferred stock will be offered to manufacturers who desire to cooperate but wish to maintain their individual organizations. Participation will be on the basis of average annual sales of each chemical handled by each manufacturer, and profits will be distributed in the same proportion as dividends on the common stock.

A new hat dye, known as the "Hat-Brite-Dye," is now being advertised by the Sherwin-Williams Company, who have hitherto been famous for their paints.

The United States has always been dependent mainly on foreign sources for its antimony supplies, China and Japan being the principal contributors, although Mexico and Bolivia have also furnished significant amounts, according to a review of the antimony situation, by the U. S. Geological Survey. This dependence is a reflection of the higher wage scale in this country as compared with that of certain foreign countries, particularly China; it is due, also, to the comparative poverty of the United States in antimony resources, although little information of a quantitative nature has been collected concerning these resources, and they may possibly be greater than has generally been assumed.

The United States formerly produced monazite from the important deposits in North and South Carolina, but since 1910 there has been practically no production, due chiefly to the fact that the mineral from the extensive seacoast deposits of Brazil could be obtained at a lower price. Monazite, vastly the most abundant of the cerium-bearing minerals, is an anhydrous phosphate of cerium, lanthanum, praseodymium, and neodymium, with variable quantities of thorium and silica, and frequently small amounts of erbium and ytterbium. It is a radioactive mineral, its activity being due to its content of mesothorium and radium. Deposits of monazite are also known in other states, especially in Idaho and Florida, and in Colorado, Georgia, and Virginia. A part of the production of monazite from the Carolinas was used in this country in the manufacture of thorium nitrate and a part was exported to Germany.

The National Reduction Company is building a large rosin and turpentine plant at Calvert, Ala.

The Supreme Court of the United States has entered a unanimous decree in the action of the Federal Trade Commission against Colgate & Company, sustaining the soap company, declaring that in refusing to sell its product to certain objectionable distributors it has done nothing contrary to the Sherman anti-trust law, and dismissing the Federal Trade Commission's complaint.

Allen Property Custodian Garvan has sold at auction 1,375 1/2 shares of common and 137 shares of preferred stock of the Jarecki Chemical Co., Cincinnati, O., to the Isaac Winkler & Brother Company for \$150,000.

The War Trade Board announces that on and after July 1, 1919, nitrate of soda and nitrate of potash will be permitted to be imported into the United States without restriction under a general import license when coming from countries with which general trade is authorized.

Fluorspar properties in Kentucky will be developed by the Cumberland River Spar Mining Co., of Fulton, Ky., incorporated with \$250,000 capital by William H. Spradlin, W. M. Nalling, and C. E. Kaiser.

The British Dyestuffs Corporation, Ltd., has been registered with a capital of \$6,000,000, in £1 shares, to take over the businesses of British Dyes, Ltd., and Levenstein, Ltd., to carry into effect agreements between those companies and the president of the Board of Trade (on behalf of the government) and to carry on the business of manufacturers of and dealers in dyes, dyestuffs, chemicals, drugs, paints, varnishes, colors, etc. One of the articles provides that the company shall supply products at reasonable prices. The first directors are Mr. H. Levenstein, Sir Harry D. McGowan, Mr. G. P. Norton, and Mr. J. Turner, and two government directors to be appointed by the Board of Trade.

The Utah Sulfur Corporation, operating at Morrissey, Beaver County, Utah, plans the immediate construction of furnaces to cost about \$180,000, for the subliming of sulfur, according to a recent announcement by Michael P. Morrissey, president and general manager.

The United States Geological Survey has completed tests of lignite mined near Ione, Cal., and has reported that the best deposits yield 62 gal. of oil per ton, and at least 18 lbs. of ammonium sulfate. This lignite is remarkably "fat," containing 31 per cent of volatile matter and 16 per cent of fixed carbon.

What is probably the first research laboratory to be put in by any department store in the United States has been installed recently by the Bannon Brothers Co., St. Paul, Minn. This laboratory, completely equipped, actually makes practical and chemical tests of the textiles, food products, linoleums, and other goods carried by the store. The research laboratory consists of a glass-enclosed room, fitted with the usual chemical laboratory equipment and, in addition, special equipment for the testing of textiles and other products. The staff includes a trained chemist and two assistants, who make analyses of goods. Both microscopical and chemical tests are made. A test is made of every article advertised so that it can be truthfully presented as "pure silk" or "80 per cent wool," with the backing of an actual test in the store's own laboratory.

The National Aniline & Chemical Company, Inc., have opened a branch office in Akron, Ohio, at the People's Saving & Trust Building, in order to give better service to the mid-western trade, and especially the rubber industry.

The Office of Drug and Oil Plant Investigations, Bureau of Plant Industry, in connection with its projects of oil-yielding crops and waste utilization, is installing a laboratory at Arlington to study the technology of fats and vegetable oils.

PERSONAL NOTES

The death of Boverton Redwood, F.R.S.E., one of the world's foremost authorities in the petroleum industry, occurred on June 6, 1919. Mr. Redwood was well known in this country in petroleum, chemical, and engineering circles, having been a frequent visitor here, in his professional capacity, to the oil fields. He was a consultant of high standing on petroleum questions and on other chemical lines. He was the author of many important papers and books upon petroleum and allied subjects, a member of the Society of Chemical Industry, the Institute of Mining Engineers, the American Chemical Society, a Fellow of the Royal Society of Edinburgh and the Royal Geographical Society, and honorary member of the American Philosophical Society and other scientific societies.

The Franklin Institute at Philadelphia has presented the Franklin Medal to Sir James Dewar, the distinguished English chemist.

Mr. M. B. Long, of the gas laboratory of the Bureau of Standards, has resigned in order to accept a position in the research laboratory of the Western Electric Company, New York City.

Professor F. Soddy, F.R.S., of the University of Aberdeen, has been elected to the second chair of chemistry recently established in the University of Oxford.

Col. William H. Walker has received his discharge from the Army and has returned to his home at Bridgeton, Me. His position as commanding officer of Edgewood Arsenal has been taken by Lt. Col. Amos A. Fries, Corps of Engineers (C. W. S.), U. S. A., who as Brigadier General, National Army, A. E. F., commanded the C. W. S. forces in France throughout the war.

Col. George A. Burrell, Col. F. M. Dorsey, and Col. William H. Walker have been awarded the Distinguished Service Medal by the War Department in recognition of their services during the war as members of the Chemical Warfare Service.

Dr. H. L. Walster, assistant professor of soils, College of Agriculture, University of Wisconsin, resigned that position recently to accept work as station agronomist and chairman of the department of agronomy of the North Dakota Agricultural College, Fargo, N. D.

The British Iron and Steel Institute has announced that it will confer the Bessemer Medal for 1919 on Dr. F. Giolitti, Director General of the Ansaldo Steel Works, Genoa, Italy. Dr. Giolitti is a member of the American Electrochemical Society.

Col. G. A. Burrell, president of the Island Refining Company, 62 Cedar Street, New York City, has been given the degree of doctor of science by Wesleyan University, Middletown, Conn. Last year his alma mater, Ohio State University, gave him the honorary degree of chemical engineer.

Mr. Milo R. Daughters, formerly connected with Mellon Institute, is now with the Dominion Canners Laboratory, Brighton, Canada.

Mr. Benjamin Markus recently resigned his position of research chemist with the Aetna Chemical Company to go into the consulting and manufacturing business with Mr. O. S. Tischler, also formerly connected with the Aetna Chemical Company.

Mr. Howard H. Johnson since his recent discharge from the Army has been working in the laboratory of the Ismert-Hinckle Milling Co., Topeka, Kan.

Messrs. G. C. Bacon, G. C. Given, R. G. Gutelius, U. J. Lebourveau, G. C. Robinson, A. M. Taylor, and W. C. Wilson have been transferred from the Experimental Laboratories of the Atlas Powder Company, Tamaqua, Pa., to Stamford, Conn., where they form the personnel of a new Atlas Powder Company Experimental Laboratory.

Mr. E. R. Lederer, formerly superintendent of the Petroleum Refining Company of Texas, is at the present time general superintendent of the Home Oil Refining Company of Texas with headquarters at Fort Worth, Texas.

Mr. O. B. Zimmerman, following his discharge from the Army, returned to his former place of employment, the International Harvester Company of America, Chicago, Ill., where he is advisory engineer to the sales department.

Drs. E. T. Allen and E. G. Zies, of the Geophysical Laboratory, Washington, D. C., are members of the expedition of the National Geographic Society to Mt. Katmai, Alaska, and will study the physical chemistry of the fumerols of that volcanic district.

Mr. G. H. Cartledge, who was associated with Col. G. A. Burrell in consulting work at Pittsburgh, is now chief chemist of the Island Refining Corp., Jones' Point, N. Y. Associated with Mr. Cartledge, as chief of development operations, is Mr. H. E. Bruce.

Dr. E. R. Stein has been discharged from the U. S. Army, where he was engaged in experimental work in the Chemical Warfare Service, Hanlon Field, France, and has accepted a position as research chemist at Shawinigan Laboratories, Ltd., Shawinigan Falls, Quebec, Canada.

Mr. L. A. Dubbs has resigned his position as chemist with the Universal Oil Products Company, Independence, Kan., and has become connected with the Pacific Potash-Alum-Sulfur Co., Los Angeles, Cal.

Mr. F. W. Mohlman, formerly chemist for the Connecticut State Department of Health in charge of the laboratory for the investigation of stream pollution and sewage disposal, is now chief chemist in charge of the laboratory of the Chicago Sanitary District, Chicago, Ill.

Mr. George H. Ellinwood, formerly chief chemist for the Boston Belting Corporation, Boston, Mass., recently entered the employ of the Federal Rubber Company, Cudahy, Wis., as technical superintendent.

Mr. D. B. Dow, who recently returned from overseas duty and who was later discharged from the service, has accepted a position with the Bureau of Mines, at the Petroleum Experiment Station, Bartlesville, Oklahoma.

Mr. J. S. Staudt, formerly with the M. W. Kellogg Company, Air Nitrate Plant No. 2, Muscle Shoals, Ala., is now with the staff of supervising engineers, in connection with the construction of the Government Infantry School of Arms, at Columbus, Ga.

Mr. Esmond R. Long is now an instructor in the department of pathology, University of Chicago, Chicago, Illinois, having been formerly on the staff of the Saranac Laboratory for the study of tuberculosis.

Mr. A. Lusskin, formerly on the chemical engineering staff (operating) of the Air Nitrates Corporation at the plant at Muscle Shoals, Ala., is now research chemist with the International Oxygen Company, Newark, N. J.

Dr. Horatio Wales, Jr., formerly chemist for the Evans Engineering Corporation, Old Bridge, N. J., is now chemical assistant to Mr. F. W. Hochstetter of the Recording and Computing Machines Company, Dayton, Ohio.

Mr. Charles V. Bacon, recently discharged from the service, while still holding a civil appointment as chief of the Research Section of the Engineering and Standardization Branch of the General Staff of the War Gas Investigations is also carrying on his work as chemical engineer, at 3 Park Row, New York City.

Mr. W. Faitoute Munn, formerly chemist in charge at the Baker & Adamson Works of the General Chemical Company, Easton, Pa., has accepted the position as chief chemist for the Brewster Film Corporation, East Orange, New Jersey.

Mr. J. Egbert Bishop, chemist, met his death recently while inspecting a 4.7 howitzer shell at the Picatinny Arsenal, Dover, N. J.

Mr. A. G. Greenamyer has accepted the position of metallurgist with the Donner Steel Company after serving as chief chemist and metallurgist with the Pittsburgh Crucible Steel Company, Pittsburgh, Pa.

Mr. Kenneth E. Bell, formerly 2nd Lieutenant in the Chemical Warfare Service at Edgewood Headquarters, is now working in the research laboratory of applied chemistry at the Massachusetts Institute of Technology under Doctors W. K. Lewis and R. E. Wilson.

Mr. Arnold H. Smith has resigned his position as assistant chemist in the Bureau of Standards, Washington, D. C., and has accepted a position in the research laboratory of the Goodyear Tire and Rubber Company, Akron, Ohio.

Mr. Robert F. Reed has resigned his position with the Ault & Wiborg Co. of Cincinnati, Ohio, as superintendent of their dye works at Norwood, Ohio, to accept a position with E. I. du Pont de Nemours & Co. in connection with the dye works at Deepwater Point, N. J.

Mr. T. Linsey Crossley, who has been associated for a number of years with Dr. J. T. Donald of Montreal and who established the Toronto laboratory of J. T. Donald and Co., consulting chemists, has taken over the Toronto office and laboratory of that firm at 43 Scott Street, and will there carry on the business of consulting chemist and chemical engineer.

Mr. George G. Wunder has resigned his position with the Rock Island Arsenal Laboratory to accept a position as assistant chief chemist of the A. O. Smith Corporation at Milwaukee, Wis.

Dr. Charles C. Scallione, formerly Lieutenant in the Research Division of the Chemical Warfare Service, has been appointed catalytic chemist of the Nitrates Division of the Ordnance Department and is now stationed at the Fixed Nitrogen Research Laboratory, American University, Washington, D. C.

Dr. Samuel C. Prescott, of the Massachusetts Institute of Technology, formerly Major in the Sanitary Corps, U. S. A., has been appointed expert in charge of dehydration investigations in the Bureau of Chemistry, Department of Agriculture, and will continue the investigations on this subject carried on during the war under the direction of the War Department.

Mr. J. P. Bonardi, assistant chemist, U. S. Bureau of Mines, who has been at the Seattle Station experimenting on flotation problems with W. H. Coghill, has returned to his assignment at the Golden, Col., Station.

Mr. Herbert Fleck has been appointed chief chemist, Crucible Steel Co., Pittsburgh, Pa., succeeding his brother, Mr. E. M. Fleck.

Mr. J. W. Howard has finished serving in the Ordnance Department of the Army and has resumed the practice of his profession as consulting engineer on roads and pavements with testing laboratory in Newark, N. J., and office in New York City.

Dr. R. F. Bacon, director of the Mellon Institute, is chairman of the committee of the American Institute of Chemical Engineers which is cooperating with the Government in the disposition of chemical plants and surplus stocks of chemicals and apparatus.

Mr. E. H. Claussen, recently discharged from military service, is with the Mine & Smelter Supply Co., 42 Broadway, New York City.

Mr. Thomas E. Fisher has resigned from the Wharton Steel Company and has become connected with the Traylor Engineering & Manufacturing Co., Allentown, Pa.

Mr. R. W. Hovey, of the Forest Products Laboratories of Canada, has resigned to accept a position with the Abitibi Power and Paper Co., Iroquois Falls, Ont.

Mr. Stuart B. Marshall, consulting engineer and metallurgist, has established his headquarters at Chevy Chase, Washington, D. C. He also retains his Roanoke, Va., address.

Capt. Edward Steidle has recently returned from Europe to resume his work with the Carnegie Institute of Technology, Pittsburgh, Pa. He will devote his time to the development of a mining department which will be in close contact with the industry.

Mr. Albert W. Davison, recently discharged from the Chemical Warfare Service, and formerly assistant professor in physical and electrochemistry at the University of Cincinnati, is now manager of the Virginia Haloid Company, Low Moor, Va.

Mr. Arthur D. Camp has been transferred from the Cleveland factory of the National Carbon Company to the American Ever-Ready Company, Long Island City, N. Y., where he has established a laboratory and general technical department.

Mr. James K. Plummer, formerly at Raleigh, associated with the North Carolina Experiment Station, has joined the staff of the Hercules Powder Company.

Mr. Eugene Waugh, president of the Waugh Chemical Corporation, 2 Rector Street, New York, died recently at New Rochelle, following an operation for stomach trouble. He was born in Jersey City in 1857. Mr. Waugh was with the General Chemical Company for fifteen years.

Mr. H. L. Marsh has resigned his position as works director and superintendent of the E. Virgil Neal Chemical Works, Long Island City, N. Y., to enter into manufacturing and consulting work on his own account. At present Mr. Marsh is president of the Norfolk Chemical Company, Inc., a newly formed corporation about to undertake the manufacture of a few special pharmaceutical chemicals and in addition he is director of the Marsh & Marshall Laboratories, consulting, research, and analytical chemists.

Mr. Samuel W. Epstein, formerly in charge of the Rubber Laboratory in Akron, Ohio, a branch of the Bureau of Standards in Washington, D. C., was recently called to Washington to take charge of rubber chemistry at that Bureau.

Mr. George H. Kimber, who was with the National Aniline & Chemical Company prior to his enlistment in the Air Service, U. S. A., has now been discharged from the latter and is with the United States Color & Chemical Co., at Ashland, Mass.

Mr. B. V. Reeves, who was discharged from the Army last March after serving at the United States Chemical Plant, Saltillo, Va., as superintendent of the retort department, with rank of 1st Lieutenant, Ordnance Corps, is now employed by the Farnam Cheshire Lime Co., Farnams, Mass., as chemical engineer.

Mr. Emory F. Almy, formerly serving as chemist at Fort Omaha at the hydrogen plant, and later transferred to the Chemical Warfare Service at Cleveland, is now chief chemist of the Lawrenceville, Pa., plant of the Nestle Food Company.

Dr. Samuel Avery, who served as Major in the Chemical Warfare Service during the war, has returned to the University of Nebraska.

Capt. O. L. Barneby, formerly commanding officer of the Defense Department, Development Division of the Chemical Warfare Service, at Nela Park, Cleveland, is now at the Nizor Laboratory of the Crouse Tremaine Co., Cleveland, Ohio.

Mr. G. O. Kildow, recently discharged from the Chemical Warfare Service, has been awarded a fellowship established by the Northwest Magnesite Company.

Dr. Benton Dales, formerly professor and head of the department of chemistry at the University of Nebraska, is now research chemist for the B. F. Goodrich Rubber Co., at Akron, Ohio.

Mr. R. P. Anderson has returned from overseas to his former position with the United Natural Gas Co., Oil City, Pa.

Mr. C. J. Engelder, who has been a lieutenant in the nitrate division of the Ordnance Department, carrying on research in connection with the operation of the United States Nitrate Plant No. 1, Sheffield, Ala., is now with William J. Knox, of New York City.

Mr. Byron S. Proper, who has been in the service for over a year, conducting water analysis for the Army in France, is now chief chemist and technical representative for the H. Reeve Angel & Co., Inc., New York City.

Mr. Archibald M. Erskine, formerly with the Chemical Warfare Service, Washington, D. C., is now with the du Pont Company at the Eastern Laboratory, Gibbstown, N. J.

Mr. Ismond E. Knapp, formerly chemical engineer and consulting chemist with the Technical Service Corporation, is now with du Pont Company at the Jackson Laboratory, Wilmington, Del.

Mr. Reginald H. Eagles, recently discharged from the Chemical Warfare Service, is now chemical engineer with the Dorr Company of New York City.

Mr. Clark M. Dennis, formerly with the Barrett Company, is at present with John E. Teeple, Ph.D., of New York City, as consulting and engineering chemist.

Mr. T. L. Nelson is now with the National Carbon Company, at Niagara Falls, N. Y., having formerly been with the Ansco Co., at Binghamton.

Lt. Lee F. Supple, of the Sanitary Corps, at present stationed at the Embarkation Hospital, Camp Stuart, Newport News, has been appointed assistant professor of organic chemistry at Lewis Institute, Chicago, and will take up his new duties at the beginning of the summer term.

Mr. R. W. Millar has been discharged from the First Gas Regiment, U. S. A., and has returned to the University of Illinois to do graduate work.

Dr. A. S. Loewenhardt, formerly chief of the Pharmacological Section, Research Division, Chemical Warfare Service, is again at his post as professor of pharmacology and toxicology, University of Wisconsin, Madison, Wis.

The honorary degree of doctor of science was conferred upon Dr. Raymond Foss Bacon, Director of the Mellon Institute of Industrial Research, on the occasion of the annual commencement of DePauw University, Greencastle, Ind., on June 11, 1919.

The election of the following officers for the ensuing year was recently announced at the annual meeting of the Manufacturing Chemists' Association in New York City: *President*, Thomas S. Grasselli; *Vice Presidents*, William Hamlin Childs and H. H. F. Handy; *Treasurer*, C. Wilbur Miller; and *Secretary*, Arthur H. Weed. The new executive committee consists of Henry Howard, *Chairman*, E. R. Grasselli, D. W. Jayne, Lancaster Morgan, J. D. Penrock, Chas. L. Reese, and A. C. Rosengarten.

Dr. Arthur W. Dox, after nineteen months' military service as Captain in the Sanitary Corps, has returned to his former position as chief of the chemistry section of the Iowa Agricultural Experiment Station.

Mr. Martin Kilpatrick, Jr., of the division of inorganic chemistry, the College of the City of New York, has accepted a position as assistant professor of chemistry at Vassar College.

Mr. W. E. Gouwens, who served in the Sanitary Corps, U. S. A., having been stationed at the Embarkation Depot at Newport News, Va., has returned to his position as curator of the Kent Chemical Laboratory, University of Chicago.

Mr. Wilbur F. Brown, formerly of Ball Brothers Glass Company at Muncie, Ind., has recently accepted a position in the laboratory of the Libby Owens Glass Company, at Kanawha Falls, W. Va.

Mr. John C. Jopling, formerly of Princeton, Ind., is now located at Barberton, Ohio, with the Diamond Match Company, and is developing some special machinery and processes which are used in the manufacture of a special match.

On the occasion of the annual commencement of the University of Pittsburgh on June 13, the honorary degree of doctor of engineering was conferred upon Mr. Van H. Manning, Director of the United States Bureau of Mines, in recognition of his noteworthy accomplishments in the investigation of problems of mineral technology. The University also conferred the honorary degree of doctor of chemistry upon Dr. Willis R. Whitney, Director of the Research Laboratory of the General Electric Company, Schenectady, N. Y., because of the valuable service which he rendered to the Government as a member of the Naval Consulting Board. These honorary degrees were given upon the recommendation of the Mellon Institute of Industrial Research, an integral part of the University of Pittsburgh.

Mr. Joseph E. Plumstead, until recently chief chemist and assistant superintendent for the Kingsport Pulp Corporation, of Kingsport, Tenn., has returned to the Celluloid Company, Newark, N. J., where he was at one time employed, to take charge of the production end of developed processes and to work on process development.

Mr. Felix Kremp, formerly with the Electric Reduction Company, Washington, Pa., is now connected with the Atlas Crucible Steel Company, as assistant metallurgist, Dunkirk, N. Y.

Dr. H. J. Broderon, formerly an instructor in industrial chemistry at the University of Illinois, is now with the Standard Oil Company located at Indiana.

Mr. E. L. Priest, formerly doing prescription and laboratory work in Joliet, Ill., is now with the William S. Merrell Chemical Company of Cincinnati, Ohio, doing pharmaceutical chemistry in their specialty department.

Lt. H. P. Gurney has been discharged from the Chemical Warfare Service, Gas Defense Division, and has returned to the Boston Belting Corporation to take charge of their technical division.

Miss Mildred E. Hinds, formerly assistant chemist, has been appointed chief chemist of the Food and Drugs Department of the state of Tennessee to succeed Mr. H. L. Walter, former chief chemist, who has resigned to take up work in Idaho.

Miss Helen Updegraff, formerly assistant research chemist of the Delaware College Agricultural Experiment Station, is now in charge of the chemical work at Columbia Hospital, Milwaukee, Wisconsin.

GOVERNMENT PUBLICATIONS

By R. S. McBRIDE, Bureau of Standards, Washington

NOTICE—Publications for which price is indicated can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. Other publications can usually be supplied from the Bureau or Department from which they originate. Commerce Reports are received by all large libraries and may be consulted there, or single numbers can be secured by application to the Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington. The regular subscription rate for these Commerce Reports mailed daily is \$2.50 per year, payable in advance, to the Superintendent of Documents.

INTERNAL REVENUE COMMISSIONER

Manual for Oil and Gas Industry under Revenue Act of 1918. 136 pp.

NATIONAL MUSEUM

Heretofore Undescribed Meteoric Stone from Kansas City, Missouri. B. P. MERRILL. Reprint No. 2259.

BUREAU OF CONSTRUCTION AND REPAIR

Gas Masks. Instructions for use of Navy gas masks, mark 2, head canister type. 13 pp.

Rivets. Specifications for riveting and reference data for use therewith. 69 pp.

NATIONAL ACADEMY OF SCIENCES

Report of National Academy of Sciences, Year 1918. 154 pp. Paper, 10 cents. Same as Senate Document 388.

DEPARTMENT OF LABOR WORKING CONDITIONS SERVICE

Investigation into Dermatic Effect and Infective Character of Lubricating Compound. F. E. DEEDS. 8 pp.

BUREAU OF EDUCATION

Statistics of State Universities and State Colleges, Year Ended June 30, 1918. Bulletin 51. 15 pp. Paper, 5 cents.

Commercial Education. F. V. THOMPSON. Bulletin 18. 81 pp. Paper, 5 cents.

Engineering Education. F. L. BISHOP. Bulletin 19. 8 pp. Paper, 5 cents.

Advanced Educational Work within Government Bureau. P. G. AGNEW. Higher Educational Circular 14. 7 pp. Issued February 1919.

FUEL ADMINISTRATION

Standardization of Petroleum Specifications Committee. Oil Division Bulletin 1. 11 pp. Reprint with slight changes of report for 1918.

PUBLIC HEALTH SERVICE

Biochemical Studies of the Saliva in Pellagra. M. X. SULLIVAN AND K. K. JONES. Public Health Reports. May 16, 1919. 12 pp.

Determination and Distribution of Arsenic in Certain Body Fluids after the Injection of Arsenobenzol, Salvarsan, and Neosalvarsan. C. N. MYERS. Public Health Reports. May 2, 1919. 10 pp.

GEOLOGICAL SURVEY

Cadmium in 1918. C. E. SEBENTHAL. Separate from Mineral Resources of the United States, 1918, Part I. 12 pp. Issued May 8, 1919.

The market for metallic cadmium was not good in the first half of 1918, and considerable stocks accumulated, amounting to 161,000 lbs. on August 31. Production was somewhat curtailed before August but more sharply curtailed after that time. The output during the first eight months of the year was

118,700 lbs. of metallic cadmium and 36,500 lbs. of cadmium sulfide, but for the last four months it was only 8,464 lbs. of metallic cadmium and 15,202 lbs. of cadmium sulfide.

There are several cadmium minerals, but none of them occurs in profitable quantities as ores. The cadmium of commerce is derived from zinc minerals and ores, in almost all of which it occurs in minute quantity, the ratio being about 1 of cadmium to 200 of zinc. Cadmium behaves metallurgically almost the same as zinc and hence constitutes a fraction of 1 per cent of almost all spelter. The sources of cadmium that have been utilized are zinc ores treated by fractional distillation, lead-furnace bag-house "fumes," and residues from the purification vats of electrolytic zinc plants and lithopone plants.

The maximum capacity for metallic cadmium reported by producers is 29,000 lbs. a month, or about 175 tons a year. This capacity will be increased by the entrance into the producing list of other electrolytic zinc plants. If the price of cadmium and the demand for it should justify expansion, the producing capacity could no doubt be brought up with reasonable promptness to 500 short tons or more yearly. The price of cadmium will be the deciding factor also in determining what grade of cadmium fumes can be worked at a profit.

Between February 1, 1918, and January 31, 1919, 42,320 lbs. of metallic cadmium, valued at \$63,020, or an average of \$1.49 per lb., were licensed for export to the countries listed, according to information furnished the War Trade Board. Of this quantity, 26,734 lbs. were licensed for export before June 30, 1918, and 15,586 lbs. between July 1 and December 10, 1918. It is believed that practically all of this cadmium was really exported.

In 1875 cadmium was quoted in the United States at \$3.20 per lb. In 1886 the average price for the total output of Germany was 80 cents per lb., but in 1890 and 1892 it fell to 38 cents. In 1897, because of certain purchases by the German government, the price rose to \$1.23 per lb. In 1907, when the United States began making cadmium, the German average price was 84 cents. The price in the United States went down to 53 cents in 1909, but it has been steadily rising since.

The price of cadmium in sticks and small bars in the first quarter of 1918 gradually declined from an average price of \$1.75 per lb. to \$1.40. In April and May the average price was \$1.40, and in June and July it was \$1.45. For the remainder of the year the quotation was \$1.50 per lb. The average price for 1918 as calculated from sales was \$1.48, as compared with \$1.47 in 1917 and with \$1.56 in 1916. The price in London during the first half of 1918 was \$1.90 per lb. and during the last half year slightly under that figure. The average selling price of cadmium sulfide in the United States in 1918 was \$1.36 per lb., as compared with \$1.41 in 1917 and with \$1.26 in 1916.

The value of the output of cadmium in the United States in 1918, calculated at the average selling price, was \$188,203, as compared with \$305,097 in 1917, and the value of the cadmium sulfide produced was \$70,315, as against \$70,939 in 1917.

The total value of the output of metallic cadmium in the United States since the beginning of production in 1907 is \$1,018,876 and of cadmium sulfide \$221,704, a total of \$1,240,580.

The Nenana Coal Field, Alaska. G. C. MARTIN. Bulletin 664. 54 pp. The coal of the Nenana field occurs in many beds of different thickness, the thickest measuring perhaps 30 or 33 ft., which are distributed rather uniformly through the coal measures. At least twelve beds are of workable thickness, and six or more measure over 20 ft. No geographic or stratigraphic variation in the character of the coal was noted. The analyses given on pages 8 and 9 show that the coal is a lignite of good grade.

of about the same quality as that of Cook Inlet. The coal will probably be used as locomotive fuel on the government railroad for generating power and for thawing at the mines in Tanana Valley, as domestic fuel in Tanana Valley, and as fuel on Tanana River boats and possibly on some of the Yukon steamers. Nenana coal, rather than the better and nearer Matanuska coal, should, if possible, be used on the greater part of the railroad, because the heavy freight traffic will be northbound, and the southbound empties will be available for hauling coal. The Nenana coal field is nearer the summit of the Alaska range than any known coal field south of the divide.

Natural-Gas Gasoline in 1917. J. D. NORTHROP. Separate from Mineral Resources of the United States, 1917, Part II. 21 pp. Issued March 17, 1919.

For the natural-gas gasoline industry in the United States the year 1917 was one of marked expansion in every phase. The quantity of raw gasoline recovered from natural gas in that year, including that produced by compression, by absorption, and by vacuum pumps, as well as that saved as drips from gas mains, was 217,884,104 gallons, a gain of 114,391,415 gallons, or 111 per cent, over the output in 1916. Of this quantity, 168,866,555 gallons, or 77.5 per cent, were recovered by compression and by vacuum pumps, and the remaining 49,017,549 gallons, or 22.5 per cent, by absorption and by salvage from gas mains. The combined gasoline obtained by compression and by vacuum pumps was greater than in 1916 by 83,943,768 gallons, or 99 per cent, and the gasoline obtained by absorption and from drips was greater by 30,447,647 gallons, or 164 per cent.

The quantity of commercial gasoline represented by the raw gasoline in 1917, though not susceptible of accurate determination, probably amounted to more than 300,000,000 gallons.

The average price received in 1917 for the raw gasoline at the sources of production was 18.45 cents a gallon, and the market value of the entire output was \$40,188,956, a gain of 4.6 cents in average unit selling price and of \$25,857,808, or 180 per cent, in gross market value, compared with 1916, which reflects the steadily appreciating value of motor fuels in the period under review.

The volume of natural gas from which the natural-gas gasoline was recovered in 1917 amounted to about 429,000,000,000 cubic feet, and the average recovery of gasoline per 1,000 cubic feet by all methods was about half a gallon.

The number of plants, including vacuum pump plants, recovering gasoline from natural gas increased from 596 at the beginning of 1917 to 886 at the end of that year, a gain of 49 per cent, and the combined daily capacity of all plants increased during the same period from 495,448 gallons to 902,385 gallons, or about 82 per cent.

Fuel Briquetting in 1918. C. E. LESHER. Separate from Mineral Resources of the United States, 1918, Part II. 3 pp. Issued April 30, 1919.

The production of fuel briquets in 1918 was 477,235 net tons, valued at \$3,212,793, an increase, compared with 1917, of 70,379 tons, or 17 per cent, in quantity and of \$978,905, or nearly 44 per cent, in value. The production in 1918 was the highest recorded and represented the third successive year of material progress in the industry, being more than double the output in 1915.

Of the 12 plants in operation in 1918, 6 used anthracite as a raw material, 1 Arkansas semianthracite, 1 semibituminous slack, 1 anthracite culm and bituminous slack, 1 bituminous slack and subbituminous coal, and 2 oil-gas residue. Six plants used coal-tar pitch and asphaltic pitch for binders, 1 used sulfite pitch, 3 used vegetable binders or other special processes in manufacturing, and 2 used no binder.

Gold and Silver in 1917. H. D. McCASKEY and J. P. DUNLOP. Separate from Mineral Resources of the United States, 1917, Part I. 47 pp. Issued May 9, 1919.

In addition to the production of gold and silver by domestic

smelters and refiners from domestic sources in 1917, amounting to 4,051,440 fine ounces of gold and 71,740,362 fine ounces of silver, these plants produced 769,171 fine ounces of gold and 50,106,811 fine ounces of silver from foreign ores. These figures represent a decrease of 31,634 ounces of gold and an increase of 3,855,794 ounces of silver compared with the corresponding figures for 1916. The foreign ores producing this bullion were mainly from Mexico and Canada.

The value of the new gold used in the arts and industries in the United States in 1917 was \$34,803,445, and the quantity of silver used for such purposes in 1917 was 15,998,807 fine ounces.

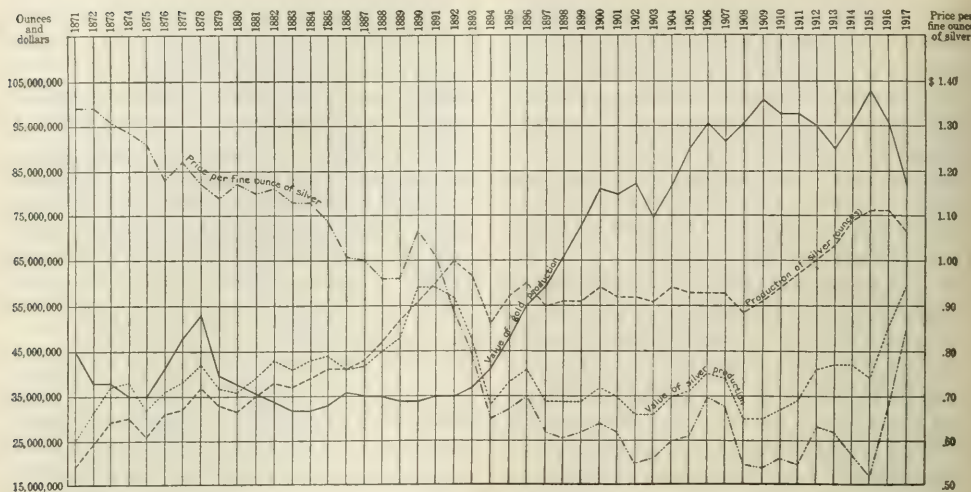
These figures show a total production of gold for the United States, from the earliest mining to the end of 1917, of 189,277,525 ounces, valued at nearly \$3,913,000,000, and an output of silver of nearly 2,380,000,000 ounces, valued at more than \$1,895,000,000. Although the production of gold was less than one-twelfth the output of silver in quantity, its value was more than twice that of the silver.

The average commercial value per fine ounce of silver for the 125 years contributing to the total domestic production was a little less than \$0.80. Fluctuations in value of silver per fine ounce are shown in the curve. It is of interest to note that the average value for the total output of silver was reached in 1893. For the years shown (1871 to 1917, inclusive) the average annual value was above \$0.80 before 1893, and has been below that figure every year since, until 1917, when the average value was \$0.8235, or 2.35 cents more than the average value 1871-1916.

A decrease in production of gold from mines of the United States of \$10,789,685 is shown for 1917, following a decrease of \$6,782,884 in 1916. A decrease of 8,209,645 ounces of silver is shown, following an increase of 6,506,298 ounces in 1916.

The average extraction values in gold and silver were comparatively high for the siliceous ores of Colorado, New Mexico, Nevada, Montana, Oregon, Utah, Idaho, Texas, and Washington, and low for the larger ore bodies of California, South Dakota, and Alaska. Some of the states produced comparatively small quantities of copper ore carrying high extraction values in gold and silver, but the copper ores of the important copper-producing states showed low extraction values. The average recovery in gold and silver from the copper ores of Arizona was \$0.41 a ton, that of Tennessee \$0.15 a ton, that of Montana \$1.63 a ton, that of Nevada \$0.26, that of New Mexico \$0.11, that of Utah \$0.27, that of California \$1.57, and that of Michigan \$0.18. The lead ores of Utah showed an average recovery in gold and silver of \$10.55 a ton, and the lead ores of Idaho only \$4.62 a ton. Idaho produced the largest quantity of gold- and silver-bearing lead ores, and also of lead-zinc ores. Utah yielded the next largest quantity of lead ore; but the gold and silver content of such ore was less than that of Montana ore of similar character. About 18.1 per cent of the output of ore considered as producing gold and silver was dry or siliceous ore, against 19.5 per cent in 1916; 73 per cent was copper ore, against 71.5 per cent in 1916; 3.71 per cent was lead ore; 4.16 per cent was lead-zinc ore; 0.95 per cent was zinc ore, and 0.05 per cent was copper-lead ore. The average precious-metal extraction value per ton of siliceous ores of the United States decreased from \$5.73 to \$5.56, that of zinc ores from \$1.21 to \$0.90, and that of copper-lead ores increased from \$5.54 to \$14.58. The average gold and silver value of copper ores per ton was 51 cents in 1916 and 49 cents in 1917, and that of lead-zinc ores increased from \$2.31 to \$2.82.

It has been estimated by H. D. McCaskey that the consumption of quicksilver in the amalgamation process in the United States (including Alaska) for the period 1911 to 1917, inclusive, has varied between 90,000 and 100,000 lbs. annually. The consumption at mills treating ore and by dredging and other methods of placer mining are given in the separate chapter



CURVES SHOWING PRODUCTION AND VALUE OF GOLD AND SILVER AND PRICE PER FINE OUNCE OF SILVER IN THE UNITED STATES, 1871-1917

entitled "Quicksilver in 1917," prepared by F. L. Ransome and published elsewhere in Mineral Resources for 1917.

It has not been possible to obtain a complete report showing the total consumption of potassium cyanide and sodium cyanide used in the recovery of gold and silver in the United States in 1917. If the quantity used in California, Alaska, and Oregon is added to the 3,710,886 lbs. reported to have been used in other western states the estimated total consumption was probably several hundred tons less than the estimated quantity, 2,600 tons, consumed in 1916.

The figures given indicate the elimination of the use of potassium cyanide in the recovery of gold and silver, for only about 69 tons were used in 1917 and this was probably from old stocks at mines. The growing scarcity of potassium cyanide necessarily increased the use of sodium cyanide. The domestic supply of sodium cyanide was sufficient to supply the domestic consumption. As the quantity of bullion recovered was less in 1917 than in 1916, however, the quantities of quicksilver and of cyanide used were less. The quantity of cyanide used per ton of ore or tailings treated and the quantity of gold and silver recovered per pound of cyanide show considerable variations. These variations are doubtless due in part to greater efficiency in large milling plants in some of the states but are mainly caused by the difference in the character and varying metal content of the ores treated.

Clay-Working Industries and Building Operations in the Larger Cities in 1917. J. MIDDLETON. Separate from Mineral Resources of the United States, 1917, Part II. 62 pp. Issued May 12, 1919.

The total value of all clay products marketed in 1917 was \$248,023,368—an increase of \$40,763,277, or nearly 20 per cent. In 1916 the increase over 1915 was \$44,139,859, or 27 per cent. In 1917 brick and tile products, embracing structural products, engineering refractories, and miscellaneous wares—the coarser clay products—were valued at \$191,860,846, or more than 77 per cent of the total, and pottery products were valued at \$56,162,522, or nearly 23 per cent of the total. Brick and tile products increased in value \$32,817,997, or nearly 21 per cent, and pottery products increased \$7,945,280, or more than 16 per cent, compared with 1916.

The most noteworthy features of the year were (1) the large increase in the quantity and value of fire brick; (2) the decrease in the quantity and value of common brick, especially in the Hudson River region; (3) the large increase in the value of hollow building tile; and (4) the successful manufacture of glasshouse pots for optical glass from domestic clays.

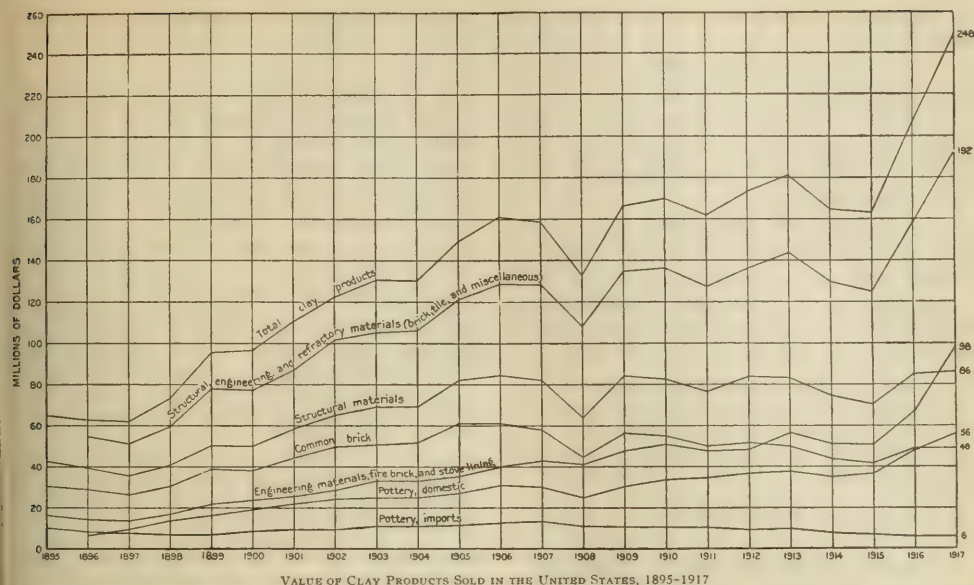
The engineering products and refractory brick—vitrified brick, draintile, sewer pipe, fire brick, and stove lining—valued at \$98,085,793, increased \$30,469,293, or 45 per cent, and the clay structural materials, valued at \$85,659,887, made a net increase of \$1,016,635, or 1 per cent, in 1917, compared with 1916.

The increase in refractories was caused principally by the demand for these wares in the munitions industries, and especially in the erection of by-product coke ovens, which require a very high-grade refractory, though the use of refractories for other purposes is increasing rapidly with the industrial development of the country. One who is unfamiliar with the many uses of refractories finds it difficult to realize their importance. They are absolutely essential to the iron and steel industries, the basis of our modern industrial development; they are used in railroad locomotives and in steamships, in the manufacture of lead and zinc, in the manufacture of glass, in the baking of bread, in the tanning of leather, in the burning of many clay products, in kitchen stoves and ranges, and almost everywhere else that fires are used, either for the generation of power or for heat.

The large decrease in common brick was caused principally by the decrease in building operations throughout the country, but it may be attributed in part to the increased and increasing use of hollow building tile.

The imports of clay products, 97 to 98 per cent of which are pottery, which have in recent years been decreasing, in 1917 showed an increase of \$876,908, or 15 per cent, compared with 1916. This increase was principally in pottery—\$732,729. Owing to the unusual demand at home, however, this increase had little or no effect on the domestic production, the proportion of which to consumption was 92 per cent, the same as for 1916 and the highest recorded.

The exportation of clay products, an unimportant factor in the industries, showed another large increase in 1917 and reached the maximum value—\$6,953,263, which was \$1,952,368, or



VALUE OF CLAY PRODUCTS SOLD IN THE UNITED STATES, 1895-1917

39 per cent, greater than the previous maximum in 1912. Fire brick continues to be the principal clay product exported.

VALUE OF THE CLAY PRODUCTS OF THE UNITED STATES IN 1916 AND 1917, AND INCREASE OR DECREASE IN 1917, BY PRODUCTS

PRODUCTS	1916	1917	Increase or Decrease in 1917	
			Value	Per cent
Common brick.....	\$ 49,357,411	\$ 47,936,344	— 1,421,067	— 2.88
Vitrified brick or block.....	12,236,890	10,664,560	— 1,572,330	—12.85
Front brick.....	11,464,614	10,391,368	— 1,073,246	— 9.36
Fancy or ornamental brick.....	109,072	192,072	+ 83,000	+76.10
Enamelled brick.....	827,443	889,890	+ 62,456	+ 7.55
Drain tile.....	10,083,642	11,008,163	+ 924,516	+ 9.17
Sewer pipe.....	13,577,006	17,307,211	+ 3,730,205	+27.47
Architectural terra cotta.....	6,466,336	6,173,550	— 292,786	— 4.53
Fireproofing and hollow building tile.....	9,942,912	13,255,433	+ 3,312,521	+33.32
Pipe, not drain.....	6,475,464	6,821,221	+ 345,757	+ 5.34
Glove lining.....	601,776	619,882	+ 18,106	+ 3.01
Fire brick.....	30,806,129	58,012,264	+ 27,206,135	+88.31
Miscellaneous.....	7,094,149	8,588,879	+ 1,494,730	+21.07
Total brick and tile.....	\$159,042,849	\$191,860,846	+ \$32,817,997	+20.63
Total pottery.....	48,217,242	56,162,522	+ 7,945,280	+16.48
GRAND TOTAL.....	\$207,260,091	\$248,023,368	+ \$40,763,277	+19.67

BUREAU OF STANDARDS

A Study of the Goutal Method for Determining Carbon Monoxide and Carbon Dioxide in Steels. J. R. CAIN and E. PETTIJOHN. Technologic Paper 126. 8 pp. Issued April 30, 1919.

Standard Samples Issued or in Preparation. Supplement to Circular 25. 6 pp. Issued April 1, 1919.

Silica Refractories: Factors Affecting Their Quality and Methods of Testing the Raw Materials and Finished Ware. D. W. ROSS. Technologic Paper 116. 84 pp. Paper, 20 cents. Issued April 19, 1919.

Aluminum and Its Light Alloys. Circular 76. 120 pp. Paper, 20 cents. Issued April 21, 1919. The circular deals primarily with the physical properties of the metal or alloy. All other features, except a few statistics of production and such methods of manufacture, presence of impurities, etc., are discussed only in their relation to these physical properties. It must be realized that the physical properties of metals and alloys are often in great degree dependent upon such factors, so that

the statement of values for such properties should include accompanying information regarding these factors by which the properties are affected.

The endeavor, therefore, in the circular is to reproduce only such data as have passed critical scrutiny and to suitably qualify in the sense outlined above all statements, numerical or otherwise, made relative to the characteristics of the metal. The data and information have been put in the form of tables and curves, the curves being reproduced in such dimensions that accurate interpolation of values on them is possible by the use of a rule graduated in decimal parts of a centimeter. The probable degree of accuracy of data is indicated or implied by the number of significant figures in the values given.

Viscosity of Gasoline. W. H. HERSCHEL. Technologic Paper No. 125. 18 pp. Paper, 5 cents. Issued May 5, 1919.

DEPARTMENT OF AGRICULTURE

A Simple Steam Sterilizer for Farm Dairy Utensils. S. H. AYERS and G. B. TAYLOR. Farmers' Bulletin 748. Revised. 16 pp.

Muscadine Grape Paste. C. DEARING. Farmers' Bulletin 1033. 15 pp. This is a contribution from the Bureau of Plant Industry. It gives directions for securing suitable fruit, the extraction of the pulp, and the sweetening, cooking, drying, and storing of the product, as well as the making of various combinations, fancy pastes, and pastes from other fruits.

Digestibility of Certain Miscellaneous Animal Fats. A. D. HOLMES. Department Bulletin 613. 25 pp. Paper, 5 cents. Issued April 25, 1919. This paper deals with the digestibility of goat's butter, kid fat, hard palate fat, horse fat, oleo oil, oleo stearin, ox-marrow, ox-tail, and turtle fats.

Experiments on the Digestibility of Wheat Bran in a Diet without Wheat Flour. A. D. HOLMES. Department Bulletin 751. 20 pp. Paper, 5 cents. Issued April 22, 1919. This gives the results of experiments made to secure data on the digestibility of wheat that will be of value in determining the most economical and physiologically efficient method of utilizing wheat for human food.

A Comparison of Concentrates for Fattening Steers in the South. W. F. WARD, S. S. JERDAN AND E. R. LLOYD. Department Bulletin 761. 16 pp. Paper, 5 cents. Issued April 7, 1919. Contribution from the Bureau of Animal Industry. This is a comparison of the values of different mixtures of cottonseed meal, cake, broken ear and shelled corn for fattening purposes.

Production of Lumber, Lath, and Shingles in 1917. F. H. SMITH AND A. H. PIERSON. Department Bulletin 768. 44 pp. Paper, 10 cents. Issued April 5, 1919.

A National Lumber and Forest Policy. H. S. GRAVES. Circular 134, Office of the Secretary. 14 pp. Paper, 5 cents. Issued April 1919. This consists of an address before the American Lumber Congress, Chicago, April 16, 1919.

List of Workers in Subjects Pertaining to Agriculture, Home Economics, and Marketing, 1918-1919. 162 pp. This was prepared in the States Relations Service and is not available for free distribution.

Articles from the Journal of Agricultural Research

Meat Extracts, Their Composition and Identification. J. A. EMERY AND R. R. HENLEY. 17, No. 1 (April 15).

Quantity and Composition of Ewes' Milk: Its Relation to the Growth of Lambs. R. E. NEIDIG AND E. J. IDINGS. 17, No. 1 (April 15).

Seed Disinfection by Formaldehyde Vapor. C. C. THOMAS. 17, No. 1 (April 15).

BUREAU OF FOREIGN AND DOMESTIC COMMERCE

Industrial Standards Series. Text as adopted by American Society for Testing Materials. Spanish-English editions prepared under supervision of Bureau of Standards. Series covers industrial standards for materials, which includes standards prepared by Government and by technical societies and other organizations.

14—Standard specifications for carbon steel car and tender axles. Revised 1918. 15 pp. 5 cents.

24—Standard specifications for staybolt iron. Revised 1918. 15 pp. 5 cents.

26—Standard specifications for refined wrought-iron bars. Revised 1918. 16 pp. 5 cents.

29—Standard specifications for cast-iron locomotive cylinders. Revised 1914. 15 pp., 4 text figs. 5 cents.

30—Standard specifications for extra-high-carbon steel splice bars. Revised 1914. 15 pp., 2 text figs. 5 cents.

34—Standard specifications for structural nickel steel. Revised 1916. 21 pp., 4 text figs. 5 cents.

35—Standard specifications for structural steel for cars. Revised 1916. 19 pp., 2 text figs. 5 cents.

36—Standard specifications for structural steel for ships. Revised 1916. 19 pp., 2 text figs. 5 cents.

37—Standard specifications for rivet steel for ships. Revised 1914. 17 pp., 4 text figs. 5 cents.

38—Standard specifications for billet-steel concrete-reinforcement bars. Revised 1914. 17 pp.

45—Standard specifications for iron and steel chain. Revised 1918. 19 pp. 5 cents.

47—Standard specifications for cast-iron car wheels. Adopted 1905. 21 pp. 5 cents.

48—Standard specifications for malleable-iron castings. Revised 1915. 13 pp., 2 text figs. 5 cents.

51—Standard specifications for medium hard-drawn copper wire. Revised 1915. 21 pp. 5 cents.

COMMERCE REPORTS—MAY 1919

In a Swedish summary of the dyestuff situation, it is stated that the United States is more than supplying its own needs, while in England, France, and Italy there is still a shortage. (P. 630)

France, once first in beet sugar production and fourth, in 1914, has suffered very serious loss in this industry, owing to destruction of plants and farms, and to removal by the Germans of machinery, etc. A marked shortage of sugar in France is therefore feared for some years. (Pp. 643-4)

The process for continuous distillation of coal tar, devised in England by H. P. Hird, is now in operation in over 130 plants in England, Japan, and Australia. (P. 692)

Detailed locations are given of deposits of gold, iron, coal, copper, manganese, tin, sulfur, antimony, salt, sodium sulfate, petroleum, graphite, mica, asbestos, fire clay, and precious stones in Siberia. (Pp. 726-38)

A new research association has been organized in the British motor trade to conduct research partly supported by government funds. Among the subjects for study are motor fuels and materials for springs, etc. (P. 766)

The United States is now purchasing about 70 per cent of the output of Banca tin. (Pp. 778-9)

The British Scientific Products Exhibition, to be held in London, July 3 to August 5, will include sections devoted to agriculture, aircraft, chemistry, education, electrical appliances, engineering, fuels, medicine, surgery, metallurgy, paper, physics, and textiles; with lectures and demonstrations. (P. 793)

Deposits of phosphorite containing 25 to 30 per cent of phosphate have been discovered in Netherlands, and will help to relieve the fertilizer situation. (P. 795)

The War Trade Board has appointed a committee of eight persons, four representing dye manufacturers, and four, dye consumers, to advise as to the extent to which importation of German dyes into this country is necessary. (P. 901)

A survey of Belgian industries shows that the coal mines were not seriously damaged; the steel plants were badly wrecked and dismantled; the pottery and glass industries can soon resume work; the sulfuric acid plants have suffered very severely; the soda plants and powder plants are in fair condition; the paper mills were badly stripped and can resume only partial operation. Detailed organizations have been developed for renewal of industries, and preliminary estimates of requirements have been made. (Pp. 902-13)

The manufacture of casein, and its use as a dry powder in bread, etc., is described. Other uses are in adhesives, plastics, etc. France is the largest producer. (Pp. 939-41)

Hydrogenation is being used in South Africa to produce stearin for candles. The hydrogen is obtained by electrolysis of water, the oxygen being sold as a by-product for acetylene welding. (Pp. 1022-3)

Great efforts are being made to expand the flax and flaxseed industry in Canada. (Pp. 1031-4)

The materials and methods used in the soap industry of South Africa are described in detail. (Pp. 1049-54)

Most of the pulp wood in Canada is used in ground wood and the balance chiefly in sulfate and sulfite pulp, with only a small amount of soda pulp. Much of this is made into paper in Canada for export. (Pp. 1059-61)

SUPPLEMENTS ISSUED

NORWAY—10a
CANADA—23a

COLOMBIA—42a
PORTUGUESE EAST AFRICA—76a

STATISTICS OF EXPORTS TO THE UNITED STATES

MOZAMBIQUE—Sup. 76a	COLOMBIA—Sup. 42a	Gum kauri
Antimony	Asphalt	Chrome ore
Beeswax	Balsam tolu	Copper ore
Copal gum	Copaiba	Copper
Copra	Divi-divi	Explosives
Corundum	Fustic	Gold
Rubber	Indigo	Hides
Mangrove bark	Ipecac	Rubber
FRANCE—P. 1012	Mangrove bark	Iron
Alcohol	Gold	Lime
Chemicals	Silver	Fish oil
Glue	Hides	Lubricating oil
Hides	Rubber	Cottonseed oil
Rubber	Platinum	Sugar-beet seed
Oils	BRITISH COLUMBIA—	Silver
Perfumery	Sup. 23a	Kelp ash
Soap	Brick	Zinc ore
Pottery	Cascara bark	Manganese ore
Glass	Gum copal	

NEW PUBLICATIONS

By CLARA M. GUPPY, Librarian Mellon Institute of Industrial Research, Pittsburgh

- Assaying: Textbook of Practical Assaying.** JAMES PARK. 5th Ed. 8vo. 354 pp. Price, 9s. Charles Griffin & Co., London.
- Cheese Making: A Book for Practical Cheesemakers, Factory Patrons, Agricultural Colleges, and Dairy Schools.** J. L. SAMMIS. 6th Ed. Entirely rewritten. 8vo. 225 pp. Price, \$1.90. Mendota Book Co., Madison, Wis.
- Chemical Science: What Industry Owes to Chemical Science.** R. B. PILCHER AND FRANK BUTLER-JONES. 12mo. 150 pp. Price, \$1.50. D. Van Nostrand Co., New York.
- Chemistry: Opportunities in Chemistry.** ELLWOOD HENDRICK. 12mo. 101 pp. Price, \$0.75. Harper & Brothers, New York.
- Civil Engineer's Pocket-Book.** J. C. TRAUTWINE. 20th Ed. 16mo. 1608 pp. Price, \$6.00. Trautwine Co., 257 S. 4th St., Philadelphia.
- Colloid Chemistry: An Introduction with Some Practical Applications.** JEROME ALEXANDER. 16mo. 90 pp. Price, \$1.00. D. Van Nostrand Co., New York.
- Colloids: An Introduction to the Physics and Chemistry of Colloids.** EMIL HATSCHEK. 3rd Ed. 8vo. 116 pp. Price, 4s. 6d. J. & A. Churchill, London.
- Cotton: Information Concerning the Raw Material, Its Preparation, and the Manufactured Products.** GEORGE BIGWOOD. 12mo. 206 pp. Price, \$1.60. Henry Holt & Co., New York.
- Graphical and Mechanical Computation.** JOSEPH LIPIKA. 372 pp. Price, \$4.00. John Wiley & Sons, Inc., New York.
- Hydrogenation of Oils: Catalysts and Catalysis of the Generation of Hydrogen and Oxygen.** CARLETON ELLIS. 2nd Ed. Revised and enlarged. 8vo. 767 pp. Price, \$7.50. D. Van Nostrand Co., New York.
- Industrial Electrical Measuring Instruments.** K. W. E. EDGEUMBE. 2nd Ed. Revised and enlarged. 8vo. 413 pp. Price, \$5.00. D. Van Nostrand Co., New York.
- Inks: Printing Inks; Their Composition, Properties, and Manufacture.** Reprinted by permission from Circular No. 53, United States Bureau of Standards. Together with some helpful suggestions about the everyday use of printing inks. PHILIP RUXTON. 8vo. 71 pp. United Typothetae of America, Committee on Education, Boston.
- Metallic Alloys: Their Structure and Constitution.** G. H. CULLIVER. 3rd Ed. 8vo. 446 pp. Price, 12s. 6d. Charles Griffin & Co., London.
- Oxy-Acetylene Welding Manual.** LORN CAMPBELL, JR. 8vo. 154 pp. Price, \$1.25. John Wiley & Sons, Inc., New York.
- Paper: How Paper is Made; A Primer of Information about the Materials and Processes of Manufacturing Paper for Printing.** W. B. WHEELWRIGHT. 8vo. 59 pp. United Typothetae of America, Committee on Education, Boston.
- Physical Chemistry: A System of Physical Chemistry.** W. C. McLEWIS. 3 Vols. 2nd Ed. Price, Vol. 1, 15s.; Vol. 2, 15s.; Vol. 3, 7s. 6d. Longmans, Green & Co., London.
- Rocks: Manual of the Chemical Analysis of Rocks.** H. S. WASHINGTON. 3rd Ed. Revised and enlarged. 8vo. 271 pp. Price, \$2.50. John Wiley and Sons, Inc., New York.
- Vegetable Oils: Production and Treatment of Vegetable Oils.** T. W. CHALMERS. 4to. 152 pp. Price, \$7.50. D. Van Nostrand Co., New York.
- Wool: Information Concerning the Raw Material, Its Preparation, and the Manufactured Products.** FRANK ORMEROD. 12mo. 221 pp. Price, \$1.60. Henry Holt & Co., New York.
- ## RECENT JOURNAL ARTICLES
- Acetone Oils: Examination of Acetone Oils.** W. J. JONES. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 9, pp. 108-110.
- Adsorption by Precipitates.** H. B. WEISER AND J. L. SHERRICK. *Journal of Physical Chemistry*, Vol. 23 (1919), No. 4, pp. 205-252.
- Alkali: Determination of Alkali in Permanganate Liquors.** T. J. I. CRAIG. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 8, pp. 96-97.
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- Cloth: Notes on the Quantitative Testing of Rainproof and Waterproof Cloth.** GEOFFREY MARTIN AND JAMES WOOD. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 7, pp. 84-87.
- Coke: Precautions Necessary in Grinding Samples of Coke for Analysis.** A. E. FINDLEY. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 7, pp. 931-941.
- Dolomites: Some American Dolomites.** BURLEIGH B. REED. *Chemical News*, Vol. 118 (1919), No. 3079, pp. 181-183.
- Fertilizers: The Setting of Mixtures of Superphosphate and Ammonium Sulfate.** F. S. FOWWEATHER. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 9, pp. 110-112.
- Gases: Device for Measuring Small Quantities of Moisture in Gases.** A. J. CROCKETT AND R. B. FORSTER. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 8, pp. 95-96.
- Graphite Crucibles: Behavior Under Brass Foundry Practice of Crucibles Containing Ceylon, Canadian, and Alabama Graphites.** R. T. STULL. *Journal of the American Ceramic Society*, Vol. 2 (1919), No. 3, pp. 208-226.
- Indophenine Reaction.** EDWARD WRAY. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 7, pp. 83-84.
- Lamp Industry: Chemistry and Chemical Control in the Lamp Industry.** ALBERT BRANN AND A. M. HAGEMAN. *The Electric Journal*, Vol. 16 (1919), No. 5, pp. 198-201.
- Leaching of Oxidized Copper Ores with Ferric Chloride.** R. W. PERRY. *Mining and Scientific Press*, Vol. 118 (1919), No. 20, pp. 669-674.
- Leather: Colloid Chemistry of Tanning.** H. R. PROCTER. *Journal of the American Leather Chemists Association*, Vol. 14 (1919), No. 5, pp. 278-299.
- Leather: Determination of Total, Soluble, and Insoluble Ash in Leather.** J. M. SELTZER. *Journal of the American Leather Chemists Association*, Vol. 14 (1919), No. 5, pp. 243-255.
- Leather: The Resurrection of Unchromed Hide Leather.** R. H. WISDOM AND W. A. WELDER. *Journal of the American Leather Chemists Association*, Vol. 14 (1919), No. 5, pp. 239-243.
- Leather Belting: Specifications for Leather Belting. Twelve Requirements to Control Quality from Viewpoint of Use.** H. A. HEY. *Paper*, Vol. 24 (1919), No. 9, pp. 18-22.
- Linseed Oil: Polymerized and Oxidized Linseed Oil.** HARRY INGLE AND A. WOODMANSEY. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 8, pp. 101-104.
- Metals: Vapor Tensions of the Metals.** J. W. RICHARDS. *Journal of the Franklin Institute*, Vol. 187 (1919), No. 5, pp. 591-598.
- Nickel: A Process for Electrolytically Refining Nickel.** G. A. GUESS. *The Canadian Chemical Journal*, Vol. 3 (1919), No. 5, pp. 148-149.
- Nitro Derivatives of Benzene and Toluene.** E. NORLINO. *Color Trade Journal*, Vol. 4 (1919), No. 5, pp. 120-122.
- Nitrous Acid: The Decomposition of Nitrous Acid.** JOSEPH KNOX AND D. M. REID. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 9, pp. 105-108.
- Paint: The White Pigments; a Summary of the Developments of White Paint Pigments, with a Survey of Present Practice and the Magnitude of These Industries.** S. J. COOK. *The Canadian Chemical Journal*, Vol. 3 (1919), No. 5, pp. 145-147.
- Paper: Chemistry of Wood Pulp Production.** ARTHUR KLEIN. *Paper*, Vol. 24 (1919), No. 10, pp. 15-19.
- Paper: A Study of Beater Consistency Changes; the Hydration of Cellulose as Applied to Paper-Making.** W. H. GESSELL AND J. E. MINOR. *Paper*, Vol. 24 (1919), No. 12, pp. 15-19.
- Paper-Making: Clays for Use in Paper-Making.** R. B. ROE. *Paper*, Vol. 24 (1919), No. 10, pp. 22-23.
- Phosphate Industry.** JAMES HENDRICK. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 9, pp. 155-157.
- Porcelain: The Effect of Time and Temperature on the Microstructure of Porcelain.** A. B. PECK. *Journal of the American Ceramic Society*, Vol. 2 (1919), No. 3, pp. 175-194.
- Rubber-Sulfur Mixtures: The Tensile Strength of Rubber-Sulfur Mixtures.** O. DE VRIES AND H. J. HELLENDORF. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 7, pp. 91-93.
- Sodammonium Sulfate, a New Fertilizer. The Utilization of Niter Cake in the Fixation of Ammonia.** H. M. DAWSON. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 8, pp. 98-101.
- Steel: Hot Deformation and the Quality of Steel. Three Experiments Determining the Effect on Tensile Strength and Impact Values.** GEORGES CHARPY. *The Iron Age*, Vol. 103 (1919), No. 17, pp. 1079-1081.
- Steel: Non-Metallic Impurities in Steel.** H. D. HIBBARD. *The Iron Age*, Vol. 103 (1919), No. 22, pp. 1427-1429.
- Sulfurous Acid: The Volumetric Determination of Sulfurous Acid.** T. J. I. CRAIG. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 8, p. 96.
- Tanning Materials: Notes on Australian Tanning Materials and the Manufacture of Sole Leather.** F. A. COOMBS. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 6, pp. 70-74.
- Tellurium: A Study of the Preparation of Certain Organic Salts of Tellurium.** A. M. HAGEMAN. *Chemical News*, Vol. 118 (1919), No. 3078, pp. 169-171.

MARKET REPORT—JUNE, 1919

WHOLESALE PRICES PREVAILING IN THE NEW YORK MARKET ON JUNE 15, 1919

INORGANIC CHEMICALS

Acetate of Lime, Basis 80%.....	100 Lbs.	2.00	@	2.05
Alum, ammonia, lump, U. S. P.....	100 Lbs.	4.25	@	4.50
Aluminum Sulfate, (iron free).....	Lb.	3	@	3 1/4
Ammonium Carbonate, domestic.....	Lb.	13	@	13 1/4
Ammonium Chloride, white.....	Lb.	19	@	20
Aqua Ammonia, 26°, drums.....	Lb.	6 1/4	@	7
Arsenic, white.....	Lb.	8 1/2	@	9
Barium Chloride.....	Ton	65.00	@	85.00
Barium Nitrate.....	Lb.	12	@	14
Barytes, prime white, foreign.....	Ton	30.00	@	35.00
Bleaching Powder, 35 per cent, Works.....	100 Lbs.	1.50	@	1.60
Blue Vitriol.....	Lb.	7 1/4	@	7 3/4
Borax, crystals, in bags.....	Lb.	7 1/4	@	10 1/4
Boric Acid, powdered crystals.....	Lb.	13 1/4	@	14
Brimstone, crude, domestic.....	Long Ton	28.00	@	35.00
Bromine, technical, bulk.....	Lb.	75	@	
Calcium Chloride, lump, 70 to 75% fused.....	Ton	18.00	@	22.00
Caustic Soda, 76 per cent.....	100 Lbs.	2.95	@	3.05
Chalk, light precipitated.....	Lb.	4 1/4	@	5
China Clay, imported.....	Ton	20.00	@	30.00
Feldspar.....	Ton	8.00	@	15.00
Fuller's Earth, foreign, powdered.....	Ton	nominal		
Fuller's Earth, domestic.....	Ton	20.00	@	30.00
Glauber's Salt, in bbla.....	100 Lbs.	2.10	@	3.00
Green Vitriol, bulk.....	100 Lbs.	2.00	@	2.25
Hydrochloric Acid, commercial, C. P.....	Lb.	8	@	8 1/4
Iodine, resublimed.....	Lb.	4.25	@	4.30
Lead Acetate, white crystals.....	Lb.	14	@	15
Lead Nitrate, C. P.....	Lb.	85	@	
Litharge, American.....	Lb.	9 1/4	@	10
Lithium Carbonate.....	Lb.	1.50	@	
Magnesium Carbonate, U. S. P.....	Lb.	21	@	22
Magnetite, "Calcined".....	Ton	60.00	@	65.00
Nitric Acid, 40°.....	Lb.	7.50	@	7.75
Nitric Acid, 42°.....	Lb.	8.00	@	8.50
Phosphoric Acid, 48/50%.....	Lb.	26	@	30
Phosphorus, yellow.....	Lb.	35	@	40
Plaster of Paris.....	100 Lbs.	2.00	@	2.50
Potassium Bichromate.....	Lb.	26	@	27
Potassium Bromide, granular.....	Lb.	1.25	@	1.30
Potassium Carbonate, calcined, 80 @ 85%.....	Lb.	15	@	17
Potassium Chlorate, crystals, spot.....	Lb.	28	@	30
Potassium Cyanide, bulk, 98-99 per cent.....	Lb.	nominal		
Potassium Hydroxide, 88 @ 92%.....	Lb.	60	@	70
Potassium Iodide, bulk.....	Lb.	3.30	@	3.50
Potassium Nitrate.....	Lb.	27	@	30
Potassium Permanganate, bulk, U. S. P.....	Lb.	55	@	65
Quicksilver, flask.....	75 Lbs.	92.00	@	
Red Lead, American, dry.....	100 Lbs.	10.25	@	10.75
Salt Cake glass makers'.....	Ton	17.50	@	22.00
Silver Nitrate.....	Oz.	65	@	67
Soapstone, in bags.....	Ton	10.00	@	12.50
Soda Ash, 58%, in bags.....	100 Lbs.	1.70	@	1.80
Sodium Acetate, broken lump.....	Lb.	8 1/4	@	10 1/4
Sodium Bicarbonate, domestic.....	100 Lbs.	2.45	@	2.50
Sodium Bichromate.....	Lb.	9	@	10
Sodium Chlorate.....	Lb.	15	@	17
Sodium Chloride.....	Lb.	29	@	30
Sodium Fluoride, commercial.....	Lb.	14	@	15
Sodium Hyposulfite.....	100 Lbs.	2.60	@	3.60
Sodium Nitrate, 95 per cent, spot.....	100 Lbs.	4.07 1/4	@	
Sodium Silicate, liquid, 40° Bé.....	Lb.	1 1/4	@	2
Sodium Sulfate, 60%, fused in bbla.....	Lb.	3 1/4	@	3 1/4
Sodium Bisulfate, powdered.....	Lb.	5	@	7
Strontium Nitrate.....	Lb.	25	@	30
Sulfur.....	100 Lbs.	2.25	@	4.60
Sulfuric Acid, chamber 66° Bé.....	Ton	16.50	@	18.50
Sulfuric Acid, oleum (fuming).....	Ton	23.00	@	
Talc, American, white.....	Ton	15.00	@	
Terra Alba, American, No. 1.....	100 Lbs.	1.17 1/4	@	
Tin Bichloride, 50°.....	Lb.	26	@	28
Tin Oxide.....	Lb.	65	@	70
White Lead, American, dry.....	Lb.	9	@	9 1/4
Zinc Carbonate.....	Lb.	18	@	20
Zinc Chloride, commercial.....	Lb.	14	@	14 1/4

ORGANIC CHEMICALS

Acetanilid, C. P., in bbla.....	Lb.	38	@	40
Acetic Acid, 56 per cent, in bbla.....	100 Lbs.	5.75	@	6.00
Acetic Acid, glacial, 99 1/2%.....	100 Lbs.	12.00	@	12.25
Acetone, drums.....	Lb.	13 1/4	@	16
Alcohol, denatured, 180 proof.....	Gal.	40	@	43

Alcohol, Ethyl, non-beverage, 190 proof.....	Gal.	4.70	@	4.95
Alcohol, wood, 95 per cent, refined.....	Gal.	1.22	@	1.24
Amyl Acetate.....	Gal.	3.75	@	3.85
Aniline Oil, drums extra.....	Lb.	23	@	24
Benzoic Acid, ex-toluol.....	Lb.	1.00	@	1.10
Benzene, pure.....	Gal.	24	@	28
Camphor, refined in bulk, bbla.....	Lb.	1.24 1/4	@	1.25
Carbolic Acid, U. S. P., crystals, drums.....	Lb.	10	@	15
Carbon Bisulfide.....	Lb.	9	@	10
Carbon Tetrachloride, drums, 100 gals.....	Lb.	13 1/4	@	14
Chloroform, U. S. P.....	Lb.	30	@	32
Citric Acid, domestic, crystals.....	Lb.	98	@	102
Cresote, beechwood.....	Lb.	2.00	@	2.10
Cresol, U. S. P.....	Lb.	15 1/4	@	17 1/4
Dextrine, corn (carload, bags).....	Lb.	7	@	8
Dextrine, imported potato.....	Lb.	nominal		
Ether, U. S. P. 1900.....	Lb.	23	@	24
Formaldehyde, 40 per cent.....	Lb.	20	@	21
Glycerin, dynamite, drums extra.....	Lb.	20	@	21
Oxalic Acid, in cake.....	Lb.	33	@	35
Pyrogallol Acid, resublimed, bulk.....	Lb.	2.60	@	2.75
Salicylic Acid, U. S. P.....	Lb.	25	@	35
Starch, corn (carload, bags) pearl.....	100 Lbs.	5.37	@	
Starch, potato, Japanese.....	Lb.	9 1/4	@	9 1/4
Starch, rice.....	Lb.	19	@	19 1/4
Starch, sago flour.....	Lb.	7	@	8
Starch, wheat.....	Lb.	10	@	10 1/4
Tannic Acid, commercial.....	Lb.	65	@	80
Tartaric Acid, crystals.....	Lb.	86 1/4	@	87

OILS, WAXES, ETC.

Beeswax, pure, white.....	Lb.	50	@	55
Black Mineral Oil, 29 gravity.....	Gal.	24	@	25
Castor Oil, No. 3.....	Lb.	19	@	
Ceresin, yellow.....	Lb.	16	@	17
Corn Oil, crude.....	100 Lbs.	19 1/2	@	
Cottonseed Oil, crude, f. o. b. mill.....	Lb.	22	@	
Cottonseed Oil, p. s. y. Oct. option.....	100 Lbs.	26.70	@	27.10
Menhaden Oil, crude (southern).....	Gal.	62	@	65
Neat's-foot Oil, 20°.....	Gal.	1.75	@	
Paraffin, crude, 118 to 120 m. p.....	Lb.	8 1/4	@	9
Paraffin Oil, high viscosity.....	Gal.	40	@	41
Rosin, "F" Grade, 280 lbs.....	Bbl.	12.15	@	12.25
Rosin Oil, first run.....	Lb.	75	@	76
Shellac, T. N.....	Lb.	nominal		
Spermacetin, cake.....	Lb.	31	@	33
Sperm Oil, bleached winter, 38°.....	Gal.	1.95	@	1.97
Spindle Oil, No. 200.....	Gal.	38	@	40
Stearic Acid, double-pressed.....	Lb.	18 1/2	@	19
Tallow, acidless.....	Gal.	1.30	@	1.35
Tar Oil, distilled.....	Gal.	36	@	38
Turpentine, spirits of.....	Gal.	79	@	80

METALS

Aluminum, No. 1, ingots.....	Lb.	33	@	
Antimony, ordinary.....	100 Lbs.	8.50	@	
Bismuth, N. Y.....	Lb.	nominal		
Copper, electrolytic.....	Lb.	17 1/4	@	
Copper, lake.....	Lb.	17 1/4	@	
Lead, N. Y.....	Lb.	5.50	@	
Nickel, electrolytic.....	Lb.	55	@	56
Platinum, refined, soft.....	Oz.	105.00	@	
Silver.....	Oz.	1.12 1/2	@	
Tin.....	Lb.	72 1/2	@	
Tungsten (Wol).....	Per Unit	7.00	@	
Zinc, N. Y.....	100 Lbs.	9.40	@	9.60

FERTILIZER MATERIALS

Ammonium Sulfate.....	100 Lbs.	4.90	@	
Blood, dried, f. o. b. New York.....	Unit	5.15	@	5.25
Bone, 3 and 50, ground, raw.....	Ton	35.00	@	37.00
Calcium Cyanamide.....	Unit of Ammonia	nominal		
Calcium Nitrate, Norwegian.....	100 Lbs.	—	@	
Castor Meal.....	Unit	—	@	
Fish Scrap, domestic, dried, f. o. b. works.....	Unit	nominal		
Phosphate, acid, 16 per cent.....	Ton	15.50	@	16.00
Phosphate Rock, f. o. b. mine.....	Ton	nominal		
Florida land pebble, 68 per cent.....	Ton	5.00	@	6.00
Tennessee, 78-80 per cent.....	Ton	9.50	@	10.00
Potassium "muriate," basis 80 per cent.....	Ton	120.00	@	130.00
Pyrites, furnace size, imported.....	Unit	15	@	17
Tankage, high-grade, f. o. b. Chicago.....	Unit	4.50	@	4.75

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EDITORIALS

A NEW DECLARATION OF INDEPENDENCE

There journeyed once to Philadelphia representative men from all sections of our country. One burning thought filled the hearts of those men—the political independence of America. Here in this land lay the opportunity for the fostering and development of new ideals which would insure a race of freemen whose genius, aided by a vast heritage of untold natural resources, should contribute in abundant measure to the welfare of the world. In Philadelphia they assembled. Within the walls of that building, to be forever known as Independence Hall, they formulated their ideals and pledged their faith. The old bell in the tower above proclaimed to all that the real America was born. The events of the last two years have justified the faith and the foresight of those men. No man questions now America's contribution to the safety and the welfare of the world.

Within the next few weeks, in the early days of September, another journey to Philadelphia will begin. Not by statesmen this time, but by men whose hearts are to the same degree filled with desire for independence, the economic independence of America. Chemists will be upon the road and within the shadow of that same Independence Hall will gather to pledge their faith and devotion.

The political declaration led to war; the economic declaration will be the result of war. This latter-day expression of men's aspirations will avow the liberation of the mind from former foreign over-influence and the guaranteeing to America from within its own borders of all those material needs whose provision is directly the responsibility of the chemist.

An assemblage for this purpose would have been impossible a few years ago. It has taken the rude shock of a world war, with all the new energies it has called into being, to open our eyes and to rouse this spirit into a militant force. But we see plainly now, and a spirit has been aroused that nothing short of complete independence will satisfy.

It will be a remarkable atmosphere of good will in which that meeting is held. That the President of the United States has recognized the need of our chemical independence is evidenced by his recent message to Congress urging prompt and favorable legislation to safeguard the work of American chemists. The Ways and Means Committee of the House of Representatives, charged with the responsibility of initiating legislation of this character, has devoted its first work to hearings on the subject, and while no definite recommendations have been made at the time of this writing, it is plainly evident that every member of the Committee, regardless of party politics, is in thorough sympathy with the principle of chemical independence. This attitude, we take it, is but a reflection of public conviction.

It is peculiarly fitting that one of the chief speakers to address the Philadelphia meeting will be the Secretary of War. The present grip of the chemist upon

public thought is due not so much to his industrial achievements as to the conviction that upon his genius and ability depends the future safety of the nation. This may well be, for, however regrettable it may be, the fact must be faced that warfare is becoming more and more a matter of chemistry. Few there be who believe that the signing of the treaty of peace by Germany portends an era of peace. Her leading men frankly avow that it does not. Under such circumstances we would be indeed a foolish people if we did not encourage to the utmost that branch of science and its applications which is so intimately bound up with national defense.

At Philadelphia Secretary Baker will have opportunity not only to address a thoroughly sympathetic audience but also to form that personal contact with American chemists which will lead to closer and closer cooperation for the country's good.

DYESTUFFS HEARINGS REOPENED

At the conclusion of the hearings on the Longworth bill on June 20, dye manufacturers and consumers left Washington, feeling that every argument for the protection of the American industry had been advanced, and confident that the Ways and Means Committee would report a bill embodying both effective tariff rates and a five-year licensing system. So far, so good. Then members of the Committee were absent from Washington until after the Fourth. "Idleness is the devil's workshop." Representative J. Hampton Moore, of Philadelphia, in a speech on the floor of the House, attacked the Chemical Foundation, Inc. Some of his statements appeared so glaringly inaccurate that Mr. Joseph H. Choate, Jr., felt that reply should be made. This was done in the form of a letter from Mr. Choate to Mr. Moore, which Mr. Choate immediately gave out to the press. This letter, or the manner of its publication, seems to have irritated Mr. Moore, whereupon he requested the Chairman to reopen the hearings, and invitations to attend were extended to all the principal officers of the Foundation. The manufacturers felt obliged to leave their customary duties and proceed again to Washington. Meanwhile rumor had it that the importers desired to be heard. Some did attend, those concerned with the importation of Swiss dyes; the rest stayed at home, where, it developed later, they were by no means idle. Thus was the second hearing opened.

The leading figure in these proceedings was Mr. Francis P. Garvan, the president of the Foundation, who has committed the unpardonable sin (in the minds of some) of being at the same time the efficient and aggressive Alien Property Custodian. There may have been liver wires than Mr. Garvan before the Committee in times past, but we were not present on such occasions. Hour after hour he answered question with a promptness and frankness and good spirit

which evidently made a deep impression. The complete records of his office were placed at the disposal of the Committee—indeed so freely offered that a thoughtful observer could not escape the conclusion that Mr. Garvan was very much tickled over the opportunity to insert in the public records those facts which it was only necessary for American citizens to know in order to establish their faith in the accomplishments of the Alien Property Custodian's office and to make them aware of the imminent peril which threatened American industry from the German industrial machine. And so Mr. Garvan smiled throughout the week until, through certain questions asked by Mr. Moore, he became convinced that the prompter behind Mr. Moore's inquisition was Mr. Herman A. Metz. This he charged direct and Mr. Moore admitted it. The smile disappeared and in its place appeared the determined look of the man who had relentlessly pursued the importers of German dyes, wrapped in their cloaks of seeming Americanism. But wait a minute—we must go back a little.

At the first hearings there had been submitted a petition to the President of the United States, signed by five hundred and sixty-six of the largest consumers of dyes, urging the enactment of a license system. It had been impressive, this action of men who desired to be freed from foreign domination in the matter of supplies so necessary to their business. But during these second hearings Mr. Moore introduced from time to time petitions from some of the signers of the petition to the President, reversing completely their former position and urging that the license plan be rejected. Someone was evidently at work, but who was conducting this campaign? Just before Mr. Garvan took the stand at the session in which the admission was made concerning Mr. Metz's part in the proceedings, word reached the Committee room that representatives of Kuttroff, Pickhardt & Co. were circulating the petitions. These were the importers who for so many years had been connected with the American branch of the Badische Anilin und Soda Fabrik and whose business had been completely taken over by the Custodian—"All except the sign over the door," as Mr. Garvan stated it. Direct confirmation of these reports was quickly obtained with the aid of the long distance phone. Then Mr. Garvan's eyes flashed. (Now our story is hooked up again.) The prosecutor of the country's most notorious criminals was back in his element. The Committee was his jury, he had found the missing evidence which he knew would convict, and straight home he drove his points, always on the aggressive, never yielding an inch, with passion in his voice and conviction in his heart, he crumpled completely that seeming reversion on the part of consuming interests until it looked pitiable and silly. The danger which had threatened was swept aside.

Unfortunately we could not stay in Washington for the session with the importers of Swiss dyes. The printer was demanding copy for the August issue. But from the press account of the proceedings their efforts were of no avail. Claims in general terms that no German dyes or intermediates had come into Switzer-

land during the war could not offset official statistics showing large importations from Germany.

Here is the record of the importers as we gather it—unfortunately the official text of the hearings is not yet available: Mr. MacKinney, according to the *Daily News Record*, "contradicted himself several times as to what he favored and what he opposed in the Longworth bill." Mr. Sykes, according to the same newspaper, opposed the license plan and thought the rates of the Longworth bill were too high. Mr. Atteaux, in his letter submitted during the first hearings, contended that present rates were ample and the rates of the Longworth bill a purely "artificial basis." Mr. Metz, at the first hearing, advocated before the Committee a license plan, and prompted Mr. Moore's line of inquiry at the second hearing. Kuttroff, Pickhardt & Co. were busy at home sending out their employees with counter-petitions. All of which suggests a question. At a time when all Americans have but one thought, the fostering and safeguarding of a complete American dye industry—Why is an importer?

Finally, there was Mr. Frusher. He appeared at both hearings. At the first he insisted that a license plan was absolutely essential; at the second he thought a license plan would be practically a crime. Well, we guess the two statements neutralized each other, at least that seemed to be the general impression.

What will be the result of it all? The next few days will tell. Our guess is that the Committee will report a bill, containing both substantial tariff rates and a license plan, which will become a law before many weeks pass by. Assuredly, we hope so.

CORNELL'S GOOD FORTUNE

"I will provide you with a chemical laboratory, fully adequate to the needs of the University, and one that will in all respects and size be the best there is in America," said President Schurman at the University dinner last evening, repeating the words of an anonymous donor who is to erect on the campus the largest and best laboratory in the country. ♦ ♦ ♦ ♦

The statement uttered by the president was greeted with cheer after cheer, by alumni and undergraduates alike, for they fully realized the needs for an adequate chemical laboratory.—*Cornell Sun*.

Those cheers will find a sympathetic echo among all American chemists, no matter where located or what institution is claimed for Alma Mater.

When the press chronicled the destruction of Morse Hall by fire some two and a half years ago it was felt that the cause of chemistry had received a serious set-back. The term "a Cornell chemist" had become a distinctive title, bearing with it the certainty of thorough training, solid foundation, vigor of mind and an ability to do things with confidence and accuracy. This of course was not due so much to the housing of Cornell's chemical department as to the inspiring leadership of its teaching staff.

It was a severe blow, therefore, when the activities of that staff had to be restricted by temporary and scattered quarters. Courageously, however, was the work resumed, in spite of the limitations as to space and equipment. Severe indeed must have been the

temptation to yield to the generous offer of loyal alumni to replace the destroyed building by one that would at least make matters better, even though not all that was fitting for such an institution; but Professor Dennis' faith was great and he resisted all such temptations, confident that some day some man of means would appreciate the situation and respond in a manner which would insure for all time Cornell's place in chemical education. That day has arrived. We understand that funds from an anonymous donor up to \$1,500,000 will be immediately available for the construction and outfitting of the new laboratory.

In 1916, addressing the AMERICAN CHEMICAL SOCIETY, and discussing the signs of the times, we said:

We cannot, however, feel that the national thought has as yet grasped in its entirety the all-pervading influence of chemistry, so long as Cornell University, with its strong chemistry staff, must delay the replacement of its burned laboratory through lack of funds; * * *

The replacement of that laboratory is now assured. Following the spirit of the quotation, the interpretation of this splendid donation must be a reflection of the wider grasp by the national thought of the importance of chemistry in our body politic.

Let us hope that when the day of dedication of this great laboratory arrives the anonymity of the donor will have disappeared, so that his name may be honored by all who realize how great a contribution he has made to the nation's weal.

FIGHTING FAR BEHIND THE TRENCHES

When the full history of our many-sided war activities is compiled no chapter will stand out more brilliantly than that which records the organization, the development and the courageous prosecution of the work of the Alien Property Custodian.

It is an especial pleasure to record that conviction here, because less than a year ago at the opening of the Fourth National Exposition of Chemical Industries we criticized the American directors of one of the seized enemy properties, and therefore the Custodian who appointed those directors. Our criticism was directed against a policy of advertising a certain medicinal in a manner which we felt was misleading to the public and unjust to American manufacturers who had entered the same field. The criticism we still feel was just, but in the light of the subsequent revelations of the conduct of the Custodian's office, as recorded in the official report of Hon. A. Mitchell Palmer and in the public addresses of his successor, Mr. Francis P. Garvan, we sincerely regret the criticism, because it seems now so petty in the light of the great work which was then in progress.

Judge Palmer's investigations in the execution of the Trading-with-the-Enemy Act, an act originally intended as a means for preserving enemy properties in this country, soon led him to see how great a menace to this country these properties would constitute if they should revert to their original owners at the

end of the war. To him recognition of a danger means only one thing—quick and decisive action. The fighting blood of the Pennsylvania Quaker was aroused; not all of our Alvin Yorks live in the Tennessee mountains. Amendments to the Trading-with-the-Enemy Act were secured from Congress: which gave the full right of sale of all enemy property to American citizens, including the power to reissue stocks inaccessible because sequestered in enemy countries, and declared enemy patents property subject to the same right of seizure as other enemy-owned property.

Armed with this practically new law, the Custodian and his associates began a battle for America, the details of which constitute one of the most fascinating stories of the war period. The ablest financiers from every section promptly and patriotically answered the call upon their services. Within an incredibly brief period enemy property valued at more than \$700,000,000 was taken over and this vast economic force turned to the direct aid of our supply of war materials. The story of the evolution of the Chemical Foundation, Inc., and its realization through the sale by executive order of enemy-owned patents has already been told in THIS JOURNAL. The Foundation stands to-day as one of the most unique and beneficial institutions of modern times.

It was perhaps only natural that in this investigative period through which we are now passing the office of the Custodian should be held up for Congressional scrutiny. Before a Senate committee Judge Palmer gladly welcomed such an inquiry, insisting only that it should be a public investigation. Turning fiercely upon his accusers, the former custodian is now presenting such overwhelming evidence that the proceedings promise to result, not only in exoneration, but in a lasting tribute to the faithfulness with which the spirit of the Congressional Act is being carried out.

In the House another attack came, led by Representative J. Hampton Moore of Philadelphia, a member of the Ways and Means Committee, during the hearings on the dyestuff bill. In this case it was directed against the present incumbent, Mr. Garvan. His fighting blood was also up. Readily answering every question, furnishing light upon every point, repelling every insinuation of unfair practice, he left no doubt in the minds of his hearers that, instead of being subject to criticism, here was a branch of governmental activity in which every American could take pride, because of its efficiency, its scrupulous integrity, and its thoroughly non-partisan character.

As illustrative of this last point, it was charged that appointments of directors of the seized concerns had been made along partisan lines. It developed, however, from a recent canvass of the directors as to political affiliation that a large majority of these directors appointed by the Custodian, a Democrat, were of the Republican faith.

All honor to those loyal, courageous Americans who have taken part in the work of the Custodian's office. Through their untiring efforts a national menace has been converted into an enduring national asset.

CONTRIBUTIONS FROM THE CHEMICAL WARFARE SERVICE, U. S. A.



MEETING OF DELEGATES TO THE INTERALLIED CHEMICAL CONFERENCE IN PARIS, APRIL 12-15, 1919¹

INTERALLIED ORGANIZATIONS FOR CHEMICAL WARFARE

By LT. COL. J. E. ZANETTI, C. W. S.

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THE INTERALLIED CONGRESS FOR CHEMICAL WARFARE

Soon after the shock caused by the introduction of gas by the Germans, it became evident to the allied commanders that, in order to meet the new weapon, the closest coöperation of the best chemical and medical brains would be necessary in order to counteract the advantage of the long preparation possessed by the enemy. Organizations to handle the new problems were formed at once in the allied armies but, although interchanges of views took place between the newly formed Chemical Warfare Services, it was not until March 1917 that the first Anglo-French Congress for Chemical Warfare was held in Paris. Up to that time chemical warfare, although its possibilities were fully realized, had not assumed the enormous importance which it suddenly acquired with the introduction of mustard gas² by the Germans in the Ypres sector in July, 1917. Chlorine, phosgene, the chloroformic esters, hydrocyanic acid, and the lachrymatory gases had indeed all been employed by the Allies and the Germans,³ but the defense against these had kept pace with their appearance and, owing to their comparatively non-persistent qualities, many were the allied commanders who were beginning to consider chemical warfare rather as a harassing than as an offensive or defensive weapon. The Anglo-French Congress of March 1917 limited

itself mostly to the discussion of problems of defense against the then known gases and the therapeutics of gas warfare. Its main achievement, however, was the bringing together of the British and French personalities engaged in research work and the arrangements made by the respective services for the interchange of information. Before adjourning, the Congress decided to meet again in September and to invite the other allied countries to participate. The delegates had not been back in their laboratories many weeks before the Germans suddenly launched on the British forces the first attack with mustard gas, such a formidable weapon that, had the Germans been able to manufacture it then on such a large scale as the Allies were at the time of the armistice, there is little doubt that the allied lines would have melted, to use the poet's words:

Like snow on the sands
Touched by the April wind.

Realization of the great importance of mustard gas was brought home to the allied commanders by the gas casualty lists which were growing at an alarming rate. In the month of July 1917, alone, after the introduction of mustard gas, the British experienced almost as many gas casualties as the total of their gas casualties since the beginning of gas warfare. There was plentiful food for thought and it was therefore in a very sober frame of mind that the first Interallied Congress for Chemical Warfare met at Paris in the early days of September 1917. The United States had in the meantime entered the war, and organization of the Gas Service of the American Expeditionary Forces, as the Chemical Warfare Service was called in those days, had been entrusted to Brig. Gen. (then Col.) Amos A. Fries. He, together with Col. Church, of the U. S. Medical Corps, and Capt. Boothby, represented the American Expeditionary Forces. The United Kingdom, France, Belgium, and

¹ This photograph reached us too late to be printed with the account of the meeting on page 691 of our July number.

² Also called "yperite" and "yellow cross gas" (dichloroethylsulfide).

³ With the exception of hydrocyanic acid, which was used only by the Allies.

Italy were represented by their scientific as well as by military men. The main topic of discussion, as might be expected, was mustard gas, and no attempt was made to belittle the importance of the new arrival in the home of chemical warfare. The meeting, which lasted three days, was almost entirely given up to discussion of protection against the therapeutics of mustard gas.

It was felt at this Congress that in the presence of the impending danger even closer coöperation was necessary, and it was voted that a permanent secretariat be instituted, stationed at Paris, to act as a liaison between the allied services, communicating not only the formal reports, but as far as possible advance information on chemical warfare topics. The Secretariat was formally organized in December 1917 with M. Terroine, agrégé of the Faculty of Sciences of the University of Paris, representing France; Capt. (later Major) Lefebure, formerly of the Department of Chemistry of the University of London, representing Great Britain; Capt. Renard representing Belgium; and Col. Cadora (later Lieut. Cardoso, professor of chemistry at the University of Naples) representing Italy; and the writer representing the American Expeditionary Forces. The Secretariat met once every two weeks to exchange reports and information which were transmitted to the respective countries. It remained in existence until the armistice and during that time over seven hundred separate reports were transmitted to the American Expeditionary Forces alone. It is of interest to note that this Secretariat was the first interallied body to have been organized with a permanent station and to have functioned continuously from its foundation in December 1917 until the armistice. Through this Secretariat the arrangements were made for the second Interallied Gas Congress, which took place at Paris, March 1 to 5, 1918.

This Congress was really the first thoroughly organized Interallied Congress for Gas Warfare. Whereas previously no definite policy as to scope of discussion had been announced, it was clearly settled that the Congress was essentially a scientific congress dealing with the research and the technical side of chemical warfare and in no way touching upon its military application or upon questions of supplies and manufacture. The session was divided in accordance with the following topics: First, physiological properties of enemy gases; second, physiological properties of substances of contemplated employment by the Allies; third, general chemical questions; fourth, technical questions relating to manufacture of war gases; fifth, protection; sixth, therapeutics of gas warfare. At least one morning or one afternoon session was devoted to each topic. Papers were read by the delegates and no time limit was set on their discussion. The Congress was opened by Gen. Ozil, in command of the French Chemical Warfare Service, and each morning and afternoon session was presided over in turn by a delegate from each of the countries represented. Great Britain had twelve representatives, headed by Prof. Pope; Belgium six, headed by Dr. Nolf; France nine, headed by Prof. Moureu; Italy seven, headed by Prof. Paterno; and the United States nine, headed by Col. (later Gen.) Amos A. Fries. English and French were the languages used, the secretaries, most of whom spoke both languages, translating for their delegations. The discussion was taken down by French and English stenographers and it was hoped that the verbatim report with all the interesting data which it contained might be ready for distribution within six or eight weeks after the Congress adjourned, but the unfortunate events which followed shortly after the close of the Congress made such demands on the time of the secretaries that it was not possible to issue the reports until the following October.

The Congress voted before adjourning to meet at Paris the following September and left to the secretaries the fixing of details of the meeting as well as the date. In any case notices were to be sent out in sufficient time to permit the preparation of suitable

communications. Unfortunately, the events of the summer of 1918 were of such nature that the secretaries did not feel it wise to call a meeting until October as, at the end of July, when notices would have been sent out for a September meeting, the military situation was still fraught with unpleasant possibilities. The date was finally fixed for October 25 to 30. The list of papers sent in response to the call was so large that it was decided to require each delegation to mimeograph the papers presented for distribution to all the representatives and to allow only twenty minutes for the presentation of any paper, although no time limit was set on the discussion. A much larger force of stenographers and interpreters was secured so that the routine of the meetings ran very smoothly. At this Congress, the United States delegates, who by this time had been turning out most important pieces of research, presented valuable papers. The sufficiently advance notice of the Congress allowed some of our research men from the American University in Washington (Underhill, Kohler, Lewis, and McPherson) to arrive in Paris in time for the meeting. Belgium was represented by six delegates, headed by Dr. Nolf; France by twelve delegates, headed by Prof. Moureu; Great Britain by fifteen delegates, headed by Sir William Pope; Italy by thirteen delegates, headed by Prof. Paterno; Japan by Dr. Iraba; and the United States by twenty-one delegates, headed by Gen. A. A. Fries. Our delegation was indeed so large that in deference to our Allies, by order of General Fries, the delegates who arrived after the printing of the program, although they were allowed to sit at the meetings and take part in the discussion, did not appear on the official list. The Congress was opened by Gen. Ozil and the chairmanship passed from one delegation to the other as in the previous meeting. The papers delivered were discussed at length, the discussion becoming very animated at times. But the spirit of the meeting was quite different from the previous one. Germany had already hoisted the white flag and every one felt that war was virtually at an end and that that Congress would be the last Interallied Congress for Chemical Warfare. The earnestness and seriousness of previous meetings were not so evident, for the feeling of relief from the War nightmare dominated all others. Some one described the meeting as "more like a faculty meeting preceding commencement than like a staff meeting on the eve of battle." The feelings of the hour found plentiful expression in the rounds of entertainments which took place during the Congress, each delegation entertaining the others, and the French government entertaining the whole Congress at an official lunch where decorations were conferred on the heads of the delegations.

It is not felt by the writer that a discussion of the subject matter of the meetings would be either appropriate or of general interest. But the human side of these Congresses cannot be overlooked. The delegates had all come in contact with some of the finest chemical and medical brains of the allied countries, not as in ordinary congresses, each moved more or less by personal motives, but all firmly united in one purpose, each willing to give and take as long as the ultimate end was reached. The delegates are now scattered far and wide but the feeling of mutual respect and comradeship fostered by these Congresses is lasting and evidently finding expression in the movement for the formation of an Interallied Federation of Chemical Societies, which, it is hoped, will culminate in a better and closer understanding between the chemists of the allied countries.

THE INTERALLIED COMMISSION FOR CHEMICAL WARFARE SUPPLIES

At the suggestion of Mr. Winston Churchill, at the time Minister of Munitions of the United Kingdom, a meeting was held on March 6, 1918, in Paris, in the offices of the Chief of the French Chemical Warfare Service, of members of the French,

British, and American services for the purpose of organizing a commission which would study the questions of production and distribution of chemical warfare material, just as the previously described Congress discussed questions of research. Duplication of orders and difficulties in securing raw materials, of which, of course, each country would try to get as much as possible without regard to the immediate needs of the others, made necessary the creation of some central organization which would regulate the flow of both raw material and manufactured products in accordance with the military requirements. This idea was nothing more than another manifestation of the generally felt need for pooling all allied resources, in order to meet effectively the ever increasing German menace, a feeling which culminated in the unity of command and the formation of the High Interallied Council. There were three representatives from each of the above-mentioned countries present: Gen. Ozil, Com. Bollaert, and Com. Perrot for France; Mr. Haigh, Capt. Moreland, and Capt. (later Major) Lefebure for the United Kingdom; and Col. (later Brig. Gen.) Fries, Capt. (later Major) Ward, and the writer for the American Expeditionary Forces. After some discussion the Commission proposed that meetings should be held every two or three months and that it should deal broadly with the following matters:

1.—The examination of allied chemical warfare manufacture and outputs, and of allied chemical warfare programs, with a view to ensuring that the demands concerned are covered.

2.—The examination of the best utilization of allied factors in manufacture, such as raw materials, plant, processes, distribution of raw materials, tonnage, etc., with a view to meeting the program indicated.

The Commission was to be represented by a permanent secretariat comprising:

1.—France, Com. Perrot

2.—Great Britain—Capt. Lefebure

3.—The United States of America—the writer

and it was to act purely in an advisory capacity. The organization plan was approved by the ministers of France and Great Britain and by the Commander-in-Chief of the American Expeditionary Forces and thereafter the Commission met on three occasions, May 11, August 9, and August 17. Owing to changes in the organizations in the allied armies, the personnel of the Commission was different at every meeting, the secretaries and the chairman, Gen. Ozil, being the only members who were present at all the meetings. Italy was asked to join and was represented by Col. Malvani at the second session, Lieut. Cardoso acting as secretary.

A certain routine was adhered to in all the meetings. Starting materials, such as chlorine, bromine, sodium cyanide, chloride of lime, etc., were first of all discussed in regard to actual production, plant, capacity, and contemplated increase or decrease. The demands of each country were recorded and the possibilities of fulfilling it from the excess production or capacity of another considered. Then such products as phosgene, chlorpicrin, and mustard gas were taken up in the same manner and finally recommendations were made to the competent authorities. Much was accomplished by these meetings, where these questions were frankly discussed. It was soon found that large stocks of gas supplies were being held by one country that were badly needed by another and in this way, to cite but one example, our gas production, which was running ahead of our shell capacity, was utilized in supplying our Allies' needs, considerable shipments of bulk gas being made at really critical times. The Commission had nothing to do with financial matters or price fixing, these being left to the proper missions to arrange.

When, in August 1918 the High Interallied Munitions Council was organized, the Commission for Chemical Warfare Supplies was taken into that body and became its "Chemical Committee." In addition to all chemical warfare material, it was

assigned glycerin, asbestos, and talcum, and not only were programs of the different countries to be considered by that Committee, but the tonnage schedules of the Interallied Maritime Council for the materials handled were to be filled out as far as possible in accordance with the military requirements for periods of six months. Only two meetings of the Chemical Committee were held, one on September 2, 1918, and one the week following the armistice, to clear up questions of existing contracts, after which the Commission adjourned *sine die*.

The writer has felt that the series of articles on the Chemical Warfare Service in THIS JOURNAL would not have been complete without a short account of the organization of these interallied bodies, which not only accomplished much on the material side but, as pointed out before, had a most beneficial effect in bringing close together chemists of the allied countries in a way that it is hoped will have lasting effects. It seemed to him worth while to call attention of chemists in general to the existence of these organizations with a hope that the work they accomplished and the spirit which animated their meetings may serve as a starting model for similar groupings in the future.

NEW YORK CITY

A FERMENTATION PROCESS FOR THE PRODUCTION OF ACETONE AND ETHYL ALCOHOL^{1,2,3}

By JOHN H. NORTHROP, LAUREN H. ASHE AND R. R. MORGAN

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Acetone was one of the substances for which the war created a greatly increased demand. It was needed by all the Allies for the dope used on airplane wings and by the English in addition for the manufacture of cordite. The ordinary source of acetone, the dry distillation of wood, proved quite inadequate to supply the quantities needed. It became necessary, therefore, to develop some new method for the production of acetone. Large quantities were made from calcium acetate which was in turn produced from acetic acid obtained by the oxidation of alcohol. The expense of this process, however, rendered it impracticable. It seemed important, therefore, under these conditions, to attempt the development of a direct fermentation process for the production of acetone, inasmuch as such a method, if successfully developed, would furnish acetone in practically unlimited quantity and at a low cost.

Several fermentation processes for the production of acetone have been described and patented,⁴ and of these, the Fernbach process,⁵ has proved to be a com-

¹ The work described in this paper is the outcome of a suggestion of the Council for National Defense that a fermentation process for the production of acetone be worked out. The laboratory work and the preliminary large scale experiments were conducted at the chemical laboratories of the Rockefeller Institute. A second series of experiments was done at the laboratory of Arthur D. Little, Inc., of Cambridge, Mass., under a grant from the Bureau of Aircraft Production, and the final work was carried out at Terre Haute, Ind., at the plant of the Commercial Solvents Corporation. The authors wish to express their indebtedness to the Commercial Solvents Corporation, and particularly to Dr. Nelson B. Mayer and Mr. Robert D. Clark, for placing every facility of the plant at Terre Haute at their disposal.

² Published by permission of the Director, Chemical Warfare Service.

³ The process described in this paper is protected by U. S. Pat. 1,293,172, assigned to the Rockefeller Institute for Medical Research. This patent has been dedicated to public use and is held, under these conditions, by the U. S. Patent Office.

⁴ Bayer and Company, D. R. P. 283,107, July 1913; D. R. P. 291,162, Jan. 1914; Brit. Pat. 14,371, June 15, 1914; Delbrick, U. S. Pat. 1,169,321; Fernbach and Strange, U. S. Pat. 1,044,368, Nov. 12, 1912.

⁵ A process similar at least to the original Fernbach process has been developed in England by Dr. Weissman. It has been used successfully in this country and in Canada.

mercial success. It has the disadvantage, however, of producing twice as much butyl alcohol as acetone. This alcohol, though valuable, is one for which there is a limited demand and is therefore difficult to dispose of when produced in large quantity. The present work is an attempt to develop a process which yielded largely ethyl alcohol as a by-product, with smaller amounts of propyl and butyl alcohols.

The organism used is described under the name of *B. acetothylicum* in a paper which is to appear shortly in the *Journal of Biological Chemistry*. The general characteristics of the organism together with the optimum conditions for its growth may be summarized as follows:

TABLE I

DESCRIPTION OF THE ORGANISM—Described according to descriptive chart of the Society of American Bacteriologists.

SOURCE—From old potatoes obtained from Berkshire Co., Mass., July 1, 1917.

PROPOSED NAME—*Bacillus acetothylicum*.

I—MORPHOLOGY

- (1) Vegetative cells, motile
From 24 hrs. agar slant, 40° C.—Short rods 4–6 μ X 0.2–0.3 μ . No chains. Ends rounded. Stain evenly with Loeffler's methylene blue or gentian violet. Gram negative.
- (2) Spores—Elliptical, form at end of rods. Stain easily with methylene blue or gentian violet. 0.5–1.0 μ in diameter.

II—CULTURAL FEATURES

- (1) 2 per cent glucose agar slant, 24 hrs., 40° C.—Moderate, spreading, effuse, dull, translucent, no odor. Condensation water opaque.
- (2) Potato, 24 hrs., 40° C.—Gas bubbles all over media. Crumbles easily. No odor.
- (3) Glucose broth, 24 hrs., 40° C.—Cloudy. No odor.
- (4) 2 per cent glucose agar, 24 hrs., 40° C.—Bottom of tube white, no gas, odor, acid, or clot.
- (5) 36 hrs., 40° C.—Milk red on top, rest white.
- (6) 72 hrs., 40° C.—Same but coagulated; clot does not digest subsequently.
- (7) Agar plate colonies, 2 per cent glucose agar, 24 hrs., 40° C.—Growth slowly spreading. Round, outline irregular. Surface smooth. Elevation—effuse.
- (8) Lintus milk, 24 hrs., 40° C.—Bottom of tube white, no gas, odor, acid, or clot.
- (9) Sodium chloride in bouillon—Inhibiting concentration 4–5 per cent.
- (10) Nitrogen—With sugar as carbohydrate obtained from peptone, proteins, or ammonium salts. With starch—Same but cannot use ammonium salts.
- (11) Best media for long-continued growth—2 per cent corn in water with CaCO₃.

III—OPTIMUM REACTION OF MEDIA

For growth, pH = 8.0 to 9.0. For fermentation, pH = 6.0 to 8.0.

IV—VITALITY OF CULTURE MEDIA

At least 6 months at room temperature. At least 1 month at 40° C.

V—TEMPERATURE RELATION

Optimum temperature 40° to 43° C. Spores may be boiled at least 20 min.

VI—RESISTANT TO DRYING

VII—PRODUCTS OF REACTION

Formic acid Ethyl, propyl, butyl alcohol. Acetone

VIII—PATHOGENICITY

Non-pathogenic to mice

IX—FERMENTATION OF SUGARS, ETC.

Ferments the following sugars in 1 per cent solution with addition of CaCO₃ and peptone or nitrogen source, 15 cc. in test tubes.

Temperature = 37° C.		Substrate = 2 per cent Sugar, 1 per cent Peptone, 2 per cent CaCO ₃ .		Time of Fermentation = 10 Days	
Substance	Acetone Per cent	Alcohol Per cent	Substance	Acetone Per cent	Alcohol Per cent
Galactose.....	4–5	22–24	Dextrin.....	6–7	14–16
Maltose.....	6–7	23–24	Dextrose.....	9–10	22–23
Mannose.....	6–7	22–23	Levulose.....	8–10	24–25
Raffinose.....	8–10	22–23	Xylose.....	4–5	18–20
d-Arabinose.....	6–7	12–16	Glycerin.....	40–43	
Calcium lactate.....			Sucrose.....	8–9	24–26
Starch.....	8–10	20–24			

Ferments levulose and galactose under following conditions:

Medium: 1 g. KH₂PO₄, 1 g. (NH₄)₂HPO₄, 0.01 g. NaCl, 1.0 g. CaCO₃, 10.0 g. levulose, per liter.

Put in tubes and sterilized as described by Schar- dinger; inoculated with pure culture of the bacteria and incubated 12 days at 40° C.

Acetone = 8–9 per cent.

Alcohol = 14–20 per cent.

Starch does not ferment under these conditions.

X—AIR RELATION

Facultative anaerobe.

XI—SLIME FORMATION

In 10 per cent sugar solutions, having a reaction of pH 8.0–9.0, large quantities of slime are formed so that the whole media becomes very viscous. Under conditions of fermentation small deposit of slime settles to the bottom.

It was found in the preliminary laboratory experiments already described that the fermentation, if carried out in the usual way by inoculating a sterile mash with a relatively small inoculating culture, required 5 to 6 days for completion. It was also found that the organisms collected in a slimy mass at the bottom of the fermenting liquid, a fact which becomes more disadvantageous with the increase in the size of the fermenting vessel. Both these difficulties were overcome by using a fermenter filled with pieces of broken marble.¹

Under these conditions the process was made semi-continuous by merely draining off the fermented liquor and adding fresh sterile mash. The organisms remain as a slimy scum on the limestones and serve to start the succeeding fermentation. The fermentation was complete in 40 to 60 hrs. and there seemed every reason to suppose that its course would not be markedly influenced by the size of the fermenting vessel. It was decided, therefore, to repeat the experiments on a larger scale.

APPARATUS

The apparatus used was of copper, tin-lined, and consisted of two closed vessels of about 10 gals. capacity each. One, which was used as a sterilizer or cooker, was fitted with stirring apparatus and an interior coil which was connected both to the steam and cold water system. The fermenter itself was a similar vessel, but without the steam coil, and was filled with broken lumps of limestone about the size of an egg. It was connected to the cooker by means of a 3/4 in. pipe. The fermenter and connecting pipe were both connected with the steam line so that they could be sterilized.

¹ It was found later that any inert material could be used, provided the fresh mash was made slightly alkaline (pH 8.0 to 9.0), so as to maintain the reaction at a pH of 6.0 to 7.0 during the course of the fermentation.

MASH

A solution of beet molasses¹ was found the material most conveniently handled in the large size apparatus. The molasses used contained 1.05 g. of sugar (determined as dextrose by reduction after hydrolysis) per cc. For fermentation it was diluted to 15 times its volume with water. This mash therefore contained 70 mg. total sugar per cc.

EXAMPLE OF AN EXPERIMENT

The fermenter and connecting pipe were heated under 10 lbs. steam pressure for 6 hrs. on three successive days and then allowed to cool to 40°, air being admitted through a cotton filter. 0.5 gal. of beet molasses was diluted to 7.5 gals. with water and heated in the cooker under 15 lbs. pressure for 4 hrs. The mash was then cooled at 40° (by running water through the coil), forced into the fermenter with air pressure, and inoculated with 1 gal. of fermenting mash. This had been sterilized in a large Pasteur flask and inoculated 24 hrs. previously with 5 agar slants of the organism. The temperature of the room in which the apparatus was placed was maintained at 40° C.

Samples were withdrawn and analyzed at intervals. The acetone and alcohol were determined by the method described in the paper on the laboratory experiments. The reaction (pH) of the mash was determined roughly by brom-cresol-purple, phenol red, or phenolphthalein.

The results of the analyses are shown in Table II.

TABLE II

After Inoculation Hrs.	—ACETONE—		—ALCOHOL—		Sugar per cc. of Solution Mg.	pH
	Per cc. of Solution	As per cent of Original Sugar	Per cc. of Solution	As per cent of Sugar		
0	0.07	0.1	..	..	70	8.5-9.0
24	0.24	0.3	..	..	10	8.5
48	2.0	3.0	..	..	11	6.0
72	3.7	5.3	8.4	12.0	11	6.0
Old mash run out and 5 gals. fresh mash run in						
1	0.4	0.5	..	..	65	8.0
48	5.4	7.7	..	..	10	6.0
50	5.6	8.0	14.5	20.0	8	6.0
Old mash run out and 5 gals. fresh sterile mash run in						
24	2.3	3.3	..	..	47	8.5
50	5.9	8.4	14.9	21.3	3	6.0
Old mash run out and 5 gals. fresh sterile mash run in						
24	2.8	4.0	..	..	40	8.3
52	5.8	8.3	14.0	20.0	4	6.0
Old mash run out and 5 gals. fresh mash run in						
24	3.0	..	..	..	..	8.1
48	5.0	..	..	..	..	..
56	5.9	..	..	..	..	..
72	6.0	8.5	15.2	21.7	3	6.0

It will be seen that, after the first refilling of the tank the fermentations were complete in 50 to 60 hrs. with a yield of 8 to 8.5 per cent of the sugar as acetone and 20 to 21 per cent as alcohol. Calculated as volume per cent of the original molasses, the acetone is 9 to 10, and the alcohol 22 to 23 per cent of the original volume. The alcohol was identified, as described in the paper on the laboratory experiments, as ethyl alcohol containing probably some propyl and some butyl. The hydrogen ion concentration varies from about pH 8.0 at the beginning to pH 6.0 at the end. The optimum condition for fermentation is within this range.

¹ Information had been received at this time from the Department of Agriculture and also from the War Industries Board that large quantities of this molasses were available for fermentation; it was found later, however, that there was actually very little of the substance on the market.

The fermented mash from the foregoing experiments was distilled and finally fractionated in glass, yielding about 75 per cent of the calculated amount of acetone and alcohol in the form of the pure substances. As no special precaution was taken to make the fractionation strictly quantitative, the yield from the distillation agrees fairly well with the quantity found by analysis.

The experiments described above were repeated by Lieut. Ashe at the laboratory of Arthur D. Little, Inc., Cambridge, on a larger scale. In these experiments the fermenter held 160 to 175 gals. The fermentation was slightly slower than in the previous trials but gave a higher yield.

It had been found in the meantime that if the mash were brought to a pH of 8.5 to 9.5 by the addition of lime before fermentation the limestone in the fermenter could be replaced by brush or any similar inert material. The work was therefore repeated in Terre Haute with a tank holding about 800 gals. and filled with brush instead of limestone chips. The fermentation took place in the same way and with the same yields as in the experiments described. In all the foregoing fermentations the principal difficulty encountered was the prevention of contamination by foreign organisms which destroyed the acetone already formed, or interfered in other respects with the fermentation. The danger of contamination was particularly great when the old mash was drawn off. It was thought, therefore, that the process would be much easier to control as well as more rapid if the mash could be drawn off and run in such a way as to avoid emptying the tank. This could be done by running in the fresh mash gently at the bottom and allowing the fermented mash to flow off at the top. In this way the fermenter could be always kept filled and under pressure and the danger of contamination greatly lessened. It was found impossible to test this method in the laboratory as the fresh and fermented mash mixed too much in a small vessel. It was decided, therefore, to install an apparatus of about 1000 gals. capacity.

APPARATUS

A steel tank 42 in. in diameter and 12 ft. high was set up and connected with the cooker and cooling coil as shown in Fig. 1. The various steam

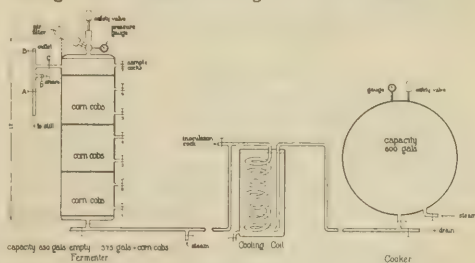


FIG. 1

connections are apparent. It will be seen that the outlet of the tank was sealed off with steam which was always kept turned on slightly (Valve D). The tank

was filled with broken corn cobs¹ and had four transverse perforated plates in order to prevent mixing.

MASH

The following experiments were made, using poor grade cane molasses ("black strap") such as is used for fermentation. It contained 760 to 780 mg. of total sugar (as dextrose) per cc. It was found to be slightly acid in reaction, so that it was necessary to use considerable lime to bring it to the proper degree of acidity. The sterilizing was complicated by the fact that the cooler was on a long (nearly 1000 ft.) steam line and therefore received very wet steam, so that the volume of mash increased greatly during sterilizing. This made it necessary to work with very dilute mashes since if high concentrations of molasses were used, so as to finish with the correct concentration, too much sugar was lost by caramelizing in the first part of the heating. Air-slaked lime was used to neutralize the molasses at the rate of 5 lbs. of lime per 5 gals. of molasses. Owing to the arrangement of the apparatus it was necessary to add this lime before sterilizing, although it was realized that this was not advisable. Nearly twice as much lime is needed if this is done and more sugar is destroyed. The lime should be pumped into the sterile mash after cooling.

INOCULATION

This molasses was difficult to bring into fermentation and the difficulty was increased by the fact that no apparatus was available for "building up" a large inoculating culture. A series of six Pasteur flasks, each of 2-l. capacity, was therefore used, giving an inoculation of about 2 gals. This was not sufficient to start fermentation in the entire 400 gals. of mash, so that at first attempts were made to start 40 to 50 gals. of mash fermenting in the bottom of the tank and then to add the remainder of the mash slowly. It was not found possible to prevent contamination by this method, a butyric acid organism being the one which caused the most trouble. It was found possible, however, to keep the top of the tank (above Stopcock 1) under low steam pressure while the culture was growing in the lowest part of the tank. Fresh mash was then added gradually until the entire tank was filled. In this way all possibility of contamination was avoided.

The following fermentation was carried out in this manner:

STERILIZATION

The fermenter was sterilized 10 hrs. a day for 8 days, under 20 lbs. steam pressure and then drained through the bottom cock. Cock 1 was now opened, all the others closed, and the steam valve at D opened slightly so as to allow a little steam to blow through the tank and out at Cock 1, Cocks A and B being closed.

¹ Corn cobs were used since they were the most readily available material and since they worked very well in laboratory experiments. They were found to be unsuited for use in a large tank as they gradually settled down and so greatly reduced the volume of liquid which the tank held. Coke or beech shavings, such as are used in vinegar towers, would probably be much more suitable.

MASH

5 gals. of molasses, 120 gals. of water, and 5 lbs. of air-slaked lime were then sterilized under 15 lbs. pressure for 3 hrs., run through the cooling coil by steam pressure, and cooled to about 30° C. before entering the hot fermenter. The latter was filled to Stopcock 1; and four 2-l. cultures run in through the inoculating cock and washed into the fermenter. These cultures had been inoculated from agar slants of *B. acetoethylicum*, and incubated for 24 hrs. The mash, owing to dilution while sterilizing, contained only about 9.5 mg. sugar per cc., whereas it was possible to ferment a mash containing more than three times as much sugar.

The pipe line connecting the cooler and fermenter was kept under 5 to 10 lbs. steam pressure when not in use and care was taken to prevent access of air to any part of the system. The outflow of gas from the fermentation was regulated so as to maintain 2 to 5 lbs. pressure per sq. in. in the tank. This greatly reduces the danger of contamination.

Percent of sugar as acetone

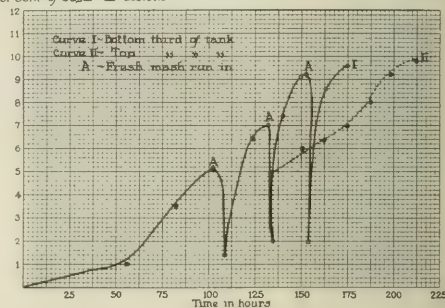


Fig. 2

After the tank had been filled the temperature was kept at about 40° C. by allowing a stream of water at approximately that temperature to flow over it.

TABLE III

After Inoculation Hrs.	Volume Mash Run In Gals.	Sugar per cc. FRESH Mg.	Mg. Acetone per 10 cc. at							—ACETONE—			
			Cock No.							Volume Mash Run Out, Gals.	Per 10 cc. Spent Mash Mg.	In Spent Mash as per cent of Original	Sugar as per cent of Original
			1	2	3	4	5	6	7				
23	100	9.4	1.4	0.4	0.35	0.4							
26													
57	75	9.0	4.3	2.8	3.3	2.4	1.2						
82			5.0	5.2	3.5	1.3							
105	75	10.0	1.3	1.7	1.9	2.4	2.4	3.6					
106			6.6	6.2	3.6	4.2	4.0	4.2					
124			7.4	6.6	4.5	4.0	4.0	4.4					
130													
131	75	9.6	1.7	2.2	3.2	4.8	5.0	5.0	5.0	50	4.3	4.3	
131.5			7.4	7.6	5.6	5.2	5.4	5.4	5.4				
139			9.2	9.0	7.4	6.2	6.0	6.0	6.2				
147			10.0	8.6	7.2	6.4	6.2	5.8	6.0				
152	100	9.5	1.8	2.0	2.6	3.6	4.0	5.8	5.4				
153			9.0	8.0	8.8	7.2	7.0	6.4	6.3				
164			8.8	8.4	10.4	7.4	7.0	7.0	7.0				
164.5	50	9.8	9.6	9.2	9.2	8.0	8.0	8.0	8.0				
175			10.6	8.9	8.9	9.1	9.0	9.3	9.2				
175.5	50	9.7								100	6.0	6.0	
187													
188	50	9.65											
199													
199.5	50	10.0											
211	50	9.7								50	8.9	8.9	22.4

It will be seen from Table III and Fig. 2 that the concentration of acetone gradually increased in the liquid in the upper part of the tank (Stopcocks 5, 6, 7), until it reached about 0.9 mg. per cc., corresponding to 8 to 9 per cent by weight of the sugar originally present. It then remained constant at this point. These changes are shown graphically in Fig. 2. The analysis of the lower part shows a decided drop immediately after every additional charge of mash was run in. The concentration of acetone then increases quite rapidly until it reaches 9 to 10 mg. per 10 cc. This shows that there is no excessive mixing under these conditions even in a tank of the size used in this experiment. It is possible, therefore to keep such a tank in continuous fermentation by adding

fresh mash at the bottom and allowing the fermented mash to run off at the top. The larger and higher the tank the more rapidly the mash could be run through.

The reaction of the mash varied from pH 8.0 to 9.0 in the fresh mash to pH 6.0 to 7.0 in the spent mash. It was therefore always near the optimum for fermentation.

SUMMARY

A brief description has been given of an organism which produces acetone and ethyl alcohol.

A method for conducting a continuous fermentation with molasses has been suggested and an experimental fermentation described.

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NEW YORK CITY

EFFICIENCY AND PRODUCTIVITY OF WAGE AND SALARY EARNERS IN THE CHEMICAL INDUSTRIES AN ATTEMPT TO OBTAIN AN ANSWER

By O. P. HOPKINS, Washington, D. C.

In the discussion of national aid to our industries which will sooner or later become an active and vital question in the national development of all our domestic industries for the purpose of making our national industrial fabric, as a whole, as self-contained, self-supporting, and self-developing as conditions will permit, exact knowledge concerning fundamental questions of markets, production, efficiency of production, and productivity, both domestic absolute values and also relative values for the leading competitive nationals, will be of paramount importance. To this our chemical industries are no exception. In furtherance of this independence, the Bureau of Foreign and Domestic Commerce has greatly aided our chemical industries by compiling and publishing the Norton Dye Census and the Pickrell Chemicals Census. Our SOCIETY, through its standing *ex-officio* Committee on Import Statistics, is endeavoring still further to reduce to quite simple terms the exact kind and character of our dependence concerning raw or partly manufactured materials as disclosed by the Pickrell Census and in this the Geological Survey and the Department of Agriculture are further aiding to reduce this dependence not only to simpler terms but are indicating, where possible, remedies for those dependencies or workable domestic substitutes therefor.

In determining competitive ability, knowledge of markets, accessibility to markets, and control of supplies of raw or partly finished materials are only some of the factors involved. Amount of product or of value added by manufacture per dollar expended for service and per individual engaged and their relative distribution over wage earners and salary earners, expressed in "exclusive averages," are of directive but not controlling importance. Up to the present little, if any, information is available on these points for our chemical industries. This may very well be because suitable fundamental information is not available. However, our Census of Manufactures offers some data capable of giving

some light on these important questions for our entire industrial activities including, of course, our chemical and allied industries. THIS JOURNAL, believing that such information, even though it be not rigidly exact nor of that ultimate refinement necessary to a definitive and conclusively binding, universal, and specific answer, would nevertheless be directionally and relatively true and to that extent helpful, has enlisted the aid of Mr. O. P. Hopkins in an effort to throw as much light on these questions as the data available for the United States, England, France, Germany, and Japan permit. To this end Mr. Hopkins has undertaken the statistical article presented in this number, in an effort to supply the material in a form from which an answer may be deduced to questions relating to productivity of labor and the like units and of expenditures for labor and the like. Should the result of this work be disappointing in this respect, it will have served its purpose eminently if it will have shown conclusively the importance of information of this kind, the need for proper fundamental information, and will have induced the proper officials of our Government to collect the fundamental data essential to a correct, complete, precise, and comprehensive answer to the questions whose answering is the ultimate object of this effort.—[EDITOR.]

This article is presented to the readers of THIS JOURNAL for the purpose of establishing in their minds certain facts as to the standing of the chemical and allied industries in the industrial community, and also for the purpose of showing, so far as is possible, how the American chemical and allied industries compare, in these certain respects, with similar industries in England, France, Germany, and Japan.

The chemical industries are contrasted with other American industries on the basis of value of annual product per wage earner, per salary earner, and per service unit (or per employee), carried to the nearest dollar; and also per wage dollar, per salary dollar,

and per service dollar (or per dollar expended in wages and salaries) carried to the nearest cent.

The yearly value added by manufacture (enhancement) is also treated from the same points of view. In addition, an attempt is made to present statistics of a similar character for chemical and allied industries in the countries named above and to contrast them with the corresponding American industries so far as the meager production returns of those countries will permit.

It was originally planned to include a chapter of conclusions, but careful study of the possibilities showed them to be almost inexhaustible and in cases so inconsistent and implausible that it was decided to leave that feature to the various industries themselves. Each can make its own deductions and point its own moral, and profit immensely by the experience since these tables do not of themselves embrace all relevant features or elements of the situation as a whole.

BASIS OF CALCULATIONS FOR AMERICAN INDUSTRIES

The figures shown in the tables were compiled from the "Abstract of the Census of Manufactures, 1914," issued by the Bureau of the Census of the Department of Commerce. The annual value of products for the various industries was divided by the number of wage earners, the number of salary earners, and by the total number of employees engaged in the respective industries, and further divided by the wages, the salaries, and by the total amount expended in wages and salaries yearly; the value added by manufacture was similarly treated.

In the taking of this census, according to the "Abstract," the instructions were to exclude the following classes of establishments:

1—All establishments reporting products valued at less than \$500 during the census year.

2—Establishments doing only work to the order of the individual customer, such as custom tailoring, dressmaking, millinery, and shoemaking establishments, the aim being to confine the census to establishments for the general or wholesale trade. Of course, this rule did not apply to large concerns manufacturing to meet special orders.

3—Establishments engaged in the building industries other than those manufacturing building materials for the general trade.

4—Establishments engaged in the so-called neighborhood industries and hand trades, such as blacksmithing, harness making, and tinsmithing, in which little, if any, power machinery is used, and which usually do only a local business.

5—Small custom flour, feed, and grist mills, and saw mills grinding or sawing for toll or for local consumption exclusively.

6—Retail stores which incidentally manufacture on a small scale, particularly where it is impossible to distinguish the data relating to the manufacturing business from those relating to the mercantile business.

7—Educational, eleemosynary, and penal institutions engaged in manufacturing industries.

From this mode of treatment it is clear that in each such arithmetical operation every factor other than the specific factor involved in each such operation is completely disregarded; for example, the value of product per wage earner obtained as described expressly disregards and excludes any and all participation of any

other factor, such as capital requirements, cost of material and the like. So that, when it appears that per wage earner \$3,446 of product are made and \$1,404 of value are added by manufacture yearly, that result must, of course, *not* be taken to mean that each wage earner *actually* produced \$3,446 worth of goods or created \$1,404 of value *without any other help*; but it must be taken to mean that *if* there were no other factor beside the wage earner (which is, of course, not true) the average value of product annually produced and value annually added by manufacture would be \$3,446 and \$1,404, respectively, per wage earner. These tacit assumptions must *not* be lost sight of in considering figures like those just employed, otherwise wholly false and indefensible conclusions will inevitably be reached, as just above indicated.

In obtaining the value of products the Bureau's agents were instructed to make every effort to secure the true net selling value of the products *at the factory*. In the case of the repair shops of railroads, few, if any, of the products are manufactured for sale, the work being done or the products manufactured solely or principally for the use and benefit of the railroads operating the establishments. In such cases, the value reported usually represents the operating cost or cost of production. Somewhat akin to the case of railroad repair shops is that of establishments which make partly finished products, or containers, or (and) auxiliary articles, for the use of other manufacturing establishments under the same ownership. In such cases the Bureau accepted as the value of products the "transfer value" assigned by the manufacturer. The value of products in the case of certain establishments represents merely the receipts for work performed on materials or commodities. In many cases manufacturing establishments do not own the principal materials on which they work or the finished products as they leave the plant.

In calculating the value added by manufacture, or *enhancement*, the Bureau has in all cases deducted the total cost of materials, including fuel and mill supplies, from the value of products.

GENERAL ECONOMIC FEATURES OF OUR DOMESTIC CHEMICAL INDUSTRY¹

Following the classification used in this article and the census returns for 1909 and 1914, if we compare the average chemical plant with the average plant in all domestic industries, we find that the chemical plant cost 262 per cent of the general average plant in 1909 and 297 per cent in 1914; that the chemical plant employed 102 per cent as many persons in 1909 and 110 per cent as many in 1914, of which the salaried employees were 200 per cent of the general average plant in 1909 and 212 per

¹ The following eight paragraphs follow closely a portion of an article entitled "Doing Our Bit," by Dr. Bernhard C. Hesse, which appeared in THIS JOURNAL for December 1917, and in which the 1909 Census classification, comprising only the nine branches of industry then treated by the Census as "chemical and allied," was employed. In these paragraphs the census figures for 1909 here used were expanded so as to include the twenty-one additional branches otherwise classified in 1909 but classified in this article as "chemical and allied" industries. This expansion of classification is the sole cause of all differences in statement as to the 1909 positions between the present article and the 1917 Hesse article above referred to.

cent in 1914, and of which the wage earners were 92 per cent in 1909 and 96 per cent in 1914; that the value of product of the chemical plant was 165 per cent of that of the average industrial plant in 1909 and 185 per cent in 1914; and that the enhancement value was 157 per cent and 162 per cent of that of the average plant in 1909 and 1914, respectively. Therefore, as a unit, the average domestic chemical plant costs more, produces more, enhances more, and employs more persons than the average industrial plant.

A dollar invested in our chemical industries is not so productive as in our industries as a whole; it spends less for wages, salaries, and materials, and produces less product-value and less enhancement-value.

Per \$100 of product, the general average and the average domestic chemical plant, respectively, expended for wages \$16.58 and \$8.48 in 1909, and \$16.82 and \$8.40 in 1914; for salaries, \$4.54 and \$5.36 in 1909, and \$5.32 and \$5.81 in 1914; and for services, \$21.12 and \$13.84 in 1909, and \$22.14 and \$14.21 in 1914.

Per individual wage earner the value of product in 1909 was \$3,125 for the general average and \$5,677 for the average domestic chemical plant; in 1914 these figures were \$3,446 and \$6,639, respectively.

Per individual salaried employee the value of product in 1909 was \$26,157 for the general average, and \$21,970 for the average domestic chemical plant; in 1914 these figures were \$25,146 and \$22,018, respectively.

For our industries as a whole and our domestic chemical industries respectively, the average salaries were \$1,188 and \$1,177 in 1909, and \$1,337 and \$1,279 in 1914; the average wages, \$518 and \$481 in 1909, and \$580 and \$558 in 1914. In the industries as a whole, in 1909, there were 8 wage earners to each salaried employee and in our chemical industries there were 4 wage earners to each salaried employee; in 1914 these figures were 7 and 3, respectively.

Relatively, our chemical establishments were 4.5 per cent of all of our industrial establishments in both 1909 and 1914.

The number of persons employed in chemical establishments was 4.6 per cent of all persons employed in manufacture in 1909 and 4.9 per cent in 1914.

COMPARISON OF CHEMICAL INDUSTRIES AS A WHOLE WITH OTHER INDUSTRIES

A general idea of how the chemical and allied industries as a whole compare with other American industries in respect to production and enhancement per wage earner, salary earner, service unit, wage dollar, salary dollar, and service dollar can be obtained from Table I. Thirty branches are included under the head of chemical and allied industries, the total production of which in 1914 was valued at slightly more than two billion dollars. The total value of all American manufactured products for the same year is placed by the Bureau of the Census at somewhat more than twenty-four billion dollars.

COMPARISON OF CHEMICAL INDUSTRIES

Similar statistics for each of the thirty branches classed as chemical or allied industries for the present

TABLE I—SUMMARY OF COMPARISON

	Per Wage Earner	Per Salary Earner	Per Service Unit	Per Wage Dollar	Per Salary Dollar	Per Service Dollar
All industries:						
Product.....	\$3,446	\$25,146	\$3,031	\$ 5.94	\$18.81	\$4.52
Enhancement....	1,404	10,245	1,235	2.42	7.66	1.84
Chemical and allied industries:						
Product.....	6,639	22,091	5,105	11.90	17.22	7.04
Enhancement....	2,372	7,894	1,824	4.25	6.15	2.51
Non-chemical industries:						
Product.....	3,302	25,465	2,923	5.69	18.97	4.37
Enhancement....	1,360	10,491	1,204	2.34	7.82	1.80

TABLE II—COMPARISON OF AMERICAN CHEMICAL AND ALLIED INDUSTRIES

INDUSTRIES	Per Wage Earner	Per Salary Earner	Per Service Unit	Per Wage Dollar	Per Salary Dollar	Per Service Dollar
Baking powders and yeast:						
Product.....	\$9,494	\$17,843	\$6,343	\$17.89	\$11.72	\$10.46
Enhancement....	5,041	9,141	3,249	9.16	6.00	5.33
Blackening and cleansing and polishing preparations:						
Product.....	6,334	9,711	3,834	12.72	7.17	4.58
Enhancement....	3,331	5,109	2,016	6.69	3.77	2.41
Bluing:						
Product.....	4,661	13,767	3,482	11.28	10.67	5.48
Enhancement....	2,736	8,081	2,044	6.62	6.26	3.22
Bone, calcium, and lampblack:						
Product.....	4,319	18,074	3,486	6.34	13.94	4.36
Enhancement....	2,295	9,605	1,852	3.37	7.41	2.32
Candles:						
Product.....	4,473	19,022	3,621	9.46	10.01	4.86
Enhancement....	1,581	6,725	1,280	3.34	3.54	1.72
Chemicals:						
Product.....	4,882	28,889	4,183	7.16	17.52	5.08
Enhancement....	2,123	12,539	1,816	3.11	7.60	2.21
Coke:						
Product.....	4,703	42,791	4,238	6.95	37.36	5.86
Enhancement....	1,428	12,559	1,286	2.11	11.34	1.78
Drugs:						
Product.....	7,630	40,603	6,423	13.86	22.95	8.64
Enhancement....	2,705	14,397	2,276	4.91	8.14	3.06
Dyestuffs and extracts:						
Product.....	2,263	31,433	5,900	12.78	14.85	6.87
Enhancement....	2,600	11,253	2,112	4.58	5.31	2.46
Explosives:						
Product.....	6,570	19,739	4,931	9.23	12.53	5.31
Enhancement....	2,507	7,530	1,881	3.52	4.78	2.03
Fertilizers:						
Product.....	6,715	29,962	5,485	14.55	21.15	8.62
Enhancement....	1,983	8,848	1,620	4.30	6.25	2.55
Gas, illuminating and heating:						
Product.....	5,029	10,945	3,446	8.22	12.56	4.97
Enhancement....	3,276	7,129	2,245	5.35	8.18	3.23
Glue, n. e. s. ¹ :						
Product.....	4,389	23,596	3,701	7.41	17.78	5.23
Enhancement....	1,395	7,500	1,174	2.35	5.65	1.66
Grease and tallow, n. e. s. ¹ :						
Product.....	4,677	31,761	4,228	7.09	24.20	5.37
Enhancement....	1,535	10,060	1,331	2.23	7.62	1.69
Ink, printing:						
Product.....	9,942	16,044	6,138	13.00	7.45	4.74
Enhancement....	5,050	8,148	3,118	6.60	3.78	2.41
Ink, writing:						
Product.....	5,438	8,212	3,271	10.59	5.22	3.50
Enhancement....	3,023	4,566	1,819	5.89	2.90	1.94
Lubricating greases:						
Product.....	10,334	11,413	5,412	17.44	8.86	5.88
Enhancement....	4,521	4,993	2,373	7.63	3.88	2.57
Matches:						
Product.....	3,304	16,922	2,764	7.09	11.92	4.47
Enhancement....	1,936	9,912	1,617	4.13	6.98	2.62
Oil, cottonseed, and cake:						
Product.....	9,726	41,967	7,895	24.99	35.83	14.72
Enhancement....	1,428	6,160	1,159	3.67	5.26	2.16
Oil, essential:						
Product.....	9,293	33,057	7,254	17.40	22.04	9.72
Enhancement....	3,008	10,700	2,348	5.63	7.13	3.15
Oil, linseed:						
Product.....	30,163	89,766	22,577	39.83	48.47	21.86
Enhancement....	3,581	10,656	2,680	4.73	5.75	2.60
Oil, n. e. s. ¹ :						
Product.....	18,565	26,343	10,890	27.91	15.49	9.94
Enhancement....	5,671	8,047	3,324	8.53	4.72	3.04
Paints and varnishes:						
Product.....	9,055	15,815	5,758	14.31	10.26	5.98
Enhancement....	3,554	6,207	2,260	5.61	4.03	2.35
Patent medicines and compounds and druggists' preparations:						
Product.....	6,563	9,494	3,881	13.17	7.27	4.70
Enhancement....	3,958	5,731	2,342	7.95	4.42	2.84
Petroleum refining:						
Product.....	15,626	70,041	12,776	20.43	50.22	14.52
Enhancement....	2,803	12,563	2,282	3.67	9.01	2.61
Salt:						
Product.....	2,765	23,969	2,479	4.63	14.54	3.51
Enhancement....	1,532	13,283	1,374	2.56	8.05	1.94
Soup:						
Product.....	9,028	23,627	6,532	15.82	19.12	8.66
Enhancement....	2,750	7,216	1,995	4.83	5.84	2.64
Sulfuric, nitric, and mixed acids:						
Product.....	4,966	28,176	4,222	6.87	17.49	4.94
Enhancement....	2,768	15,706	2,353	3.83	9.75	2.75
Turpentine and rosin:						
Product.....	603	11,309	572	2.45	14.64	2.14
Enhancement....	444	8,321	449	1.80	10.78	1.50
Wood distillation, not including turpentine and rosin:						
Product.....	3,552	30,503	3,182	6.32	24.52	5.02
Enhancement....	1,217	10,454	1,090	2.16	8.40	1.72

¹ N. e. s. is used in all tables in this article for "not elsewhere specified."

purpose are shown in Table II. It is a difficult matter to determine just what industries should be included in this class, for the chemist plays some part in almost every line of manufacturing endeavor, but an effort has been made to keep within the limits that will be acknowledged as reasonable, and the classification here followed is substantially that of the 1914 Census of Manufactures.

For further convenience in comparing the various chemical and allied industries in the twelve particulars indicated in Table II, a series of thirteen tables (III to XV) has been prepared to show the rank of each industry in each particular and collectively (Table XV). Bold-faced type has been employed to designate the branches that exceed the average for the chemical and allied industries. These tables follow:

TABLE III—RANK BY "PRODUCT PER WAGE EARNER"
(Branches exceeding average for chemical industries shown in bold-face type)

1—\$30.163 Oil, linseed	12— 7.263 Dyestuffs and extracts	21— 4.703 Coke
2— 18.565 Oil, n. e. s.	13— 6.715 Fertilizers	22— 4.677 Grease and tallow, n. e. s.
3— 15.626 Petroleum refining	14— 6.570 Explosives	23— 4.661 Bluing
4— 10.334 Lubricating greases	15— 6.563 Patent medicines and compounds and druggists' preparations	24— 4.473 Candles
5— 9.942 Ink, printing	16— 6.334 Blackening and cleansing and polishing preparations	25— 4.389 Glue, n. e. s.
6— 9.841 Baking powder and yeast	17— 5.438 Ink, writing	26— 4.319 Bone, carbon, and lampblack
7— 9.726 Oil, cottonseed, and cake	18— 5.029 Gas, illuminating and heating	27— 3.552 Wood distillation, not including turpentine and rosin
8— 9.293 Oils, essential	19— 4.966 Sulfuric, nitric, and mixed acids	28— 3.304 Matches
9— 9.055 Paints and varnish	20— 4.882 Chemicals	29— 2.765 Salt
10— 9.028 Soap		30— 603 Turpentine and rosin
11— 7.630 Drug grinding		

TABLE IV—RANK BY "PRODUCT PER SALARY EARNER"
(Branches exceeding average for chemical industries shown in bold-face type)

1—\$89.766 Oil, linseed	11— 28.889 Chemicals	22— 16.044 Ink, printing
2— 70.041 Petroleum refining	12— 28.176 Sulfuric, nitric, and mixed acids	23— 15.815 Paints and varnish
3— 42.791 Coke	13— 26.343 Oil, n. e. s.	24— 13.767 Bluing
4— 41.967 Oil, cottonseed, and cake	14— 23.969 Salt	25— 11.413 Lubricating greases
5— 40.603 Drug grinding	15— 23.627 Soap	26— 11.309 Turpentine and rosin
6— 33.057 Oils, essential	16— 23.596 Glue, n. e. s.	27— 10.945 Gas, illuminating and heating
7— 31.761 Grease and tallow, n. e. s.	17— 19.739 Explosives	28— 9.494 Patent medicines and compounds and druggists' preparations
8— 31.433 Dyestuffs and extracts	18— 19.022 Candles	29— 9.711 Blackening and cleansing and polishing preparations
9— 30.503 Wood distillation, not including turpentine and rosin	19— 18.074 Bone, carbon, and lampblack	30— 8.212 Ink, writing
10— 29.962 Fertilizers	20— 17.843 Baking powder and yeast	
	21— 16.922 Matches	

TABLE V—RANK BY "PRODUCT PER SERVICE UNIT"
(Branches exceeding average for chemical industries shown in bold-face type)

1—\$22.577 Oil, linseed	12— 5.485 Fertilizers	21— 3.701 Glue, n. e. s.
2— 12.776 Petroleum refining	13— 5.412 Lubricating greases	22— 3.621 Candles
3— 10.890 Oil, n. e. s.	14— 4.931 Explosives	23— 3.486 Bone, carbon, and lampblack
4— 7.895 Oil, cottonseed, and cake	15— 4.238 Coke	24— 3.482 Bluing
5— 7.254 Oils, essential	16— 4.228 Grease and tallow, n. e. s.	25— 3.446 Gas, illuminating and heating
6— 6.532 Soap	17— 4.222 Sulfuric, nitric, and mixed acids	26— 3.271 Ink, writing
7— 6.423 Drug grinding	18— 4.183 Chemicals	27— 3.182 Wood distillation, not including turpentine and rosin
8— 6.343 Baking powder and yeast	19— 3.881 Patent medicines and compounds and druggists' preparations	28— 2.764 Matches
9— 6.138 Ink, printing	20— 3.834 Blackening and cleansing and polishing preparations	29— 2.479 Salt
10— 5.900 Dyestuffs and extracts		30— 572 Turpentine and rosin
11— 5.758 Paints and varnish		

TABLE VI—RANK BY "PRODUCT PER WAGE DOLLAR"
(Branches exceeding average for chemical industries shown in bold-face type)

1—\$39.83 Oil, linseed	12— 13.17 Patent medicines and compounds and druggists' preparations	21— 7.41 Glue, n. e. s.
2— 27.91 Oil, n. e. s.	13— 13.00 Ink, printing	22— 7.16 Chemicals
3— 24.99 Oil, cottonseed, and cake	14— 12.78 Dyestuffs and extracts	23— 7.09 Grease and tallow, n. e. s.
4— 20.43 Petroleum refining	15— 12.72 Blackening and cleansing and polishing preparations	24— 7.09 Matches
5— 17.89 Baking powder and yeast	16— 11.28 Bluing	25— 6.95 Coke
6— 17.44 Lubricating greases	17— 10.59 Ink, writing	26— 6.87 Sulfuric, nitric, and mixed acids
7— 17.40 Oils, essential	18— 9.46 Candles	27— 6.34 Bone, carbon, and lampblack
8— 15.82 Soap	19— 9.23 Explosives	28— 6.32 Wood distillation, not including turpentine and rosin
9— 14.55 Fertilizers	20— 8.22 Gas, illuminating and heating	29— 4.63 Salt
10— 14.31 Paints and varnish		30— 2.45 Turpentine and rosin
11— 13.86 Drug grinding		

TABLE VII—RANK BY "PRODUCT PER SALARY DOLLAR"
(Branches exceeding average for chemical industries shown in bold-face type)

1—\$50.22 Petroleum refining	11— 17.78 Glue, n. e. s.	22— 11.72 Baking powder and yeast
2— 48.47 Oil, linseed	12— 17.52 Chemicals	23— 10.67 Bluing
3— 37.36 Coke	13— 17.49 Sulfuric, nitric, and mixed acids	24— 10.26 Paints and varnish
4— 35.83 Oil, cottonseed, and cake	14— 15.49 Oils, n. e. s.	25— 10.01 Candles
5— 24.52 Wood distillation, not including turpentine and rosin	15— 14.85 Dyestuffs and extracts	26— 8.86 Lubricating greases
6— 24.20 Grease and tallow, n. e. s.	16— 14.64 Turpentine and rosin	27— 7.45 Ink, printing
7— 22.95 Drug grinding	17— 14.54 Salt	28— 7.27 Patent medicines and compounds and druggists' preparations
8— 22.04 Oils, essential	18— 13.94 Bone, carbon, and lampblack	29— 7.17 Blackening and cleansing and polishing preparations
9— 21.15 Fertilizers	19— 12.56 Gas, illuminating and heating	30— 5.22 Ink, writing
10— 19.12 Soap	20— 12.53 Explosives	
	21— 11.92 Matches	

TABLE VIII—RANK BY "PRODUCT PER SERVICE DOLLAR"

(Branches exceeding average for chemical industries shown in bold-face type)

1—\$21.86 Oil, linseed	12— 5.88 Lubricating greases	22— 4.86 Candles
2— 14.72 Oil, cottonseed, and cake	13— 5.86 Coke	23— 4.74 Ink, printing
3— 14.52 Petroleum refining	14— 5.48 Bluing	24— 4.70 Patent medicines and compounds and druggists' preparations
4— 10.40 Baking powder and yeast	15— 5.37 Grease and tallow, n. e. s.	25— 4.58 Blacking and cleansing and polishing preparations
5— 9.94 Oil, n. e. s.	16— 5.31 Explosives	26— 4.47 Matches
6— 9.72 Oils, essential	17— 5.23 Glue, n. e. s.	27— 4.36 Bone, carbon, and lampblack
7— 8.66 Soap	18— 5.08 Chemicals	28— 3.51 Salt
8— 8.64 Drug grinding	19— 5.02 Wood distillation, not including turpentine and rosin	29— 3.50 Ink, writing
9— 8.62 Fertilizers	20— 4.97 Gas, illuminating and heating	30— 2.10 Turpentine and rosin
10— 6.87 Dyestuffs and extracts	21— 4.94 Sulfuric, nitric, and mixed acids	
11— 5.98 Paints and varnish		

TABLE IX RANK BY "ENHANCEMENT PER WAGE EARNER"

(Branches exceeding average for chemical industries shown in bold-face type)

1—\$5.671 Oils, n. e. s.	10— 3,023 Ink, writing	21— 1,983 Fertilizers
2— 5,050 Ink, printing	11— 3,008 Oils, essential	22— 1,936 Matches
3— 5,041 Baking powder and yeast	12— 2,803 Petroleum refining	23— 1,581 Candles
4— 4,521 Lubricating greases	13— 2,768 Sulfuric, nitric, and mixed acids	24— 1,535 Grease and tallow, n. e. s.
5— 3,958 Patent medicines and compounds and druggists' preparations	14— 2,750 Soap	25— 1,532 Salt
6— 3,581 Oil, linseed	15— 2,736 Bluing	26— 1,428 Coke
7— 3,554 Paints and varnish	16— 2,705 Drug grinding	27— 1,428 Oil, cottonseed, and cake
8— 3,331 Blacking and cleansing and polishing preparations	17— 2,600 Dyestuffs and extracts	28— 1,395 Glue, n. e. s.
9— 3,276 Gas, illuminating and heating	18— 2,507 Explosives	29— 1,217 Wood distillation, not including turpentine and rosin
	19— 2,295 Bone, carbon, and lampblack	30— 444 Turpentine and rosin
	20— 2,123 Chemicals	

TABLE X—RANK BY "ENHANCEMENT PER SALARY EARNER"

(Branches exceeding average for chemical industries shown in bold-face type)

1—\$15,706 Sulfuric, nitric, and mixed acids	11— 10,000 Grease and tallow, n. e. s.	22— 7,216 Soap
2— 14,397 Drug grinding	12— 9,912 Matches	23— 7,129 Gas, illuminating and heating
3— 13,283 Salt	13— 9,605 Bone, carbon, and lampblack	24— 6,725 Candles
4— 12,563 Petroleum refining	14— 9,141 Baking powder and yeast	25— 6,207 Paints and varnish
5— 12,559 Coke	15— 8,848 Fertilizers	26— 6,160 Oil, cottonseed, and cake
6— 12,539 Chemicals	16— 8,321 Turpentine and rosin	27— 5,731 Patent medicines and compounds and druggists' preparations
7— 11,253 Dyestuffs and extracts	17— 8,148 Ink, printing	28— 5,109 Blacking and cleansing and polishing preparations
8— 10,700 Oils, essential	18— 8,081 Bluing	29— 4,993 Lubricating greases
9— 10,656 Oil, linseed	19— 8,047 Oil, n. e. s.	30— 4,566 Ink, writing
10— 10,454 Wood distillation, not including turpentine and rosin	20— 7,530 Explosives	
	21— 7,500 Glue, n. e. s.	

TABLE XI—RANK BY "ENHANCEMENT PER SERVICE UNIT"

(Branches exceeding average for chemical industries shown in bold-face type)

1—\$3,324 Oil, n. e. s.	11— 2,260 Paints and varnish	21— 1,620 Fertilizers
2— 3,249 Baking powder and yeast	12— 2,245 Gas, illuminating and heating	22— 1,617 Matches
3— 3,118 Ink, printing	13— 2,112 Dyestuffs and extracts	23— 1,374 Salt
4— 2,680 Oil, linseed	14— 2,044 Bluing	24— 1,331 Grease and tallow, n. e. s.
5— 2,373 Lubricating greases	15— 2,016 Blacking and cleansing and polishing preparations	25— 1,286 Coke
6— 2,353 Sulfuric, nitric, and mixed acids	16— 1,995 Soap	26— 1,280 Candles
7— 2,348 Oils, essential	17— 1,881 Explosives	27— 1,174 Glue, n. e. s.
8— 2,342 Patent medicines and compounds and druggists' preparations	18— 1,852 Bone, carbon, and lampblack	28— 1,159 Oil, cottonseed, and cake
9— 2,282 Petroleum refining	19— 1,819 Ink, writing	29— 1,090 Wood distillation, not including turpentine and rosin
10— 2,276 Drug grinding	20— 1,816 Chemicals	30— 449 Turpentine and rosin

TABLE XII—RANK BY "ENHANCEMENT PER WAGE DOLLAR"

(Branches exceeding average for chemical industries shown in bold-face type)

1—\$9.16 Baking powder and yeast	10— 5.61 Paints and varnish	21— 3.52 Explosives
2— 8.53 Oils, n. e. s.	11— 5.35 Gas, illuminating and heating	22— 3.37 Bone, carbon, and lampblack
3— 7.95 Patent medicines and compounds and druggists' preparations	12— 4.91 Drug grinding	23— 3.34 Candles
4— 7.63 Lubricating greases	13— 4.83 Soap	24— 3.11 Chemicals
5— 6.69 Blacking and cleansing and polishing preparations	14— 4.73 Oil, linseed	25— 2.56 Salt
6— 6.62 Bluing	15— 4.58 Dyestuffs and extracts	26— 2.35 Glue, n. e. s.
7— 6.60 Ink, printing	16— 4.30 Fertilizers	27— 2.23 Grease and tallow, n. e. s.
8— 5.89 Ink, writing	17— 4.13 Matches	28— 2.16 Wood distillation, not including turpentine and rosin
9— 5.63 Oil, essential	18— 3.83 Sulfuric, nitric, and mixed acids	29— 2.11 Coke
	19— 3.67 Oil, cottonseed, and cake	30— 1.80 Turpentine and rosin
	20— 3.67 Petroleum refining	

TABLE XIII—RANK BY "ENHANCEMENT PER SALARY DOLLAR"

(Branches exceeding average for chemical industries shown in bold-face type)

1—\$11.34 Coke	11— 7.41 Bone, carbon, and lampblack	22— 4.78 Explosives
2— 10.78 Turpentine and rosin	12— 7.13 Oil, essential	23— 4.72 Oil, n. e. s.
3— 9.75 Sulfuric, nitric, and mixed acids	13— 6.98 Matches	24— 4.42 Patent medicines and compounds and druggists' preparations
4— 9.01 Petroleum refining	14— 6.26 Bluing	25— 4.03 Paints and varnish
5— 8.40 Wood distillation, not including turpentine and rosin	15— 6.25 Fertilizers	26— 3.88 Lubricating greases
6— 8.18 Gas, illuminating and heating	16— 6.00 Baking powder and yeast	27— 3.78 Ink, printing
7— 8.14 Drug grinding	17— 5.84 Soap	28— 3.77 Blacking and cleansing and polishing preparations
8— 8.05 Salt	18— 5.75 Oil, linseed	29— 3.54 Candles
9— 7.62 Grease and tallow, n. e. s.	19— 5.65 Glue, n. e. s.	30— 2.90 Ink, writing
10— 7.60 Chemicals	20— 5.31 Dyestuffs and extracts	
	21— 5.26 Oil, cottonseed, and cake	

TABLE XIV—RANK BY "ENHANCEMENT PER SERVICE DOLLAR"
(Branches exceeding average for chemical industries shown in bold-face type)

1—\$5.33 Baking powder and yeast	11—2.61 Petroleum refining	21—2.16 Oil, cottonseed, and cake
2—3.23 Gas, illuminating and heating	12—2.60 Oil, linseed	22—2.03 Explosives
3—3.22 Bluing	13—2.57 Lubricating greases	23—1.94 Ink, writing
4—3.15 Oil, essential	14—2.55 Fertilizers	24—1.94 Salt
5—3.06 Drug grinding	15—2.46 Dyestuffs and extracts	25—1.78 Coke
6—3.04 Oil, n. e. s.	16—2.41 Blackening and cleansing and polishing preparations	26—1.72 Candles
7—2.84 Patent medicines and compounds and druggists' preparations	17—2.41 Ink, printing	27—1.72 Wood distillation, not including turpentine and rosin
8—2.75 Sulfuric, nitric, and mixed acids	18—2.35 Paints and varnish	28—1.69 Grease and tallow, n. e. s.
9—2.64 Soap	19—2.32 Bone, carbon, and lampblack	29—1.66 Glue, n. e. s.
10—2.62 Matches	20—2.21 Chemicals	30—1.54 Turpentine and rosin

TABLE XV—RANK OF CHEMICAL INDUSTRIES IN ALL TWELVE PARTICULARS

	"PRODUCT"				"ENHANCEMENT"			
	Per wage earner	Per salary earner	Per service unit	Per service dollar	Per wage earner	Per salary earner	Per service unit	Per service dollar
Baking powder.....	6	20	8	5	22	4	1	16
Blackening and cleansing and polishing preparations.....	16	29	20	15	29	25	8	28
Bluing.....	23	24	26	16	23	14	6	14
Bone, carbon, and lampblack.....	19	13	27	18	27	19	13	18
Candles.....	20	18	22	18	22	23	24	26
Chemicals.....	20	7	18	22	12	18	20	6
Coke.....	21	3	15	25	3	26	5	25
Drug grinding.....	11	5	7	11	7	14	2	10
Dyestuffs and extracts.....	12	8	10	14	15	17	13	15
Explosives.....	14	17	14	19	20	18	20	17
Fertilizers.....	13	10	12	9	9	21	15	16
Gas, illuminating and heating.....	18	25	20	19	20	9	23	12
Glue, n. e. s.....	25	16	21	11	17	28	21	26
Grease and tallow, n. e. s.....	22	7	6	23	6	24	11	24
Ink, printing.....	5	22	9	13	27	2	17	3
Ink, writing.....	17	30	26	17	19	10	30	19
Lubricating greases.....	4	25	13	6	26	4	29	5
Matches.....	28	21	28	24	21	22	12	22
Oil, cottonseed, and cake.....	7	4	4	3	4	27	26	28
Oil, essential.....	8	6	5	7	8	11	8	7
Oil, linseed.....	9	11	1	2	1	6	9	4
Oil, n. e. s.....	2	1	3	2	14	1	12	18
Paints and varnish.....	2	12	3	14	5	19	1	23
Patent medicines and compounds and druggists' preparations.....	23	11	10	24	11	7	25	10
Petroleum refining.....	15	28	19	12	28	5	27	8
Salt.....	3	2	4	1	3	12	4	9
Soap.....	29	14	29	19	17	25	33	25
Sulfuric, nitric, and mixed acids.....	10	15	6	8	10	17	15	16
Turpentine and rosin.....	19	12	17	26	13	1	6	18
Wood distillation, not including turpentine and rosin.....	30	26	30	30	30	30	2	30
	27	9	27	28	5	19	20	28

TABLE XVI—NON-CHEMICAL INDUSTRIES (Continued)

	Per Wage Earner	Per Salary Earner	Per Service Unit	Per Wage Dollar	Per Salary Dollar	Per Service Dollar
	Per wage earner	Per salary earner	Per service unit	Per wage dollar	Per salary dollar	Per service dollar
Belt and hose, wooden and rubber:						
Product.....	4,615	21,376	3,796	8.30	13.78	5.19
Enhancement.....	2,005	9,287	1,649	3.62	5.99	2.26
Billiard tables and materials:						
Product.....	3,368	16,252	2,787	4.97	13.37	3.62
Enhancement.....	1,656	7,941	1,370	2.44	6.57	1.78
Boots and shoes, including cut stock and findings:						
Product.....	2,863	29,777	2,607	5.21	23.16	4.26
Enhancement.....	1,009	1,049	920	1.84	8.16	1.50
Boots and shoes, rubber:						
Product.....	2,880	32,229	2,644	5.39	27.49	4.50
Enhancement.....	1,598	17,884	1,467	2.99	15.25	2.50
Boxes, cigar:						
Product.....	1,428	20,791	1,337	3.63	17.44	3.00
Enhancement.....	697	10,145	632	1.77	8.31	1.46
Boxes, fancy and paper:						
Product.....	1,649	16,431	1,498	3.99	12.69	3.04
Enhancement.....	848	8,455	771	2.06	6.55	1.16
Brass and bronze products:						
Product.....	4,024	35,570	3,615	6.47	22.93	5.04
Enhancement.....	1,159	10,244	1,041	1.86	6.00	1.45
Bread and other bakery products:						
Product.....	3,965	24,587	1,658	6.40	24.88	5.00
Enhancement.....	1,754	10,879	730	2.83	11.01	2.25
Brick, tile, pottery, and other clay products:						
Product.....	1,364	17,732	1,267	2.42	13.02	2.04
Enhancement.....	932	12,111	865	1.65	8.89	1.39
Brooms and brushes:						
Product.....	2,488	16,612	2,164	5.26	13.90	3.81
Enhancement.....	1,149	7,672	999	2.43	6.42	1.76
Butter, cheese, and condensed milk:						
Product.....	15,796	54,153	12,230	22.99	59.42	16.58
Enhancement.....	2,132	7,523	1,654	3.11	8.03	2.27
Butter, reworking:						
Product.....	19,306	77,224	15,445	29.35	59.79	19.69
Enhancement.....	2,678	10,658	2,132	4.05	8.27	2.72
Buttons:						
Product.....	1,427	16,583	1,314	3.22	12.54	2.56
Enhancement.....	828	9,616	762	1.87	7.27	1.49
Canning and preserving:						
Product.....	3,287	25,387	2,910	5.95	21.37	6.69
Enhancement.....	1,131	8,737	1,001	3.08	7.30	2.17
Card cutting and designing:						
Product.....	2,041	16,746	1,819	3.98	14.45	3.12
Enhancement.....	1,066	10,763	1,093	2.39	8.68	1.88
Carpets and rugs, other than rag:						
Product.....	2,208	40,191	2,093	4.70	24.05	3.93
Enhancement.....	858	15,609	813	1.82	9.34	1.53
Carpet rag:						
Product.....	1,308	10,798	1,167	2.80	11.42	2.25
Enhancement.....	969	8,094	865	2.07	8.46	1.67
Carriages and sleds, children's:						
Product.....	1,922	22,007	1,827	3.69	15.75	2.99
Enhancement.....	1,029	11,365	943	1.91	8.14	1.55
Carriages and wagons, and materials:						
Product.....	2,511	20,471	2,237	4.04	16.92	3.26
Enhancement.....	1,251	10,244	1,119	2.02	8.47	1.63
Cars and general shop constructions and repair by steam-railroad companies:						
Product.....	1,514	22,942	1,420	2.19	21.38	1.99
Enhancement.....	796	12,060	747	1.13	11.24	1.05
Cars and general shop construction and repairs by electric-railroad companies:						
Product.....	1,462	21,115	1,367	2.07	20.14	1.88
Enhancement.....	794	11,476	743	1.12	10.95	1.02
Cars, steam-railroad, not including operations of railroad companies:						
Product.....	3,588	41,339	3,303	4.71	4.71	4.03
Enhancement.....	1,153	13,545	1,061	1.51	1.51	1.29
Cars, electric-railroad, not including operations of railroad companies:						
Product.....	2,733	23,531	2,425	4.25	14.30	3.28
Enhancement.....	1,079	9,294	967	1.68	5.65	1.30
Cash registers and calculating machines:						
Product.....	3,408	8,032	2,393	5.00	5.57	6.23
Enhancement.....	2,962	6,981	2,080	4.34	4.84	2.29
Cement:						
Product.....	3,645	25,237	2,393	5.59	16.77	4.19
Enhancement.....	1,785	12,344	2,080	2.74	8.21	2.05
Charcoal:						
Product.....	1,763	22,333	1,634	4.06	33.50	4.82
Enhancement.....	742	9,389	687	2.09	14.08	1.32
China, decorating:						
Product.....	2,464	16,156	2,138	4.57	12.98	3.38
Enhancement.....	1,346	8,822	1,168	2.50	7.09	1.84
Chocolate and cocoa products:						
Product.....	8,325	40,629	7,087	17.54	24.58	10.24
Enhancement.....	2,700	12,776	2,229	5.52	7.73	3.27

TABLE XVI.—NON-CHEMICAL INDUSTRIES (Continued)

	Per Wage Earner	Per Salary Earner	Per Service Unit	Per Wage Dollar	Per Salary Dollar	Per Service Dollar		Per Wage Earner	Per Salary Earner	Per Service Unit	Per Wage Dollar	Per Salary Dollar	Per Service Dollar
Clocks and watches, including cases and materials:							Flax and hemp, dressed:						
Product.....	1,464	20,209	1,365	2.53	14.83	2.16	Product.....	2,440	12,304	1,011	6.19	18.87	4.72
Enhancement....	992	13,688	925	1.71	10.04	1.46	Enhancement....	1,644	4,261	350	2.18	6.53	1.63
Cloth, sponging and refinishing:							Flour-mill and grist-mill products:						
Product.....	1,690	13,549	1,510	2.33	8.51	1.83	Product.....	22,098	66,250	16,571	35.53	53.62	21.43
Enhancement....	1,552	12,372	1,379	2.12	7.77	1.67	Enhancement....	3,158	9,466	2,368	5.10	7.66	3.06
Clothing, horse:							Food preparations:						
Product.....	3,086	22,687	2,716	7.71	20.68	5.62	Product.....	10,801	28,837	7,858	20.19	23.29	10.81
Enhancement....	1,947	6,965	834	2.37	6.35	1.72	Enhancement....	3,230	8,622	2,350	6.04	6.96	3.23
Clothing, men's, buttonholes:							Foundry and machine-shop products:						
Product.....	949	42,533	929	1.96	45.57	1.88	Product.....	2,432	14,842	2,100	3.65	10.45	2.72
Enhancement....	815	36,533	798	1.68	39.14	1.61	Enhancement....	1,382	8,433	1,187	2.07	6.05	1.54
Clothing, men's, including shirts:							Foundry supplies:						
Product.....	2,454	22,168	2,210	5.23	17.90	4.03	Product.....	3,627	7,833	2,479	6.69	5.82	3.11
Enhancement....	1,211	10,937	1,090	2.58	8.70	1.99	Enhancement....	1,831	3,953	1,251	3.38	2.94	1.57
Clothing, women's:							Fuel, manufactured:						
Product.....	2,806	21,287	2,479	5.12	5.12	3.99	Product.....	6,121	29,759	5,076	7.71	27.84	6.03
Enhancement....	1,312	9,952	1,159	2.39	2.39	1.87	Enhancement....	1,801	8,759	1,494	2.27	8.19	1.78
Coffee and spice, roasting and grinding:							Fur goods:						
Product.....	17,634	24,757	10,298	33.44	16.91	11.23	Product.....	4,832	16,824	3,773	6.89	15.68	4.79
Enhancement....	4,004	5,621	2,338	7.59	3.84	2.55	Enhancement....	2,191	7,808	1,719	3.12	7.11	2.17
Coffins, burial cases, and undertakers' goods:							Furnishing goods, men's:						
Product.....	2,780	14,123	2,323	4.89	10.48	3.33	Product.....	2,251	19,272	2,023	5.55	15.15	4.06
Enhancement....	1,380	7,011	1,153	2.43	4.50	1.66	Enhancement....	697	8,497	892	2.45	6.68	1.78
Confectionery:							Furniture and refrigerators:						
Product.....	3,185	17,273	2,688	7.96	13.84	5.05	Product.....	2,103	17,435	2,078	3.72	12.93	2.89
Enhancement....	1,301	7,060	1,099	3.25	5.66	2.07	Enhancement....	1,138	9,435	1,125	2.02	7.00	1.56
Confectionery (ice cream):							Fur, dressed:						
Product.....	3,395	22,519	4,353	8.18	21.61	5.93	Product.....	1,885	20,683	1,728	3.11	10.57	2.41
Enhancement....	1,490	9,337	1,803	3.39	8.96	2.46	Enhancement....	1,291	14,165	1,183	2.13	7.24	1.64
Cooperage and wooden goods, n. e. s.:							Garbings:						
Product.....	2,556	37,309	2,392	5.05	27.95	4.60	Product.....	5,367	29,964	4,552	9.20	22.86	6.56
Enhancement....	946	13,815	886	1.87	10.35	1.74	Enhancement....	1,384	7,728	1,174	2.37	5.89	1.69
Copper, tin, and sheet-iron products:							Gas and electric fixtures and lamp appliances:						
Product.....	3,023	22,172	2,660	5.04	16.85	3.88	Product.....	2,514	13,576	3,984	2.53	9.67	2.95
Enhancement....	1,318	9,664	1,160	2.20	7.34	1.69	Enhancement....	1,290	6,965	2,044	2.18	4.96	1.52
Cordage and twine, and jute and linen goods:							Glass:						
Product.....	3,762	34,325	2,880	7.30	34.12	6.47	Product.....	1,632	29,243	1,564	2.53	18.79	2.23
Enhancement....	831	14,846	787	2.00	9.32	1.77	Enhancement....	1,034	18,311	979	1.58	11.77	1.40
Cordials and flavoring syrups:							Glass cutting, staining, and ornamenting:						
Product.....	16,487	26,361	10,143	33.22	17.48	11.46	Product.....	2,039	13,949	1,779	3.52	12.60	2.75
Enhancement....	8,310	13,253	5,113	16.75	8.81	5.77	Enhancement....	1,153	7,891	1,017	1.99	7.09	1.55
Cork, cutting:							Gloves and mittens, leather:						
Product.....	2,280	31,375	2,126	4.98	19.79	3.98	Product.....	2,026	17,154	1,812	4.74	15.44	3.63
Enhancement....	904	12,446	843	1.97	7.85	1.58	Enhancement....	885	7,494	792	2.07	6.75	1.58
Corsets:							Glucose and starch:						
Product.....	1,978	15,909	1,759	5.08	9.50	3.31	Product.....	11,669	38,182	8,768	14.82	27.12	9.58
Enhancement....	1,023	8,224	909	2.63	4.91	1.71	Enhancement....	2,752	9,004	2,108	3.50	6.40	2.26
Cotton goods, including cotton, small wares:							Gold and silver, leaf and foil:						
Product.....	1,783	70,004	1,738	4.54	40.30	4.13	Product.....	2,143	26,725	1,984	4.88	19.30	3.90
Enhancement....	653	25,731	639	1.69	14.81	1.52	Enhancement....	863	10,769	799	1.97	5.64	1.37
Cruelies:							Gold and silver, reducing and refining, not from the ore:						
Product.....	6,245	34,926	5,290	11.03	13.10	5.99	Product.....	62,693	133,589	42,669	73.12	90.47	40.44
Enhancement....	2,040	11,407	173	3.60	4.28	1.96	Enhancement....	4,004	13,449	4,296	7.36	9.11	4.07
Cutlery and tools, n. e. s.:							Graphite, ground and refined:						
Product.....	1,778	14,952	1,589	3.08	10.68	2.39	Product.....	6,896	10,708	4,195	9.52	7.12	4.08
Enhancement....	1,167	9,814	1,043	2.02	7.09	1.57	Enhancement....	1,535	6,217	2,436	5.53	4.14	2.37
Dairymen's, poultrymen's, and apiarists' supplies:							Grindstones:						
Product.....	2,814	12,944	2,701	5.63	11.24	3.75	Product.....	997	15,545	937	2.12	11.03	1.78
Enhancement....	1,748	6,627	1,383	2.88	5.75	1.92	Enhancement....	826	1,299	778	1.76	9.02	1.48
Dental goods:							Haircloth:						
Product.....	5,247	27,343	4,402	10.00	19.95	6.66	Product.....	4,025	42,018	3,673	8.26	24.19	6.16
Enhancement....	1,768	9,213	1,483	3.37	6.92	2.24	Enhancement....	1,245	13,000	1,137	2.56	7.48	1.90
Dyeing and finishing textiles:							Hair work:						
Product.....	2,255	24,543	2,065	4.39	16.89	3.49	Product.....	2,779	14,131	2,334	5.74	12.71	3.96
Enhancement....	1,085	11,809	993	2.11	8.13	1.67	Enhancement....	1,589	7,653	1,204	3.11	6.89	2.14
Electric machinery, apparatus and supplies:							Hammocks:						
Product.....	2,839	12,761	2,322	4.54	9.50	3.07	Product.....	2,534	14,587	2,027	5.64	13.42	3.97
Enhancement....	1,528	6,870	1,250	2.44	5.11	1.65	Enhancement....	1,088	6,739	967	2.61	6.20	1.83
Electroplating:							Hand stamps and stencils and brands:						
Product.....	1,847	14,290	1,636	2.79	12.53	2.28	Product.....	2,538	7,855	1,918	3.90	7.65	2.59
Enhancement....	1,330	10,290	1,178	2.01	9.02	1.64	Enhancement....	1,725	5,357	1,308	2.66	5.22	1.76
Emery and other abrasive wheels:							Hat and cap materials:						
Product.....	2,987	11,746	2,381	4.78	7.94	2.98	Product.....	1,903	35,352	3,515	8.62	26.35	6.49
Enhancement....	1,227	6,792	1,377	2.77	4.59	1.73	Enhancement....	1,057	9,577	952	2.33	7.14	1.76
Enameling and japanning:							Hats and caps, other than felt, straw, and wool:						
Product.....	1,652	11,443	1,522	3.19	14.64	2.62	Product.....	2,539	22,592	2,283	4.12	20.12	3.42
Enhancement....	962	11,321	886	1.86	8.52	1.52	Enhancement....	1,272	11,330	1,145	2.07	10.09	1.72
Engravers' materials:							Hats, fur felt:						
Product.....	7,245	16,340	5,020	10.52	10.52	5.26	Product.....	1,752	25,741	1,644	3.09	19.36	2.67
Enhancement....	1,047	4,617	1,418	2.97	2.97	1.49	Enhancement....	957	14,061	896	1.69	10.58	1.46
Engraving and diesinking:							Hats, straw:						
Product.....	2,040	14,509	1,789	2.91	13.87	2.41	Product.....	2,683	25,469	2,427	4.65	14.40	3.62
Enhancement....	1,652	11,750	1,449	2.36	11.23	1.95	Enhancement....	1,198	11,369	1,184	2.16	6.43	1.62
Engraving, wood:							Hones and whetstones:						
Product.....	2,381	9,986	1,922	2.32	6.54	1.71	Product.....	1,519	8,387	1,244	4.06	8.12	2.70
Enhancement....	2,063	8,653	1,666	2.01	5.66	1.48	Enhancement....	1,028	5,881	861	2.70	5.41	1.80
Fancy articles, n. e. s.:							Horseshoes, not made in steel works or rolling mills:						
Product.....	2,283	13,876	1,961	4.68	10.92	3.27	Product.....	3,037	14,288	2,505	4.93	8.55	3.13
Enhancement....	1,166	7,091	1,002	2.39	5.58	1.67	Enhancement....	1,864	8,768	1,537	3.03	5.24	1.92
Files:							Hosiery and knit goods:						
Product.....	1,289	15,281	1,189	2.63	12.06	2.16	Product.....	1,720	32,962	1,635	4.33	22.95	3.64
Enhancement....	923	10,935	851	1.88	8.63	1.54	Enhancement....	746	14,287	709	1.88	9.95	1.58
Firearms and ammunition:							House-furnishing goods, n. e. s.:						
Product.....	2,230	25,112	2,049	3.50	18.06	2.93	Product.....	959	21,630	3,223	8.00	15.19	5.24
Enhancement....	1,209	13,612	1,111	1.90	9.79	1.59	Enhancement....	1,308	7,410	1,100	2.74	5.21	1.80
Fire extinguishers, chemical:							Ice, manufactured:						
Product.....	5,070	10,817	3,452	6.49	4.90	3.09	Product.....	2,624	11,141	2,124	4.07	10.58	2.94
Enhancement....	2,828	6,033	1,926	3.62	3.29	1.72	Enhancement....	1,853	7,866	1,499	2.87	7.49	2.07
Fireworks:							Instruments, professional and scientific:						
Product.....	1,734	18,079	1,582	3.73	13.51	2.92	Product.....	2,462	10,514	1,995	3.76	8.97	2.65
Enhancement....	748	8,583	751	1.77	6.41	1.39	Enhancement....	1,676	7,159	1,358	2.56	6.11	1.80
Flags, banners, regalia, society badges, and emblems:							Iron and steel, blast furnaces:						
Product.....	461	10,197	1,983	5.17	9.79	3.38	Product.....	10,821	83,090	9,574			

TABLE XVI—NON-CHEMICAL INDUSTRIES (Continued)

	Per Wage Earner	Per Salary Earner	Per Service Unit	Per Wage Dollar	Per Salary Dollar	Per Service Dollar	Per Wage Earner	Per Salary Earner	Per Service Unit	Per Wage Dollar	Per Salary Dollar	Per Service Dollar
Iron and steel, bolts, nuts, washers, and rivets:												
Product.....	2,196	21,510	1,992	3.93	13.45	3.04						
Enhancement.....	984	9,642	893	1.76	6.03	1.36						
Iron and steel, doors and shutters:												
Product.....	2,012	13,361	2,185	3.37	9.47	4.78						
Enhancement.....	1,606	8,216	1,343	2.07	5.10	2.94						
Iron and steel forgings:												
Product.....	2,709	23,431	2,429	3.87	14.52	3.05						
Enhancement.....	1,363	11,610	1,203	1.93	7.19	1.51						
Iron and steel, nails and spikes, cut and wrought, including wire nails, not made in steel, works or rolling mills:												
Product.....	2,723	14,543	2,293	4.77	10.42	3.27						
Enhancement.....	1,363	7,283	1,148	2.39	5.22	1.64						
Iron and steel pipe, wrought:												
Product.....	4,257	45,096	3,890	6.55	30.24	5.38						
Enhancement.....	1,284	13,604	1,173	1.98	9.12	1.62						
Jewelry:												
Product.....	2,864	14,582	2,394	4.43	11.06	3.16						
Enhancement.....	1,481	7,341	1,238	2.29	5.72	1.63						
Jewelry and instrument cases:												
Product.....	1,440	12,200	1,367	3.31	11.57	2.57						
Enhancement.....	907	8,514	820	1.98	6.94	1.54						
Labels and tags:												
Product.....	2,532	11,551	2,077	4.51	7.81	2.86						
Enhancement.....	1,414	6,449	1,160	2.52	4.36	1.60						
Lapidary work:												
Product.....	9,178	51,538	7,791	8.36	32.29	6.64						
Enhancement.....	2,430	13,644	2,063	2.21	8.55	1.76						
Lard refined, not made in slaughtering and meat-packing establishments:												
Product.....	7,737	9,800	4,324	12.25	13.36	6.39						
Enhancement.....	2,368	3,000	1,324	3.75	4.09	1.96						
Lasts:												
Product.....	2,191	13,149	1,878	3.04	7.64	2.17						
Enhancement.....	1,073	9,301	1,329	2.15	5.40	1.54						
Lead, bar, pipe, and sheet:												
Product.....	33,027	9,174	18,26	19.25	9.37							
Enhancement.....	2,381	6,147	1,707	4.48	3.88	1.74						
Leather goods, n. e. s.:												
Product.....	3,269	18,061	2,768	5.76	14.67	4.13						
Enhancement.....	1,358	7,664	1,175	2.44	6.22	1.75						
Leather, tanned, curried, and finished:												
Product.....	6,565	85,835	6,098	11.50	49.78	9.35						
Enhancement.....	1,483	19,391	1,378	2.60	11.25	2.11						
Lime:												
Product.....	1,480	17,582	1,365	3.04	14.26	2.51						
Enhancement.....	872	10,357	804	1.79	8.31	1.48						
Liquors, distilled:												
Product.....	32,848	122,572	25,906	51.77	62.53	28.32						
Enhancement.....	26,336	98,270	20,769	41.51	50.13	22.71						
Liquors, malt:												
Product.....	7,122	34,481	5,904	8.30	16.37	5.51						
Enhancement.....	5,033	24,364	4,172	5.87	11.57	3.89						
Liquors, vinous:												
Product.....	7,250	27,976	5,758	13.92	18.65	7.97						
Enhancement.....	3,154	12,002	2,470	5.97	8.00	3.42						
Locomotives, not made by railroad companies:												
Product.....	2,494	26,192	2,277	3.91	15.66	3.13						
Enhancement.....	1,140	11,973	1,041	1.79	7.14	1.43						
Looking-glass and picture frames:												
Product.....	2,301	12,587	1,945	3.86	10.22	2.80						
Enhancement.....	1,267	7,481	1,156	2.30	6.07	1.67						
Lumber and timber products:												
Product.....	1,811	27,065	1,697	3.47	20.52	2.97						
Enhancement.....	964	14,404	903	1.85	10.92	1.58						
Machinery:												
Product.....	29,200	99,861	19,479	26.33	36.91	15.37						
Enhancement.....	4,492	18,535	3,616	4.89	6.85	2.85						
Marble and stone work:												
Product.....	4,471	19,029	1,766	2.82	15.18	2.38						
Enhancement.....	1,278	12,309	1,143	1.82	9.82	1.54						
Mats and matting, from cocoa fiber grass, etc.:												
Product.....	2,573	22,816	2,312	4.91	23.05	4.05						
Enhancement.....	1,227	10,878	1,102	2.34	10.99	1.93						
Mattresses and spring:												
Product.....	3,279	17,409	2,771	5.76	14.39	4.11						
Enhancement.....	1,389	7,337	1,168	2.43	6.07	1.73						
Milinery and lace goods:												
Product.....	1,522	18,043	2,212	5.30	15.53	3.95						
Enhancement.....	1,248	8,927	1,094	2.62	7.69	1.95						
Mineral and soda waters:												
Product.....	3,766	14,994	3,010	6.59	13.04	4.51						
Enhancement.....	1,939	8,119	1,630	3.57	7.72	2.44						
Minerals and earths, ground:												
Product.....	2,190	15,069	1,912	4.12	11.74	3.06						
Enhancement.....	1,221	8,401	1,066	2.31	6.54	1.71						
Mirrors, framed and unframed:												
Product.....	3,200	21,587	2,787	5.17	15.39	3.87						
Enhancement.....	1,314	8,845	1,142	1.12	6.31	1.59						
Models and patterns, not including paper patterns:												
Product.....	2,013	13,361	2,185	3.37	11.55	2.27						
Enhancement.....	1,535	10,361	1,337	2.11	8.81	1.70						
Motorcycles, bicycles, and parts:												
Product.....	3,328	21,612	2,885	4.69	18.92	3.76						
Enhancement.....	1,693	11,019	1,467	2.38	9.62	1.91						
Mucilage and paste:												
Product.....	8,136	15,689	5,357	14.27	12.71	6.72						
Enhancement.....	3,367	6,493	2,217	5.91	5.26	2.78						
Musical instruments and materials, n. e. s.:												
Product.....	2,080	10,594	1,666	3.12	9.41	2.27						
Enhancement.....	1,421	7,542	1,196	2.25	6.76	1.68						
Musical instruments, pianos and organs and materials:												
Product.....	2,368	22,541	2,143	3.81	13.72	2.98						
Enhancement.....	1,270	12,087	1,149	2.04	7.37	1.60						
Needles, pins, and hooks and eyes:												
Product.....	1,478	20,182	1,377	3.15	13.20	2.54						
Enhancement.....	871	11,890	811	1.85	7.76	1.50						
Oakum:												
Product.....	3,095	25,643	2,762	7.33	18.89	5.28						
Enhancement.....	1,069	8,857	954	2.53	6.53	1.82						
Oilcloths and linoleum:												
Product.....	4,530	44,441	4,111	7.97	27.35	6.17						
Enhancement.....	1,384	13,580	1,256	2.43	8.36	1.89						
Oleomargarine:												
Product.....	16,445	43,458	11,930	25.82	30.28	13.94						
Enhancement.....	5,260	13,899	3,816	8.26	9.68	4.46						
Optical goods:												
Product.....	2,297	8,409	1,804	3.91	7.52	2.57						
Enhancement.....	1,463	5,355	1,149	2.49	4.79	1.64						
Paper and wood pulp:												
Product.....	3,755	48,574	3,486	6.24	25.71	5.02						
Enhancement.....	1,345	17,398	1,248	2.23	9.21	1.80						
Paper goods, n. e. s.:												
Product.....	3,316	16,491	2,761	6.63	12.69	4.36						
Enhancement.....	1,405	6,989	1,174	2.81	5.38	1.85						
Paper patterns:												
Product.....	2,835	3,240	1,508	5.23	4.00	2.27						
Enhancement.....	2,237	2,570	1,196	4.16	3.17	1.80						
Paving materials:												
Product.....	1,826	20,260	1,675	3.19	14.19	2.60						
Enhancement.....	1,122	12,711	1,110	1.92	8.55	1.57						
Peanuts, grading, roasting, cleaning, and shelling:												
Product.....	6,373	70,736	5,846	26.36	49.49	17.20						
Enhancement.....	1,031	11,439	945	4.26	8.00	2.78						
Penicillin lead:												
Product.....	1,923	19,413	1,750	4.28	11.25	3.10						
Enhancement.....	869	8,774	791	1.94	5.09	1.40						
Pens, fountain, stylographic, and gold:												
Product.....	6,701	9,738	3,458	8.42	10.94	4.76						
Enhancement.....	3,994	7,253	2,576	6.27	8.15	3.54						
Pens, steel:												
Product.....	895	8,274	809	2.11	6.04	1.56						
Enhancement.....	691	6,387	624	1.63	4.66	1.21						
Photographs and graphophones:												

TABLE XVI—NON-CHEMICAL INDUSTRIES (Continued)

	Per Wage Earner	Per Salary Earner	Per Service Unit	Per Wage Dollar	Per Salary Dollar	Per Service Dollar
Slaughtering and meat packing:						
Product.....	16,552	75,503	13,582	26.26	59.65	18.23
Enhancement....	1,127	9,698	1,664	3.39	7.66	2.34
Smelting and refining copper:						
Product.....	25,042	238,337	22,151	27.44	122.72	22.46
Enhancement....	3,658	34,817	3,310	4.02	17.90	3.28
Smelting and refining gold:						
Product.....	23,233	264,782	21,359	27.97	114.77	22.49
Enhancement....	2,378	27,105	2,186	2.86	11.74	2.30
Smelting and refining zinc:						
Product.....	5,567	75,619	5,185	7.99	36.25	6.55
Enhancement....	1,452	19,725	1,353	2.08	9.45	1.71
Smelting and refining, not from the ore:						
Product.....	15,436	72,417	12,724	21.18	37.82	13.58
Enhancement....	3,347	15,701	2,759	4.59	8.20	2.94
Soda-water apparatus:						
Product.....	3,940	14,985	3,119	5.29	10.36	3.50
Enhancement....	2,197	8,358	1,740	2.95	5.78	1.95
Springs and athletic goods:						
Product.....	2,363	22,432	2,139	4.78	18.48	3.80
Enhancement....	1,122	10,649	1,015	2.27	8.77	1.80
Springs, steel, car and carriage:						
Product.....	3,131	23,615	2,765	4.46	13.53	3.35
Enhancement....	1,172	11,104	1,300	2.10	6.36	1.58
Stationery goods, n. e. s.:						
Product.....	2,834	10,779	2,244	4.57	7.88	2.89
Enhancement....	1,442	5,482	1,141	2.33	4.01	1.47
Statuary and art goods:						
Product.....	1,967	17,854	1,772	2.47	12.86	2.07
Enhancement....	1,543	14,009	1,390	1.94	10.07	1.63
Steam packing:						
Product.....	3,374	13,575	2,702	5.63	9.64	3.55
Enhancement....	1,433	5,766	1,129	2.39	4.09	1.51
Stereotyping and electrotyping:						
Product.....	2,359	9,162	1,876	2.72	7.59	2.00
Enhancement....	1,706	6,628	1,357	1.96	5.48	1.45
Stoves and furnaces, including gas and oil stoves:						
Product.....	2,396	14,697	2,059	3.46	10.20	2.58
Enhancement....	1,485	9,115	1,277	2.14	6.33	1.60
Sugar, beet:						
Product.....	7,829	38,267	6,432	9.48	27.00	7.06
Enhancement....	2,652	12,962	2,179	3.21	9.39	2.39
Sugar, cane, including refining:						
Product.....	20,896	152,468	18,377	33.14	103.92	25.13
Enhancement....	2,082	15,191	1,831	3.30	10.35	2.50
Surgical appliances and artificial limbs:						
Product.....	3,442	11,284	2,637	6.36	9.21	3.76
Enhancement....	1,888	6,189	1,447	3.49	5.05	2.06
Theatrical scenery:						
Product.....	3,716	8,838	2,616	3.67	4.54	2.03
Enhancement....	2,295	5,459	1,616	2.27	2.83	1.25
Tin plate and ternplate:						
Product.....	13,048	139,191	11,929	17.42	90.04	14.60
Enhancement....	1,992	21,255	1,822	2.66	13.75	2.23
Tin foil:						
Product.....	4,916	50,178	4,477	9.62	32.49	7.42
Enhancement....	1,354	13,822	1,233	2.65	8.95	2.04
Toiletry manufactures:						
Product.....	27,403	29,138	2,505	6.30	22.16	4.90
Enhancement....	1,582	10,880	1,446	3.64	12.79	2.83
Toys and games:						
Product.....	1,744	17,436	1,586	4.05	13.83	2.75
Enhancement....	1,011	10,110	919	2.41	8.02	1.60
Type-founding and printing materials:						
Product.....	3,000	8,827	2,319	4.40	5.12	2.58
Enhancement....	1,873	5,510	1,398	2.75	3.90	1.61
Typewriters and supplies:						
Product.....	2,209	8,272	1,774	3.52	7.16	2.36
Enhancement....	1,632	6,985	1,376	2.73	5.55	1.83
Umbrellas and canes:						
Product.....	2,883	18,666	2,497	6.37	13.29	4.31
Enhancement....	1,090	7,055	944	2.41	5.03	1.63
Upholstering materials:						
Product.....	3,726	26,860	3,272	7.69	17.89	5.38
Enhancement....	1,287	9,275	1,130	2.66	6.18	1.86
Vault lights and ventilators:						
Product.....	3,413	11,269	2,619	4.49	8.43	3.40
Enhancement....	1,817	6,000	1,395	2.39	4.44	1.81
Vinegar and cider:						
Product.....	6,356	15,256	4,487	19.06	13.28	6.00
Enhancement....	2,743	6,584	1,936	4.73	5.73	2.59
Wall paper:						
Product.....	3,353	16,794	2,795	5.88	10.47	3.76
Enhancement....	1,551	7,771	1,293	2.72	4.82	1.74
Wall plaster:						
Product.....	3,070	15,220	2,555	4.79	10.44	3.28
Enhancement....	1,587	7,867	1,320	2.48	5.39	1.70
Washing machines and clothes wringers:						
Product.....	3,345	14,757	2,698	6.22	10.86	3.96
Enhancement....	1,500	6,703	1,223	2.83	4.93	1.80
Waste:						
Product.....	5,931	50,286	5,308	14.78	31.21	10.03
Enhancement....	796	6,749	712	1.98	4.19	1.35
Wheelbarrows:						
Product.....	2,916	12,730	2,373	4.73	9.52	3.16
Enhancement....	1,588	6,932	1,267	2.58	5.18	1.72
Whips:						
Product.....	2,719	12,548	2,235	5.66	7.87	3.29
Enhancement....	1,557	7,226	1,287	3.26	4.53	1.89
Window shades:						
Product.....	2,812	16,026	2,392	4.39	10.84	3.13
Enhancement....	1,505	8,577	1,280	2.35	5.81	1.67
Window shades and fixtures:						
Product.....	4,279	21,093	3,557	8.00	16.18	5.35
Enhancement....	1,363	6,717	1,133	2.55	5.15	1.70
Wire:						
Product.....	4,650	38,568	4,150	7.43	27.48	5.85
Enhancement....	1,444	11,978	1,289	2.31	8.53	1.82

TABLE XVI—NON-CHEMICAL INDUSTRIES (Concluded)

	Per Wage Earner	Per Salary Earner	Per Service Unit	Per Wage Dollar	Per Salary Dollar	Per Service Dollar
Wireworks, including wire rope and cable:						
Product.....	3,447	20,188	2,944	6.22	14.54	4.36
Enhancement....	1,457	8,539	1,245	2.63	6.15	1.84
Wood carpet:						
Product.....	3,355	25,318	2,963	3.36	19.89	2.87
Enhancement....	1,500	11,318	1,324	1.50	8.89	1.28
Wood preserving:						
Product.....	7,440	33,905	6,101	11.80	22.33	7.72
Enhancement....	1,765	8,043	1,444	2.80	5.30	1.83
Wood, turned and carved:						
Product.....	1,640	19,616	1,513	3.37	16.96	2.81
Enhancement....	851	10,176	785	1.75	8.80	1.46
Woolpulling:						
Product.....	11,685	98,488	10,446	18.30	57.85	13.90
Enhancement....	2,318	19,536	2,072	3.63	11.48	2.76
Wool scouring:						
Product.....	4,311	6,305	2,560	7.40	28.18	5.86
Enhancement....	4,312	9,919	779	2.24	8.57	1.78
Woolen worsted, and felt goods, and wool hats:						
Product.....	2,410	64,426	2,323	5.02	33.55	4.37
Enhancement....	850	22,720	819	1.77	11.83	1.54
All other industries ¹ :						
Product.....	3,092	19,714	2,673	4.70	3.35	1.95
Enhancement....	1,821	11,607	1,574	2.77	9.97	1.15

¹ Includes the following industries, with number of establishments indicated: Motion pictures, 16; millstones, 2; ordnance and accessories, 2; pulp from fiber other than wood, 3; and whalebone cutting, 1.

COMPARISON OF NON-CHEMICAL INDUSTRIES

The branches of industry remaining after deducting the thirty classed as "chemical and allied" number two hundred and twenty-nine. These are not all separate industries in the generally accepted sense, but are given separately in the census of manufactures.

Table XVI contains statistics for these industries worked out on the same basis as followed for the chemical and allied industries.

COMPARISON OF AMERICAN WITH FOREIGN CHEMICAL INDUSTRIES

In the tables that follow are shown statistics compiled for the purpose of indicating how the American chemical industry compares with those of England, Germany, and Japan on the basis of production and enhancement per wage earner, per salary earner, per service unit, per wage dollar, per salary dollar, and per service dollar.

It was found impossible, however, to carry out the comparisons in all these particulars, for the reason that there is for none of these countries a recent census of manufactures that compares at all favorably with those taken by our own Government. As planned, France is included in the comparison, although it was found that there is nothing in print that could be termed a census of French manufactures, and it was possible to get only incomplete results for two industries.

It should be explained that the failure to publish more adequate and frequent production figures in these countries is not due primarily to the unwillingness or indifference of the respective governments, but is rather an inevitable consequence of the innate conservatism of the foreign manufacturer, who has always been much more secretive about the details of his business than has his American rival. Probably the attitude is a natural one under the circumstances existing in the various countries, but no one who has attempted to get information from manufacturers in those countries will deny its reality.

TABLE XVII—COMPARISON WITH ENGLISH CHEMICAL INDUSTRIES

ARTICLES	PER WAGE UNITED Kingdom	EARNER UNITED States	PER SALARY UNITED Kingdom	EARNER UNITED States	PER SERVICE UNIT UNITED Kingdom	UNITED States	PER WAGE UNITED Kingdom	DOLLAR UNITED States
Chemicals, coal-tar products, drugs, and perfumery:								
Product.....	\$2,537	\$4,276	\$18,787	\$16,760	\$2,235	\$3,407	\$8.31	\$7.51
Enhancement.....	1,010	2,195	7,477	8,605	890	1,749	3.31	3.85
Coke:								
Product.....	4,642	4,703	150,906	42,791	4,503	4,238	...	...
Enhancement.....	1,370	1,428	44,543	12,559	1,329	1,286	...	...
Explosives:								
Product.....	1,624	6,570	20,901	19,739	1,507	4,931	6.10	9.23
Enhancement.....	621	2,507	7,991	7,330	576	1,881	2.33	3.52
Fertilizers, glue, sheep dip, and disinfectants:								
Product.....	2,640	6,434	17,371	29,311	2,292	5,276	...	...
Enhancement.....	865	1,912	5,690	8,711	751	1,568	...	...
Gas, illuminating and heating:								
Product.....	2,012	5,029	17,872	10,945	1,807	3,446	5.27	8.22
Enhancement.....	1,071	3,276	9,529	7,129	963	2,245	2.81	5.35
Ink, gum, and sealing wax:								
Product.....	3,598	8,570	9,519	14,264	2,611	5,354	...	...
Enhancement.....	1,876	4,198	4,963	6,987	1,361	2,623	...	...
Matches and firelighters:								
Product.....	1,077	3,304	10,642	16,922	978	2,764	...	...
Enhancement.....	515	1,936	3,090	9,912	468	1,617	...	...
Oil and tallow:								
Product.....	6,982	8,893	24,956	25,521	5,456	6,595	...	...
Enhancement.....	1,174	2,832	4,197	8,128	918	2,400	...	...
Paints and varnish:								
Product.....	3,906	9,055	12,645	15,815	2,984	5,758	...	...
Enhancement.....	1,228	3,554	3,975	6,207	938	2,260	...	...
Salt:								
Product.....	732	2,765	10,713	23,969	685	2,479	2.48	4.63
Enhancement.....	350	1,532	5,123	13,283	328	1,374	1.19	2.56
Seed-crushing trade:								
Product.....	9,269	11,031	70,791	46,250	8,196	8,609	30.71	26.72
Enhancement.....	993	1,566	7,581	6,564	878	1,222	3.29	3.79
Soap and candles:								
Product.....	3,812	8,907	19,045	23,551	3,177	6,463	14.11	15.68
Enhancement.....	907	2,726	4,530	7,208	756	1,978	3.36	4.80
Total chemical and allied trades:								
Product.....	2,970	6,639	21,388	22,091	2,608	5,105	...	11.90
Enhancement.....	999	2,372	7,197	7,894	877	1,824	...	4.25

ENGLAND¹

Most of the returns for England are figured on the basis of the Census of Production of 1907. Since, in the act authorizing this census, wages are specifically excluded from the list of subjects about which information is to be obtained, there are no data on salaries and wages in the census returns. Only the product and enhancement per wage earner, per salary earner, and per service unit were based on the census figures; the product and enhancement per wage dollar were supplied for some industries from data as to wages contained in the Earnings and Hours Inquiry of the British Board of Trade, Vol. 8, relating to the year 1906.

The following industries are directly comparable in the British and American statistics: Coke, explosives, illuminating and heating gas, matches, paints and varnish, and salt. For the other chemical industries the British statistics are not so detailed as the American and it has been necessary in a number of cases to group several United States items in order to arrive at comparable figures. Thus in Table XVII the figures for the United States under "chemicals, coal-tar products, drugs, and perfumery" were obtained by combining the American items, chemicals, drug grinding, druggists' preparations, patent medicines, and perfumery; sulfuric, nitric, and mixed acids; essential oils; wood-distillation products; dye-stuffs and extracts; dyeing and finishing textiles; and photographic materials. These groups tally closely with those included in the British classification.

The British figures for "fertilizers, glue, sheep dip, and disinfectants" are compared with the United States figures for fertilizers and glue only, since the

Census of Manufactures does not list disinfectants, insecticides, etc. The difference in the make-up of the two groups consists in the inclusion in the British results of disinfectants, insecticides, etc., and cattle dip, together valued at \$3,913,000, or 14 per cent of the value of products in the group. The figures for wage earners and salary earners in this case and in similar cases that will be discussed later are given only for the group as a whole; only the value of production is given for its component parts.

Gum and sealing wax will be found in the United States census under the heading "mucilage and paste," and these figures were accordingly added to those for printing ink and writing ink in order to make a group that would be roughly comparable with the British "ink, gum, and sealing wax." Oil, n. e. s., lubricating greases, and grease and tallow in the American classification together represent the industries included in the British oil and tallow trades. The products of the British seed-crushing industries are 73 per cent cottonseed and linseed oil and cake, the remainder being made up of rapeseed oil and cake, other oils and compound, and other cakes. The nearest American equivalent to this group is represented by the combined figures for cottonseed and linseed oil and cake, and these have therefore been used in the tabular comparison. The United States soap and candle items were combined to correspond with the British "soap and candles."

The Earnings and Hours Inquiry gives average wages for men, boys, women, and girls in various industries during a typical week in 1906. The classification of industries is not so detailed as that of the Census of Production; but it has been possible, by means of some of these returns, a calculation of the number of working weeks in the different industries, and the

¹ England is used in the popular sense—including Great Britain and Ireland.

number of employees given in the census, to approximate the total wage bill and the product and enhancement per wage dollar. From the Board of Trade's Fifteenth Annual Report on Changes in Wages and Hours of Labor, there appears to have been a very slight increase in wages in the chemical industry in 1907, but the amount of the increase could not be estimated closely enough to be allowed for in the figures. It was not sufficient, however, to affect greatly the results.

In the Earnings and Hours Inquiry wages are given for the manufacture of chemicals separately; pharmaceutical preparations are included in "other chemical industries." The product and enhancement per wage dollar for the group "chemicals, coal-tar products, drugs, and perfumery" have been calculated by means of the weekly wage given for chemicals only. The other industries for which wages were worked out are directly comparable with the Census of Production classification.

FRANCE

The Ministère du Commerce, de l'Industrie, des Postes, et des Telegraphes, published in 1917 a volume called "Évaluation de la Production," which gives either the value of product or the quantity produced and the value per unit, for a number of the chemical industries, such as explosives (results for 1912), salt (1912), coke (1912), inks (1912), sulfuric acid (1913), nitric acid (annual, before the war), carbonic acid (1912), and dyes and dyestuffs (annual before the war).

Except in the case of the first two items, however, the only available figures for the number of employees are those of the census of occupations of 1906. Only for gas works, matches, explosives, and "all other" chemical industries are figures for the number of employees obtainable from the census of 1911, which is less detailed with regard to occupations than the census of 1906. Of these items, gas is not given at all in the "Évaluation de la Production," the quantity only is given for matches, and the value of production cannot be calculated to cover so broad a classification as "all other chemical industries." For explosives, the product per service unit has been obtained by dividing the value of production in 1912 (\$6,562,000) by the number of employees and wage earners (6,664, not stated separately) according to the census of 1911.

The value and the number of wage earners for the salt industry given in the "Évaluation de la Production" were taken from the "Statistique de l'Industrie Minérale pour l'Année 1912," published by the Ministère des Travaux Publics. The latter report also gives wages.

The value is stated as \$3,059,000, the number of workers as 9,392, and the aggregate wages as \$315,533. The results obtained from these figures are not to be accepted unreservedly, however, because it is stated that the majority of the 7,900 workers in the sea-salt industry are only temporary employees

and also because 3,155 of the total number of wage earners were paid in kind and their earnings are not included in the figures for aggregate wages.

A series of reports on French industries, commerce, and agriculture has been issued from time to time since 1917 by the Association Nationale d'Expansion Économique. In the three monographs on the chemical industries in this series the quantity and not the value of products is given and there are no figures for the number of employees or for wages.

TABLE XVIII—COMPARISON WITH FRENCH CHEMICAL INDUSTRIES

ARTICLES	PRODUCT PER WAGE EARNER		PRODUCT PER SERVICE UNIT		PRODUCT PER WAGE DOLLAR	
	France	United States	France	United States	France	United States
Explosives (1911 and 1912)			\$985	\$4,931		
Salt (1912)	\$326	\$2,765			\$9.69	\$4.63

GERMANY

No official figures are available for the value of production in the German chemical industry. A few figures for individual industries have been published from time to time in the "Vierteljahrshefte zur Statistik des Deutschen Reichs" and in the "Statistisches Jahrbuch;" and the latest of these have been made the basis for the accompanying table. Because of the paucity of material, several items have been included as of general interest for which it was not possible to supply corresponding figures for the United States.

In the American statistics, for example, both coal-tar products and potash are included in the group "chemicals," and carbonic acid is not mentioned.

TABLE XIX—COMPARISON WITH GERMAN CHEMICAL INDUSTRIES

ARTICLES	PER WAGE EARNER		PER WAGE DOLLAR	
	Germany	United States	Germany	United States
Carbonic acid, liquid (1912):				
Product	\$1,980	(a)	5.88	(a)
Enhancement	1,734	(a)	5.15	(a)
Coal-tar, water-gas tar, and oil-gas tar products (1912):				
Product	4,494	(a)	12.12	(a)
Enhancement	1,501	(a)	4.05	(a)
Coke (1912):				
Product	5,300	4,703	14.32	6.95
Enhancement	1,586	1,428	4.29	2.11
Petroleum refining (1912):				
Product	8,112	15,626	23.64	20.43
Potash and potash salts (1913):				
Product	1,304	(a)	3.78	(a)
Enhancement	481	(a)	1.39	(a)
Salt (1913):				
Product	1,007	2,765	3.40	4.63
Sulfuric acid and by-products (1912):				
Product	4,555	4,966	12.86	6.87
Enhancement	1,425	2,768	4.03	5.83

(a) Not available.

Where enhancement is omitted from the table, the raw material has been given in quantity only. The German group "sulfuric acid and by-products" is compared with the American group "sulfuric, nitric, and mixed acids." The number of employees given in the German statistics is the number that must take out insurance, *i. e.*, all wage earners and all clerks earning 2,500 marks (\$595) or less per year. The figures correspond more closely with the American wage earners than with either the salary earners or the service group, and the comparisons have been made on that basis.

JAPAN

The results for Japan have been taken from the Thirty-first and Thirty-second Statistical Reports of the Department of Agriculture and Commerce and refer to 1914 or 1915, the latter year having been used for industries not given in the report for 1914. Two tables in the Japanese report have been utilized; one gives the number of factories and workshops, the number of employees, and the value of products, and the other gives the number of employees in factories, the average daily wages of employees, the number of "laborers," and the number of working days in the year.

The cost of raw materials is not available; consequently enhancement figures cannot be given. For the factory employees it is possible from the items stated to calculate the yearly wage budget, *i. e.*, by multiplying the average daily wage by the number of employees by the number of working days in the year.

The resultant amount paid in wages is incomplete because it does not include the wages of "laborers," whose daily wage is not stated. The laborers are distinguished in the Japanese statistics from the persons actually engaged in the manufacturing processes. Their number is comparatively small, and their wages, which must be smaller than those of the factory employees, would probably, even in the aggregate, make little difference in the product per wage dollar. Moreover, the laborers are not included in the figure for the number of employees in the table that gives production; hence they could not be considered in the product per wage earner and they have accordingly been omitted in the product per factory wage earner also.

Usually the number of factory employees given is much smaller than the number for the factories and workshops; and the product per wage dollar would show important differences if it were possible to get the total amount of wages for all workers, including those in small shops. In the case of chemicals in 1914, however, owing evidently to a difference in classification, the number of workers in 44 factories is given as 3,415 in the table stating wages, while there are 402 "factories," with 3,182 employees, in the table stating the value of production. The chemical industries in which the 3,182 workers were employed included establishments producing sulfuric acid, hydrochloric acid, nitric acid, sodium sulfate, carbonate of soda, caustic soda, iodine, potassium iodide, potassium chloride, alum, ammonium sulfate, calcium acetate, and cleaning powder, to the aggregate value of \$3,824,000.

The other table gives 44 factories for "industrial chemicals," which are not further specified. They are evidently, however, a larger group than the chemicals mentioned in the other table; the value of production of "industrial chemicals" should be larger, therefore, than the value given, and this would make the value per wage dollar larger, as would be expected from the low scale of wages in Japan. In 1915, with

a product more than double in value that of 1914, the number of employees had increased to 5,115, the number of factory workers on "industrial chemicals" to 3,995, and the number of factories from 44 to 61. The product per wage earner for this year rose to \$1,628, the product per factory wage earner to \$2,084, and the product per wage dollar to \$27.34.

The number of employees in the fertilizer industry is not stated; but the number of licensed manufacturers at the end of 1914 was 23,790 and the product given is the aggregate from all these manufacturers.

The manufacture of artificial fertilizers is so overwhelmingly a small-shop industry that the product per factory wage earner given in the table (\$12,021) and the product per wage dollar (\$154.69) must both be greatly in excess of the actual output. Without doubt, the former should be lower than the American figure instead of higher; but the product per wage dollar, though lower than the figure given, must be much higher than in the United States, as was stated in connection with chemicals, because of the low wages paid in Japanese industry. There seems to be great variation in this industry from year to year. In 1915 the value of production was smaller and the number of employees larger than in 1914, so that the product per factory employee works out for 1915 at only \$5,506 and the product per wage dollar at \$71.10.

In the case of soap and candles (which are not shown separately in the statistics for wages), there were in 1915, 1,816 establishments in all, with 5,073 employees, of which 45 were factories with 1,646 employees (exclusive of laborers). The figure for factory product per wage earner (\$4,031) is evidently too high because the value of product given includes the output of the 1,771 small shops, as well as the 45 factories.

The figures given for the product per wage dollar is of doubtful value because of the large number of employees in the industry outside the factories, whose wages it is impossible to estimate. If, however, they were paid at the rate of only 50 per cent of the wages of the factory hands, the addition of their wages to the wages of the factory employees would lower the product per wage dollar to \$31.11.

TABLE XX—COMPARISON WITH JAPANESE CHEMICAL INDUSTRIES

ARTICLES	Total	PRODUCT PER WAGE EARNER		PRODUCT PER WAGE DOLLAR	
		Japan In factories	United States	Japan (factory workers only)	United States
Candles (1915).....	\$ 794	...	\$4.473	...	...
Chemicals (1914).....	1,202	\$1,120	4,898	\$13.85	\$7.14
Coke (1915).....	1,621	...	4,703	...	...
Fertilizers (1914).....	12,021	...	6,715	154.69	14.55
Matches (1914).....	494	...	3,304	...	...
Oils and oilcake (1914).....	1,089	6,229	11,031	84.84	26.72
Soap.....	1,691	...	9,028	...	...
1915.....	2,038	...	...	...	...
Soap and candles (1915).....	1,308	4,031	8,907	63.50	15.68

Details as to wages are not given in the Japanese statistics for coke and for match factory hands, and figures for product per wage dollar could not be calculated for these industries.

ORIGINAL PAPERS

INCLUSIONS AND FERRITE CRYSTALLIZATION IN STEEL¹

By EDWARD G. MAHIN

The injurious effects exerted by non-metallic inclusions upon the properties of iron and steel have long been recognized but no attempt to avoid the presence of such inclusions has been entirely successful. Their origin may be outlined briefly.

1—During the process of slag formation in the furnace the agitation of liquid iron results in trapping minute particles of slag, whose relative surface is so large as to prevent rapid separation. Many of these remain with the iron when it is tapped from the furnace and they are finally definitely locked up in the solidified ingot.

2—Manganese is added to steel in order to correct the objectionable effects of sulfur and to add desirable properties of its own. Manganese sulfide then forms distinct small particles, recognizable under the microscope as pale gray, rounded or elongated masses. They may contain also certain variable quantities of ferrous sulfide or of manganese.

3—During passage of the melted steel to the moulds oxidation of manganese sulfide occurs, manganese oxide and sulfur dioxide being produced, the latter escaping. At the same time there is some oxidation of iron silicide, ferrous oxide and silicon dioxide being formed. The result of the proximity of these bodies is the formation of a secondary slag, consisting of one or more of the silicates of iron and manganese, or mixtures or solutions of these with each other or with manganese sulfide.²

These processes give rise to the formation of rather complex materials and the recognition of distinct compounds becomes very difficult. Ordinary methods of chemical analysis are entirely useless for the purpose because the particles are usually so minute as to make a separation into their physical components impossible. Qualitative tests, together with metallographic and other examination of artificially produced inclusions of known composition, have made possible the following approximate statements:

1—The pale gray rounded or elongated masses, occurring either alone or embedded in a darker matrix, are manganese sulfide, possibly containing dissolved ferrous sulfide or manganese.

2—Darker gray masses, sometimes of varying shading and often carrying lighter masses of manganese sulfide or of silicates of different composition, are one or more of the silicates $\text{FeO} \cdot \text{SiO}_2$, $2\text{FeO} \cdot \text{SiO}_2$, $\text{MnO} \cdot \text{SiO}_2$, $2\text{MnO} \cdot \text{SiO}_2$, or solid solutions of these in each other. Figs. 1 and 2 illustrate these forms of inclusions.

The effects of inclusions upon the properties of steel may be regarded as being essentially the same as would be produced by cavities of similar size and shape. Many failures of steel have been traced to

inclusions. For instance, Fay¹ has shown that a large number of failures of steel rails are due to manganese sulfide inclusions occurring in abnormal quantities. In addition to this easily understandable effect there has long been noticed a certain connection between inclusions and grain formation that has been the subject of much discussion. Ordinary annealed steel of hypo-eutectoid composition is usually found to contain practically all of the inclusions within ferrite grains, and very rarely in pearlite.

Whatever may be the real cause of this phenomenon the result is the segregation of ferrite about the inclusions, often in relatively large granules or thickened network, this structure taking the place of the more nearly normal dissemination of smaller grains. Figs. 3 and 4 illustrate the structure of a steel containing manganese sulfide in ferrite. In these figures and in Fig. 5 some of the inclusions are indicated by arrows. Similar inclusions will be recognized without difficulty in the other photomicrographs. When a steel having such a structure is rolled or forged all structural entities are flattened³ or elongated and the result is a banded structure appearing in the section as alternating streaks of pearlite and ferrite with the latter containing the inclusions, now in the form of plates, threads, or elongated particles, according to the nature of the working that has been performed. Streaks thus appearing in section are often called ferrite "ghosts."

Segregation which has occurred in steel containing inclusions cannot be corrected by any ordinary thermal treatment, such as would break up ordinary grain systems and generate new ones. The steel is left in practically the same condition as before the treatment, except that grain size may be changed according to the time consumed and the temperature attained by the thermal treatment. If the steel is one that has not been subjected to mechanical treatment the inclusions will still be found within ferrite grains, whether the latter be large or small. If the steel has been previously rolled or forged the banded structure will persist through many repetitions of the reheating process and the threads of inclusions will still be found in the ferrite bands.

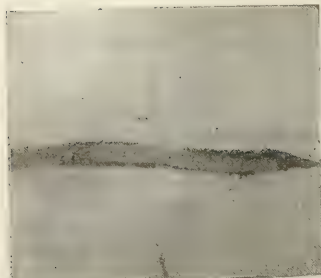
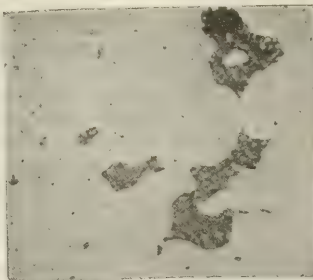
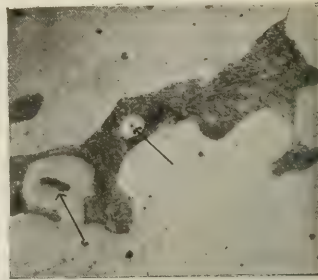
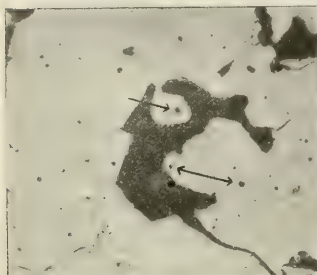
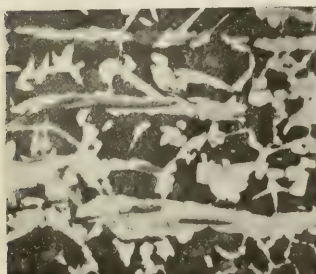
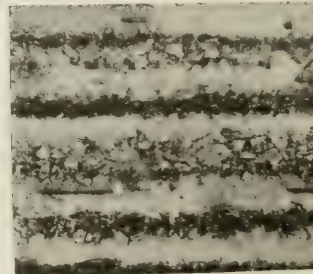
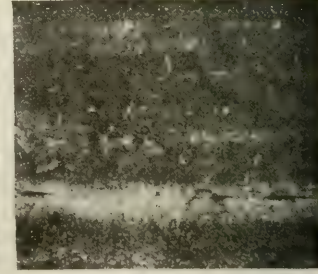
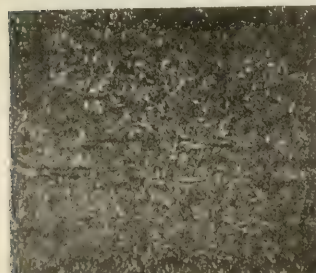
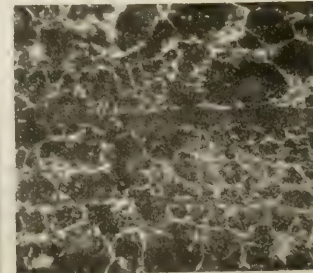
Whether the presence of non-metallic inclusions is the cause of ferrite segregation or simply incidental to it is a question that has been the subject of considerable interesting experimentation and discussion. Brearley suggested that inclusions are the cause of ferrite segregation and Ziegler proposed² as an explanation of the co-segregation of ferrite and inclusions the view that at high temperatures the inclusions are present as a more or less homogeneous solid solution in austenite and that as the latter begins to form grains at temperatures somewhat higher than A_1 , the impurities are rejected to the grain boundaries where they serve, at A_1 , as nuclei for the crystallization of ferrite. Ziegler's theory has never been generally accepted, as there is a mass of experimental evidence against it, as well as serious theoretical objections.

¹ Presented before the Indiana Section on January 17, 1919, and before the Division of Chemists and Chemical Engineers of the American Chemical Society at the Buffalo Meeting, April 7 to 11, 1919.

² McCance, *J. Iron and Steel Inst.*, **97** (1918), 256.

¹ *Proc. Am. Soc. Testing Materials*, **8** (1908), 74.

² *Rev. métal.*, **8** (1911), 655.

FIG. 1—SLAG FIBER IN ROLLED STEEL. $\times 500$ FIG. 2—SLAG IN WROUGHT IRON. $\times 100$ FIG. 3—STEEL. INCLUSIONS SURROUNDED BY FERRITE. $\times 500$ FIG. 4—STEEL. INCLUSIONS SURROUNDED BY FERRITE. $\times 500$ FIG. 5—UNTREATED RAIL ETCHED WITH NITRIC ACID. ELONGATED INCLUSIONS (DARK) LYING WITHIN FERRITE BANDS (LIGHT). $\times 100$ FIG. 6—UNTREATED RAIL ATTACKED BY COPPER REAGENT. $\times 100$ FIG. 7—STEEL HELD AT 850° TO 1000° FOR 91 HRS. ETCHED WITH NITRIC ACID. $\times 100$ FIG. 8—STEEL HELD AT 850° TO 1000° FOR 91 HRS. TREATED WITH COPPER REAGENT. $\times 100$ FIG. 9—STEEL QUENCHED IN OIL AT 20°. ETCHED WITH NITRIC ACID. $\times 100$ FIG. 10—STEEL QUENCHED IN WATER AT 20°. ETCHED WITH NITRIC ACID. $\times 100$ FIG. 11—STEEL COOLED IN OPEN AIR. ETCHED WITH NITRIC ACID. $\times 100$ FIG. 12—STEEL QUENCHED IN OIL AT 20°. TREATED WITH COPPER REAGENT $\times 100$

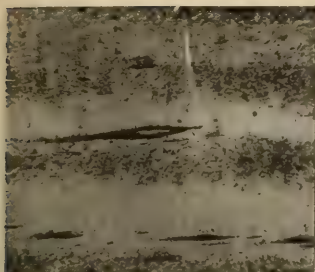


FIG. 13—STEEL QUENCHED IN WATER AT 20°, TREATED WITH COPPER REAGENT. $\times 100$



FIG. 14—STEEL COOLED IN OPEN AIR TREATED WITH COPPER REAGENT. $\times 100$

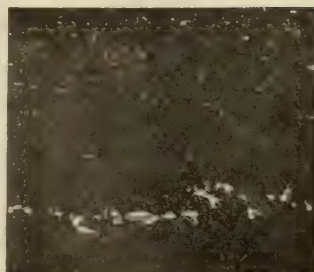


FIG. 15—STEEL COOLED IN FURNACE TO 775°, THEN QUENCHED. ETCHED WITH NITRIC ACID. $\times 100$

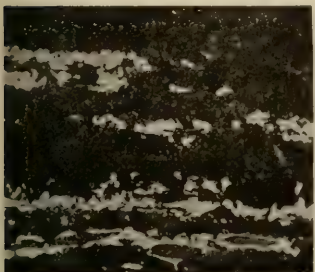


FIG. 16—STEEL COOLED IN FURNACE TO 750°, THEN QUENCHED. ETCHED WITH NITRIC ACID. $\times 100$

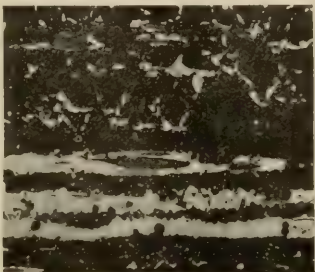


FIG. 17—STEEL COOLED IN FURNACE TO 725°, THEN QUENCHED. ETCHED WITH NITRIC ACID. $\times 100$

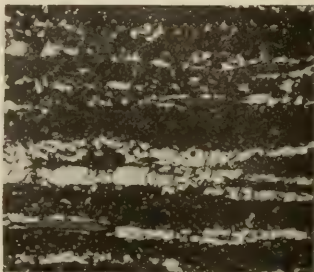


FIG. 18—STEEL COOLED IN FURNACE TO 700°, THEN QUENCHED. ETCHED WITH NITRIC ACID. $\times 100$



FIG. 19—STEEL COOLED IN FURNACE TO 775°, THEN QUENCHED. TREATED WITH COPPER REAGENT. $\times 100$

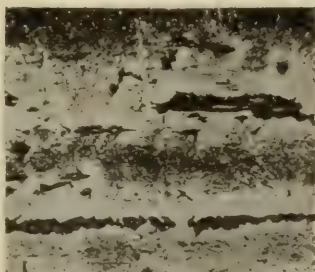


FIG. 20—STEEL COOLED IN FURNACE TO 750°, THEN QUENCHED. TREATED WITH COPPER REAGENT. $\times 100$

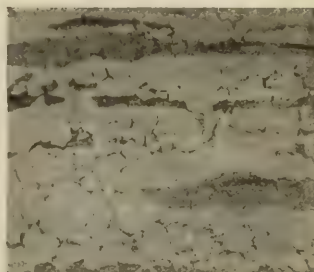


FIG. 21—STEEL COOLED IN FURNACE TO 725°, THEN QUENCHED. TREATED WITH COPPER REAGENT. $\times 100$

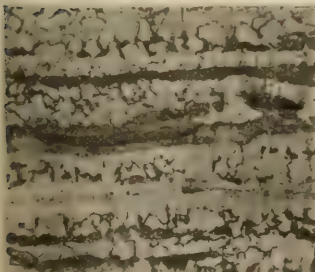


FIG. 22—STEEL COOLED IN FURNACE TO 700°, THEN QUENCHED. TREATED WITH COPPER REAGENT. $\times 100$

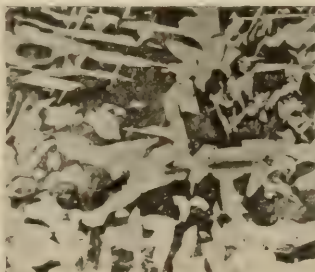


FIG. 23—STEEL HEATED FOR 3 DAYS AT 1100°. ETCHED WITH NITRIC ACID. $\times 100$



FIG. 24—STEEL HEATED FOR 3 DAYS AT 1100°. ETCHED WITH NITRIC ACID. $\times 100$



FIG. 25—STEEL HEATED FOR 3 DAYS AT 1100°. ETCHED WITH NITRIC ACID. $\times 100$

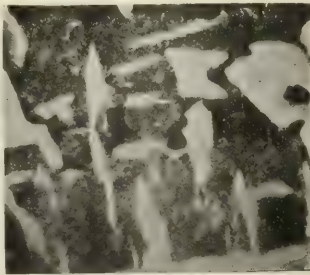


FIG. 26—STEEL HEATED FOR 3 DAYS AT 1100°. TRANSVERSE SECTION. ETCHED WITH NITRIC ACID. $\times 500$

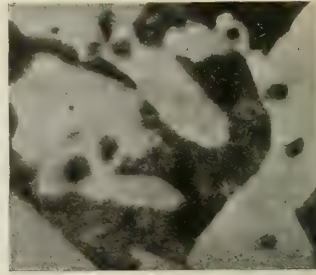


FIG. 27—STEEL HEATED FOR 3 DAYS AT 1100°. TRANSVERSE SECTION. ETCHED WITH NITRIC ACID. $\times 500$

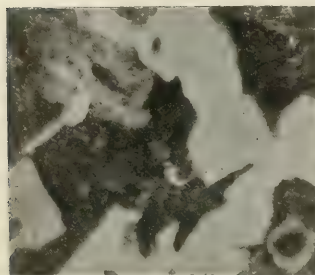


FIG. 28—STEEL HEATED FOR 3 DAYS AT 1100°. TRANSVERSE SECTION. ETCHED WITH NITRIC ACID. $\times 500$

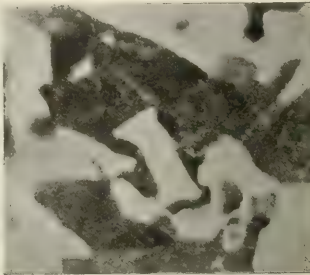


FIG. 29—STEEL HEATED FOR 3 DAYS AT 1100°. TRANSVERSE SECTION. ETCHED WITH NITRIC ACID. $\times 500$

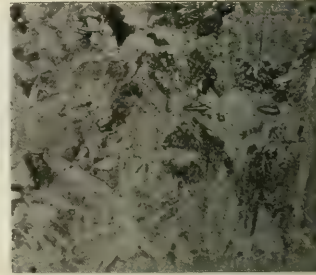


FIG. 30—STEEL HEATED FOR 3 DAYS AT 1100°. LONGITUDINAL SECTION. TREATED WITH COPPER REAGENT. $\times 100$

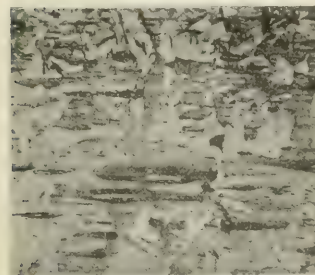


FIG. 31—STEEL HEATED FOR 3 DAYS AT 1100°. LONGITUDINAL SECTION. TREATED WITH COPPER REAGENT. $\times 100$

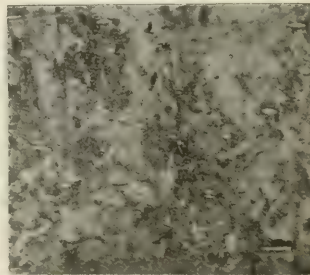


FIG. 32—STEEL HEATED FOR 3 DAYS AT 1100°. LONGITUDINAL SECTION. TREATED WITH COPPER REAGENT. $\times 100$

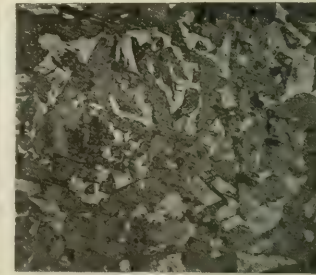


FIG. 33—STEEL HEATED FOR 3 DAYS AT 1100°. TRANSVERSE SECTION. TREATED WITH COPPER REAGENT. $\times 100$

This theory would involve the reabsorption of inclusions when steel is reheated to temperatures considerably above A_{c3} , a supposition that is absolutely without experimental justification. It will be shown later in the present paper that elongated inclusions in rolled steel retain their form and orientation even after prolonged heating at 1100°, a fact which would not be noticed if absorption and coagulation had successively taken place. Similar observations have been made by numerous other investigators.

Quite otherwise has been the reception of the idea that inclusions can act repeatedly as nuclei for crystallization of ferrite as the latter is thrown out of solid solution during the cooling of austenite through the transformation range. This view has been accepted by many metallurgists, although combatted vigorously

by others, notably Stead and H. M. Howe. The former has carried on investigations regarding the relations existing between phosphorus and iron, as one result of which he concludes that slag or other inclusions are not, in any sense, the direct cause of ferrite segregation but that they are purely incidental to it. He has brought out, by very extensive experiments, the behavior of iron phosphide in both high and low phosphorus steel and its effect upon carbon distribution.¹ However, it may fairly be doubted whether the matter is settled, so far as the general acceptance of his views regarding inclusions is concerned. Briefly, Stead's theory is as follows:

The "solid solution pressure" of iron phosphide

¹ *J. Iron and Steel Inst.*, **58** (1900), 60; **91** (1915), 140; **97** (1918), 287 and 389.

and iron carbide existing together in austenite is greater than that of iron carbide alone. When a steel containing phosphorus cools, these two substances therefore tend to withdraw from each other and, as carbide is more mobile than phosphide, the result is concentration of carbide in localities relatively free from phosphide. Thus steel cooling past A_1 becomes supersaturated with ferrite earliest in the phosphoretic regions and ferrite accordingly separates first at these points. The insoluble inclusions are also found in the regions high in phosphorus because cooling of liquid steel leaves iron phosphide and inclusions in the last portions to solidify. It is then concluded (1) that phosphorus and inclusions generally occur together and (2) that carbon recedes from phosphorus during cooling through the transformation range, leaving ferrite containing dissolved iron phosphide surrounding the inclusions. Stead thus regards phosphorus as being the true cause of segregation of this kind.

Howe¹ also expresses the idea that the occurrence of inclusions within ferrite (or cementite) grains or network is due to the tendency of austenite to reject both inclusions and ferrite to grain boundaries during the process of crystal formation and when cooling through the transformation range. Theoretical reasoning and experimental evidence are brought forward in support of this view and Howe also shows that the logical result of this action is expulsion of ferrite and inclusions to the surface of the piece, thus giving a low-carbon and highly impure surface layer. Ferrite segregation is shown to exist in the zone immediately surrounding mechanical cavities in steel.

In the course of Stead's paper on "Inclusions in Steel and Ferrite Lines,"² he reports a series of experiments designed to test the question as to whether non-metallic inclusions or mechanically produced cavities induce the crystallization of ferrite about them. In these experiments small holes were drilled in three series of hypo-eutectoid steels. Some of these holes were then partly filled with various powdered materials while others were left empty. The holes were tightly plugged and the plugs were sealed in. The pieces were heated to high temperatures and some were reheated to 1000° C. and cooled slowly. The substances used as inclusions were quartz, magnesite, fluorspar, lime, basic slag, titanium cyanonitride, acid slag, mill scale, and manganese sulfide. The polished and etched sections failed to exhibit any evidence of ferrite segregation at the borders of the inclusions, with the single exception of fluorspar. From this it is concluded that neither inclusions of the sort usually found in steel nor cavities themselves can act as nuclei for ferrite crystallization.

It is difficult to see how these experiments can be regarded as conclusive. No matter how finely the materials might be powdered or how closely packed, a certain (though small) amount of air would necessarily be enclosed in the interstices between the powder grains. Upon heating the piece the very first effect would be to produce a film of oxide upon the lining

of the cavity. This must necessarily prevent the close and intimate contact that occurs between steel and inclusions when these have cooled from the liquid state together, and for this reason it would appear that inclusions produced in this manner could exert little or no effect upon carbon segregation, although they might act as would cavities of corresponding size.

EXPERIMENTAL

A section of an open hearth steel rail was selected, having the following composition: Carbon 0.55, silicon 0.06, phosphorus 0.14, sulfur 0.13, manganese 0.85. From such a statement one might expect to find comparatively small amounts of siliceous slag but appreciable quantities of manganese sulfide. This rail exhibited a pronounced banded structure, ferrite streaks almost without exception containing threads and elongated particles of inclusions. The structure of the untreated material is shown in Fig. 5, etched with nitric acid, and in Fig. 6, treated with Stead's copper reagent.¹ The dark areas in Fig. 6 show where copper has coated iron that is relatively free from phosphorus, while the light areas are higher in phosphorus.

FIRST SERIES—Four pieces of this material were placed in a furnace and held at temperatures ranging from 850° to 1000° C. The furnace was cooled after periods of 18, 41, 67, and 91 hrs., respectively, one piece being removed after each period. Fig. 7 shows that this treatment served to break up the continuity of pearlite bands to a considerable extent and to coarsen the grain, but that the inclusions are not changed in form and that they still lie surrounded by ferrite. Fig. 8 shows the action of Stead's copper reagent upon the material that had been heated for 91 hrs. Phosphide bands are still shown in a very striking manner and it is interesting here to note that inclusions do lie, for the most part, in the phosphide bands. That this rule is not without many exceptions will be made clear presently.

SECOND SERIES—One each of five specimens was heated to 900° C. and quenched. The quenching media were as follows: Oil at 20°, water at 20°, iced brine at approximately -10°, water at 100°, and open air. Figs. 9 and 10 illustrate some of the structures as brought out by etching in nitric acid. The specimens that were quenched in oil or water are sorbitic or martensitic. There is little evidence of carbon segregation except in the specimen quenched in oil. Here ferrite bands begin to appear and inclusions are found in these bands. The specimen that was air cooled has been caught at the beginning of ferrite formation and the normal arrangement of ferrite network surrounding sorbitic grains is evident. (The slag thread that is seen in this photomicrograph is abnormally large and is, in this respect, not representative.)

These photomicrographs show that above A_1 the carbon distribution is uniform, so far as the microscope is able to detect, and that when cooling is moderately

¹ "The Metallography of Steel and Cast Iron," pp. 280, et seq.

² *J. Iron and Steel Inst.*, 97 (1918), 287.

¹ Cupric chloride, 1 g.; magnesium chloride, 4 g.; hydrochloric acid, 1 cc.; water, 20 cc.; absolute alcohol, 100 cc. This reagent deposits copper upon the areas lowest in phosphorus.

rapid, as in air-quenching, ferrite is rejected at the boundaries of austenite grains in a normal manner. We should thus conclude that segregation of ferrite and pearlite into bands requires more time than is allowed by most quenching baths or even by air when the pieces of steel are small. In the case of the air-cooled specimen one may easily notice that a ferrite lining surrounds a considerable part of the threads of inclusions. Figs. 12, 13 and 14 show the action of the copper reagent upon these specimens. Phosphide bands have persisted throughout the treatment and as these are shown to be considerably wider than the inclusions it seems scarcely probable that phosphorus is responsible for the thin ferrite lines lying directly against the inclusion threads in the air-cooled specimen. Attention is also called to the fact that Fig. 14 shows inclusions lying in bands low in phosphorus as well as in those high in phosphorus.

THIRD SERIES—A third series of four specimens was heated to 900° C. and allowed to cool in the furnace to specified temperatures, followed by quenching in iced brine at -10°. The quenching temperatures were 775°, 750°, 725°, and 700° C. In this way an attempt was made to arrest the breakdown of austenite at various stages in order to obtain some information as to the mode of progress of ferrite segregation. Photomicrographs of these specimens are shown in Figs. 15, 16, 17, and 18, as etched with nitric acid, and in Figs. 19, 20, 21, and 22 as acted upon by the copper reagent.

The progress of the changes occurring during cooling may be followed fairly well by this process. Given sufficient time for ferrite and carbide migration, as in furnace cooling, small ferrite grains begin to form around inclusions (Fig. 15). Fig. 19 shows that in the specimen quenched from 775°, inclusions lie in phosphide bands and purer iron bands, almost indiscriminately. In the specimen quenched from 750° (Fig. 16), ferrite bands are wider and considerably more numerous and the rule here, as in other cases, is that inclusions are surrounded by ferrite. Specimens quenched from 725° and 700° (Figs. 17 and 18) show further progress of these changes, although the austenite is not completely broken down, even at the latter temperature.

The action of the copper reagent upon the pieces quenched from 750°, 725°, and 700°, respectively, is worthy of special notice. It is rather remarkable that, in these cases, inclusions that lie in phosphorus-rich bands are, nevertheless, surrounded by well-defined zones of purer iron, comparatively free from phosphorus. This is very strikingly shown in Figs. 20, 21, and 22. Ferrite appears to show, in these specimens, a preference for crystallization about inclusions, leaving not only the solution with iron carbide, but the solution with iron phosphide, as well.

FOURTH SERIES—Stead has shown that long heating at high temperatures will destroy a banded structure and that phosphorus becomes, by this treatment, uniformly distributed. In order to determine what effect this might have upon ferrite segregation, a piece of steel similar to that used in the experiments already

described was placed in an iron crucible, covered with fusible glass to prevent oxidation, and heated for three days at 1100° C. After cooling in the furnace the piece was cut for both longitudinal and transverse sections. The results of the nitric acid etching of the longitudinal sections are shown in Figs. 23, 24, and 25, and of transverse sections in Figs. 26, 27, 28, and 29, the last four being at a magnification of 500 diameters. The action of the copper reagent is shown in Figs. 30, 31, and 32 for longitudinal sections and in Fig. 33 for the transverse section. These tests show (1) that all banding, of either ferrite or phosphide, has disappeared as a result of the thermal treatment, (2) that ferrite still persistently crystallizes about inclusions, and (3) that the distribution and orientation of these inclusions has not been altered in any manner.

SUMMARY AND CONCLUSIONS

The writer is unable to confirm Stead's theory, which is to the effect that inclusions are not responsible in any way for ferrite segregation and that such segregation is entirely due to the presence of iron phosphide dissolved in the regions surrounding the inclusions. Neither does Howe's explanation appear to cover the case, in view of the fact that the orientation and relative positions of inclusions appear to remain unaltered by repeated heating and cooling through the transformation range, and by protracted heating at 1100°, followed by slow cooling.

That the persistence of ferrite-pearlite banding of forged steel through ordinary thermal treatments is due in considerable measure to the presence of phosphide banding seems to be indicated by the experiments described in this paper, as well as by the work of Stead. If, then, it be granted that certain inclusions may exert some sort of influence upon the segregation of ferrite there still remains the question as to why ferrite ghosts disappear after prolonged heating at high temperatures, since the inclusions remain throughout in their original positions, no migration being observable. It is well here to recall the fact that even in such low-phosphorus steels as this the inclusions are relatively quite small, compared with portions occupied by phosphorus. Forging the mass in such a manner as to produce an approximate cylinder from an approximate sphere elongates the masses in proportion to their respective radii for a given reduction, that is, the volume of a sphere is $\frac{4}{3}\pi R^3$ and that of a cylinder is $\pi r^2 l$, where R and r represent the radii of sphere and cylinder, respectively. For a given reduction $R = ar$, a being a constant for this reduction. Then $l = \frac{4}{3}a^3r$. For instance, if forging has reduced the radius three times, then $a = 3$ and $l = 36r$, a very considerable attenuation. The inclusion may be regarded as being elongated according to the same law but as its radius is so much shorter than that of the ferrite streak, the absolute difference in the lengths of the two is very large. Measurement of the dimensions of a considerable number of ferrite bands and of the inclusions enveloped by them, in the specimens used in these

experiments, gave an approximate average of 10 for the ratio of the radius of the ferrite band to that of the inclusion. In such a case the distance between the ends of the ferrite cylinder and the corresponding ends of the contained inclusion would be ten times as great as that between the sides of these entities. This would place the major part of a given ferrite streak entirely outside the "sphere of influence" of the inclusion at its core.

The mathematical reasoning given above must be regarded as the roughest sort of approximation for the practical case. The amount of reduction by forging or rolling varies from piece to piece and this does not really produce a cylinder from the original equiaxed grain, but rather a lenticular mass of variable and more or less indefinite form. However, the general qualitative deductions are valid and it is obvious from this that the continued recurrence of ferrite ghosts after repeated cooling through the transformation range must rest upon some action other than the influence of inclusions upon ferrite crystallization, unless the inclusions are scattered fairly thickly and uniformly throughout the recurrent band, a condition that is met in a comparatively small number of cases. The experimental work described in this paper shows that it is only in these exceptional cases that a ferrite band of appreciable length and continuity survives long soaking at 1100° C. and that the long, well-formed bands disappear when iron phosphide has diffused to a fairly uniform distribution throughout the piece. But even after this condition has been reached the large majority of inclusions are still seen to be surrounded by ferrite and, while an occasional particle is seen to penetrate a pearlite grain or even to be embedded in the latter, these cases are exceptional. On the other hand, many instances are shown in the photomicrographs where inclusions are found within pearlite grains *but entirely surrounded* by "islands" of ferrite. A ferrite grain embedded in one of pearlite is not a normal formation and it seems probable that non-metallic inclusions must be found somewhere within most ferrite masses included in this way in pearlite grains, even when the non-metallic inclusion fails to show in the section, since the chance of cutting the relatively small inclusion is so much less than that for the ferrite and pearlite masses.

The work described in this paper would appear to justify the following conclusions:

1—The recurrence of ferrite ghosts after repeated thermal treatment which would serve to break up any ordinary carbon segregation is due, largely if not entirely, to phosphorus banding which is little changed by ordinary treatment.

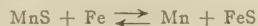
2—Even after phosphorus distribution has been made uniform, repeated heating followed by slow cooling still leaves inclusions surrounded by ferrite.

The explanation of the second point is not obvious. It might be supposed, as has been held by Brearley, Ziegler, and many others, that the inclusions can act as actual nuclei for crystallization; or it is possible that either the inclusion itself or some reaction product may exist in very dilute solution in a limited zone

surrounding the particle and that the solubility of iron in austenite in this zone is thereby lowered in some degree. This would serve to start ferrite separation in these regions, during the cooling process, before supersaturation is ready to break down at other points, with the result that has been seen.

In connection with the hypothesis that the inclusion may act as a crystal nucleus, Rosenhain observed,¹ in the discussion of Stead's paper, that in order that this may be the case the nucleus must itself be isomorphous with the surrounding material. While little appears to be known regarding the crystalline nature of inclusions, reference may be made to Levy's statement² to the effect that manganese sulfide crystallizes in the cubic system and to the well-known fact that naturally occurring manganese sulfide (alabandite) also crystallizes in this system. If this should be true the necessary condition is attained for this common inclusion, since alpha iron also crystallizes in the cubic system.

That the materials of inclusions in general are slightly soluble in steel is not to be doubted. Theoretical reasoning would lead to this conclusion and numerous investigators are agreed upon this point. Since the inclusions that are ordinarily regarded as manganese sulfide probably contain also varying (though small) quantities of ferrous sulfide, either of these substances might, conceivably, show the effect mentioned above.³ That is, by dissolving to a slight extent they might lower the solubility of iron sufficiently to start ferrite separation in the zone surrounding the inclusion before ferrite has been thrown out at other points. No doubt both ferrous sulfide and manganese are present in this zone as equilibrium products of the reaction of manganese sulfide with surrounding iron:



These hypotheses are offered, at this time, merely as suggestions, but some experimental work now in progress will, it is believed, show that the slight solubility of the inclusion in the surrounding metal is actually responsible for the action discussed in this paper. These experiments will be reported in a subsequent paper.

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ANALYTICAL METHOD FOR DETERMINING EFFICIENCY OF AMMONIA OXIDATION

By D. F. GAILLARD¹

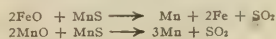
Received March 26, 1919

The writer has read with interest the papers on the analytical control of ammonia oxidation by Fox,²

¹ *J. Iron and Steel Inst.*, **97** (1918), 296.

² *Carnegie Scholarship Memoirs, Iron and Steel Inst.*, **3** (1911), 304.

³ It is not considered probable that oxides of iron and manganese can exist in solution in manganese sulfide, in quantities greater than the merest traces. The following reactions would certainly occur at high temperatures:



⁴ Published by permission of the Chief of Ordnance.

⁵ *THIS JOURNAL*, **9** (1917), 737.

Taylor and Davis,¹ and he believes that a considerably simpler method of analysis that has been used for control in practical plant operation for more than two years will be of interest, particularly as in one or two cases at least, it has supplanted the methods heretofore described.

In an ammonia oxidation converter it is evident that if all the ammonia is converted to oxides of nitrogen, the percentage by weight of nitrogen in the form of oxides of nitrogen in the exit gases will be equal to the percentage by weight of nitrogen in the form of ammonia in the entrance gases. It is further evident that if only a portion of the ammonia is so converted, the ratio of these percentages will measure that portion; that is, this ratio is equal to the efficiency of conversion.

The determination of conversion or oxidation efficiency in this manner resolves itself, therefore, into a determination of these percentages by weight of combined nitrogen in the entrance and exit gases. To determine this percentage in a given sample of gas it is necessary to know both the weight of combined nitrogen in the sample, and the weight of the sample.

The determination of the weight of combined nitrogen in the sample is a relatively simple matter of absorption and titration, and the several methods of analysis differ but little in this respect. The determination of the weight of the sample by volumetric methods and calculations offers comparatively little difficulty in the case of the ammonia-air mixture in the entrance gases, but offers considerably more difficulty in the case of the exit gases, which consist of nitrogen, oxygen, water vapor, a small amount of ammonia, and a variable mixture of oxides of nitrogen. A study of the several volumetric methods previously described shows that the determination of the amount of the exit sample involves complications, both in the analytical procedure and in the necessary computations, which are not present in the following "bulb" method of analysis.

"BULB" METHOD OF ANALYSIS

In this method a sample of the gases to be analyzed is drawn into a previously weighed evacuated bulb; a second weighing is made to obtain the weight of the sample so drawn in; the ammonia or nitrogen oxides contained in the bulb are then absorbed and titrated and the percentage of combined nitrogen by weight in the gases so determined.

DETAILED PROCEDURE

The detailed analytical procedure for an efficiency test, with samples of entrance and exit gases taken in duplicate, is as follows:

Four glass bulbs (500-600 cc. capacity, 60-80 g. weight with gas-tight stopcock) with stopcock well greased, are evacuated to a pressure of approximately 2 cm. of mercury, carefully wiped on the exterior, and weighed, the bulbs being hung on the balance beam by means of small wire loops. A check weighing is made after an interval of a minute to make sure that there is no leakage. Leakage can also be detected by

inverting the bulb and allowing the small amount of water remaining inside after the previous test to run down into the glass tube of the stopcock. The slightest leak will then show itself by air bubbles.

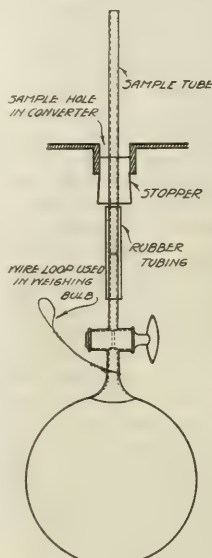


FIG. 1—ARRANGEMENT OF BULB, ETC., WHEN TAKING SAMPLE OF GAS

As soon as possible after the check weighing, the bulbs are connected to short, glass sample tubes of small bore by means of tight rubber tubes; over the glass tubes are stoppers which fit tightly into the sample holes of the converter. The bulbs are now adjusted to the sample holes, and are kept there about $1\frac{1}{2}$ min. before the samples are taken to bring the tubes to the same temperature as the gas. The samples are then taken as rapidly as possible, with stopcocks opened wide to prevent moisture from condensing in the tubes. This is of special importance in the case of the exit sample because of the water formed during the reaction. The bulbs are now disconnected from the sample tubes, wiped, allowed to remain near the balance case for 5 min., and weighed.

In the case of the entrance samples the tube of the bulb is immersed in distilled water and the cock opened. Due to the partial vacuum inside, owing to the cooling of the gas and the solubility of the ammonia, water is drawn into the bulb. As much water as possible is allowed to enter and the stopcock closed. The bulb is then shaken for 1 min. to absorb the ammonia. The tube is then applied to the mouth, the cock opened, and air blown into the bulb. The contents of the bulb are then discharged (by opening the cock) into 25 cc. $N/10$ sulfuric acid accurately measured from a burette into a 600 cc. beaker. The bulb is washed out three times and the washings added to the beaker, water being introduced into the bulb by first sucking on it. The excess acid in the beaker is then titrated, using methyl red as an indicator.

In the case of the exit sample, approximately 100 cc. of water is introduced, care being taken not to introduce any air in so doing. About 25 cc. of oxygen are then drawn in from a small gas holder or other convenient container, the bulb is shaken for 1 min. and allowed to stand for at least another minute. Any vacuum remaining is then relieved by opening the stopcock to the air. The stopcock is then closed and the bulb shaken for 5 min. The liquid in the bulb and the three subsequent washings are then transferred to a 600 cc. beaker containing approximately 15 cc. of $N/10$ sodium hydroxide diluted with water to about 75 cc. and titrated, using methyl red as an indicator.

¹ THIS JOURNAL, 9 (1917), 1106.

It is desirable that the titration of both the entrance and exit samples be made in the same direction, usually from acid to alkali, to minimize as far as possible the personal error of the analyst in judging end-points under the varied conditions of lighting during the 24 hrs.

COMPUTATIONS¹

A representative calculation is as follows:

ENTRANCE SAMPLES

	Bulb Number 1	Bulb Number 2
Weight of bulb and sample.....	63.1600 g.	69.0565 g.
Weight of bulb.....	62.5025	68.4605
Weight of sample.....	0.6575 g.	0.5960 g.
Standard acid used.....	21.05 \times 0.0014	18.95 \times 0.0014
Per cent combined nitrogen.....	0.6575 4.48	0.5960 4.45

EXIT SAMPLES

	Bulb Number 3	Bulb Number 4
Weight of bulb and sample.....	75.0775 g.	67.6830 g.
Weight of bulb.....	74.4865	67.0580
Weight of sample.....	0.5910 g.	0.6250 g.
Standard alkali used.....	17.23 cc.	18.30 cc.
Per cent combined nitrogen.....	17.23 \times 0.0014	18.30 \times 0.0014
	0.5910 4.08	0.6250 4.10

Efficiency of conversion = $\frac{4.09}{4.47} = 91.6$ per cent

¹ Slide rule used for all computations.

VARIATIONS IN PROCEDURE

The procedure described above can be varied by the absorption of the entrance sample in an acid solution and the absorption of the exit sample in an alkaline solution. While this, perhaps, is more correct in theory, experience shows that absorption in water, if the manipulation is carefully done, gives practically the same results, and is somewhat simpler. Also, a neutralized hydrogen peroxide solution may be introduced, instead of oxygen, into the exit sample, but by so doing the end-point may be somewhat obscured, and it is believed that the use of oxygen is preferable. In fact when running on mixtures comparatively low in ammonia, the addition of any oxidizing agent is apparently unnecessary, additional air being drawn into the bulb instead of either oxygen or peroxide.

PRECISION OF METHOD

There is a very slight error introduced in this method by the dilution of the sample with the air drawn from the sample tube into the bulb ahead of the sample. This is so small, however, as to be negligible. Other sources of error which can be practically eliminated by care in manipulation are condensation in the sample tube when taking the exit gases, leakage into the converter itself around the edges of the sample hole because of the suddenly applied vacuum, thus giving a false sample, changes in temperature, barometric pressure, and moisture conditions between the successive weighings of the same bulb and incomplete absorption of the gases in the bulb.

Also any small amount of ammonia passing the catalyzer unoxidized, together with an equivalent amount of oxidized ammonia, is not determined in the titration of the exit gas sample, but this amount is usually well within the probable error of the method, and hence can be neglected. If desired, however, an estimation of this ammonia can be made by colorimetric methods, and the results modified accordingly.

It is also to be noted that an efficiency determination by this method will be correct even if the two standard solutions are "off," provided they have been checked against each other, which is normally done once on every shift.

The fact remains, however, that the effect of all these possible sources of error is slight, and the efficiencies obtained by this method appear to be as precise as those obtained by any of the other methods, the average precision of a single efficiency determination in duplicate being, it is believed, within about plus or minus $\frac{3}{4}$ per cent.

COMPARISON WITH OTHER METHODS

The chief merit of the "bulb" method is its simplicity, both in the analytical work and in the calculations, a decided advantage in practical plant control. It has been found that two plant chemists using this method can average for an 8-hour shift one efficiency determination an hour, run in duplicate, which is considerably oftener than determinations can be made by two men using any of the volumetric methods. This saving in time is important as it is believed that for a thorough study of converter operation a large number of tests taken as frequently as possible is very desirable. In fact, a succession of instantaneous samples seem to give better and more reliable operating data than a continuous sample taken over the same period.

For plant operation, however, the ideal method would be one that would give a continuous record in chart form of the instantaneous efficiencies, as a check on the operating force. There are possibilities along this line, but, in the meantime, it is believed that the "bulb" method is the most satisfactory of the methods yet described for practical plant use.

USE OF METHOD

This method was devised by the writer in 1916, for use in the experimental ammonia oxidation plant of the American Cyanamid Company, at Warners, New Jersey. It was used at that plant for all experimental work, and was later used for plant control and testing at U. S. Nitrate Plant No. 2, Muscle Shoals, Alabama, and was used with slight modifications at U. S. Nitrate Plant No. 1, Sheffield, Alabama, and at the experiment station connected therewith.

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THE CUPROUS CHLORIDE-IODINE METHOD FOR REDUCING SUGARS SIMPLIFIED

By F. M. SCALES

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About three years ago, in the course of an investigation for converting cellulose into dextrose, the author found it necessary to work out a volumetric method for determining the amount of cuprous oxide precipitated in the Soxhlet solution recommended by Munson and Walker. This solution was employed because it gave the most satisfactory results in the presence of the salts in the sugar solution. A new method was

found for determining cuprous oxide by dissolving it with hydrochloric acid, adding in excess a known quantity of iodine, to react with the cuprous chloride formed, and then titrating the excess iodine with sodium thiosulfate. A report of the work was published at the time.¹ Two years later Cammidge² published a modification of the method that appeared to be satisfactory except that he retained the undesirable procedure that I had found necessary, *i. e.*, transferring the hot cuprous chloride solution from one flask to another. He found that if Benedict's solution was used the acidification with hydrochloric acid produced sufficient carbon dioxide to prevent the oxidation of the cuprous chloride by the air. This discovery afforded a means for greatly simplifying the procedure. Clark³ has taken full advantage of this discovery by carrying out the whole process in one flask. The latter author has done much work to show the accuracy of the method but unfortunately his procedure does not give him a thiosulfate-dextrose ratio that is constant within the limits that he has taken for the method. It is for the purpose of setting forth the possible improvements in procedure that the present report is written.

When the Benedict's solution containing the sugar has been boiled and the cuprous oxide has been precipitated, the solution may be acidified with a dilute acetic acid which does not attack the cuprous oxide, a known excess of iodine may be added, and the cuprous oxide then dissolved by the addition of a very small quantity of hydrochloric acid. The cuprous chloride formed is immediately acted on by the iodine with the formation of cuprous iodide and finally cupric iodide. The presence of the cuprous iodide is not evident in this method as it is in the others, for the solution never has any cloudiness or precipitate. As soon as the cuprous oxide is all dissolved by the hydrochloric acid the excess of iodine is titrated with the thiosulfate, starch solution being used as the indicator. The difference between the thiosulfate value of the iodine added in a determination and the thiosulfate required to reduce the iodine after the formation of cupric iodide is equivalent to the amount of reducing sugar present. The value of the iodine in cc. of thiosulfate must be determined by titration in distilled water and not in the presence of the reagents employed in a determination. In a test with all the reagents, but no sugar present, 0.3 or 0.4 cc. of iodine is reduced to hydriodic acid and so the results are low by this amount, but in a regular determination all this iodine unites with the copper so that the full iodine value is obtained.

This method for sugar determination may be carried out in one flask without the thistle tube and pipettes which Clark's method requires. It does not necessitate the precautions against oxidation by the air nor the care that he had to exercise in measuring the iodine from a pipette since the iodine may be

rapidly run into the solution from a burette without great care concerning the exact quantity, although the amount used must be carefully read at the end of the titration with thiosulfate before making any calculations.

METHOD

REAGENTS—The Benedict's solution¹ employed is the one recommended by Clark. In addition to this the method requires an approximately 0.04 *N* iodine solution; a thiosulfate solution² made approximately 0.04 *N*; hydrochloric acid solution diluted so that every 25 cc. contains 1.5 cc. of the concentrated acid (1.19 sp. gr.); an acetic acid solution containing 2.4 cc. of the glacial acid in every 100 cc.; and a starch solution made in the usual way with either potato or soluble starch. A pure dextrose³ solution should be employed to standardize the apparatus and thiosulfate solution.

APPARATUS—The solutions were boiled in a 300 cc. Erlenmeyer flask with a 2-hole rubber stopper. A smaller flask will serve as well. In addition to this there is required a 100 cc. cylinder or any container for approximately this quantity, a 25 cc. pipette, and two burettes, or, if one prefers to deliver the iodine from a pipette, a 10 cc. and a 25 cc. pipette may be substituted for one of the burettes. If pipettes are used, one of 5 cc. will be convenient where the reduction to cuprous oxide is so slight that the solution shows practically no clouding or precipitate; the 10 cc. pipette may be employed where very small quantities of the oxide settle to the bottom of the flask; and the larger pipette for all larger quantities of the precipitate. All the data given in this report were obtained by measuring the iodine from a burette.

PROCEDURE—The procedure for making a determination consists in pouring 20 cc. of the modified Benedict's solution into a 300 cc. Erlenmeyer flask and then making the volume up to 30 cc. with the sugar solution and distilled water if necessary. If there are present more than 20 mg. of dextrose better results may be obtained by using 25 cc. of Benedict's solution and making the volume up to 35 cc. with the sugar solution. The flask is then placed over a flame or on a hot plate. When using the electric hot plate to heat the solution, the flask should be closed with a

¹ Modified Benedict's solution:

Copper sulfate crystals.....	16.0 g.
Sodium citrate.....	150.0 g.
Sodium carbonate, anhyd.....	130.0 g.
Sodium bicarbonate.....	10.0 g.
Water to make a final volume of 1 liter.	

The copper may be dissolved separately in 125 to 150 cc. of water; the remaining solid constituents in about 650 cc. of water, heating to accelerate solution. When all are in solution pour the copper solution slowly into the other with stirring, make up nearly to volume, cool, complete the volume to 1 liter, and filter.

None of the weighings or measurements need to be made with extreme accuracy.

² The thiosulfate solution was made by dissolving 10 g. of the pure salt in 1 liter of water. Its sugar equivalent should be determined by making some regular sugar determinations with pure dextrose. The solution used in this work was standardized against *N/20* potassium bichromate, 15 cc. of the latter equalling 18.6 cc. of thiosulfate; an exactly 0.04 *N* solution would have required 18.75 cc. A fresh solution was used in this work, but the strength during the first two weeks, when most of the change takes place, could be determined more easily with potassium bichromate than by making a regular sugar determination.

³ A pure dextrose for this purpose may be obtained from the Bureau of Standards.

¹ "The Determination of Reducing Sugars," *J. Biol. Chem.*, **23**, 81.

² "An Improved Method for the Estimation of Sugar in the Urine and Blood," *Lancet*, **192** (1917), 613.

³ "Volumetric Determination of Reducing Sugars," *J. Am. Chem. Soc.*, **40**, 1759.

2-hole rubber stopper in order to bring the solution to the boiling point quickly. The hot plate employed in this work, required about 5 min. to bring the solution to boiling. When the total volume was 35 cc. it required one and three-quarter minutes longer to boil. As Clark has shown in his work, when a burner is used to heat the solution it should be adjusted so that the total time of heating will be about one minute less than that allowed for the plate. The period of heating and the intensity of the heat must be constant for all determinations. The boiling was continued for 3 min. The solution was then cooled as quickly as possible, usually in a minute, by holding the flask under the cold water faucet and rotating it. When cold, the 100 cc. of dilute acetic acid may be poured into the solution and the iodine immediately run in from a burette. The dilute hydrochloric acid is then run in from a 25 cc. pipette which is held against the side of the flask up near the neck, so that the acid will spread over the side of the flask as it runs down; the solution is vigorously rotated to produce an immediate distribution of the acid and thus prevent any concentration of it that might act on the iodine. The pipette and the side of the flask are washed down with a few cubic centimeters of water and the solution rotated for exactly one minute. Any precipitate should be entirely dissolved in this time. The thiosulfate solution is now carefully run into the flask till its brown or blue solution changes to a light sea green, when 2 cc. of starch solution may be added and the titration continued until the dark iodo-starch blue suddenly fades away and the solution remains the light blue characteristic of acidified copper solutions. The end point obtained is permanent.

DATA

The accuracy of the method was tested with varying quantities of pure dextrose. The solutions were prepared by dissolving 0.75 g. of dextrose in 250 cc. of distilled water.

The results obtained with duplicate samples are shown in Table I.

Dextrose Present Mg.	Iodine Added Cc.	Equivalent to Iodine Cc.	Required in Determinations Cc.	Difference between Iodine Equivalent and Determination Cc.	Average Cc.	Dextrose Value per Cc. Mg.
0.0	10.0	9.78	.....	.....	.....	.....
...	10.0	9.83	.....	.....	.....	.....
...	1.0	0.981	.....	.....	.....	.....
1.5	6.0	5.89	4.57	1.32	.....	.....
1.5	6.0	5.89	4.61	1.28	1.30	1.15
3.0	6.0	5.89	3.23	2.66	.....	.....
3.0	5.7	5.59	2.96	2.63	2.65	1.13
4.5	10.00	9.81	5.73	4.08	.....	.....
4.5	10.15	9.96	5.92	4.04	4.06	1.11
6.0	9.98	9.79	4.34	5.45	.....	.....
6.0	9.98	9.79	4.38	5.41	5.43	1.11
9.0	19.99	19.61	11.59	8.02	.....	.....
9.0	19.80	19.42	11.42	8.00	8.01	1.12
12.0	19.58	19.21	8.52	10.73	.....	.....
12.0	19.62	19.25	8.19	10.67	10.70	1.12
15.0	21.96	21.54	8.54	13.35	.....	.....
15.0	22.00	21.58	8.22	13.36	13.36	1.12
24.0	24.97	24.50	3.00	21.50	.....	.....
24.0	25.00	24.53	3.00	21.53	21.52	1.12

The figures in the last column of the table show that the method is very accurate and they are so nearly the

same value that any error arising from taking 1.12 mg. of dextrose as the constant value of the thiosulfate, under these conditions, would easily fall within the limits of experimental error.

A total heating period of 8 min. was used in all the determinations except the one where 24 mg. of dextrose were present, in which case it required 9³/₄ min. in order to allow a 3-min. boiling period. More time was necessary for the latter determinations, partly because of the larger volume of solution employed, but principally because of a fluctuation in the source of heat. Fluctuations in heat gave considerable trouble. The influence of drafts around the flask was overcome by placing an asbestos cylinder 7 in. high and 6 in. in diameter on the hot plate. This arrangement helped some, but could not of course offset fluctuations in the temperature of the hot plate as the following figures show:

Dextrose Present Mg.	Time Required to Reach Boiling Point Min.	Boiled Min.	Thiosulfate Equivalent to Dextrose Cc.	Dextrose per Cc. Thiosulfate Mg.
1.5	4.0	3.0	1.35	1.11
1.5	4.0	3.0	1.37	1.10
15.0	4.75	2.25	13.14	1.14
15.0	4.0	3.0	13.33	1.13
15.0	4.0	3.0	13.28	1.13
1.5	4.0	3.0	1.36	1.10

The reagents used for this test were the same as those employed for the determinations given in Table I. These determinations, however, were made 3 days later and the total heating period, due to the presence of the asbestos cylinder, was one minute less.

In these determinations it will be noted that when 15 mg. of dextrose are employed the value of 1 cc. of thiosulfate is equal to 1.13 mg. of dextrose or within 0.01 mg. of the value obtained in Table I. When 1.5 mg. are used the dextrose value of cc. of thiosulfate varies from that obtained with the larger quantity of dextrose by 0.03 mg. just as it did in Table I. In the latter case, however, the value per cubic centimeter is less with the smaller quantity of dextrose, while in Table I it was greater by 0.03 mg. The variation in the quantity of dextrose obtained is very slight if the true value of the thiosulfate is taken as that obtained with the 15 mg. of dextrose.

It is best to have an excess of iodine present equivalent to from 5 to 8 cc. of the approximately 0.04 *N* thiosulfate solution. Determinations were made with 1.5 mg. of dextrose using iodine equivalent to 6.00 cc. and 10.00 cc. of thiosulfate; the results were the same. Fifteen milligrams of dextrose with iodine equivalent to, 19.00 cc. and 24.00 cc. also gave the same results.

Clark's¹ results gave a gradually decreasing dextrose value per cubic centimeter of thiosulfate, as larger quantities of sugar were used in a determination. A total difference of 0.12 mg. per cc. of thiosulfate exists between the value obtained with 1.0 mg. and that with 25.0 mg. of dextrose. In the present method the only change from a constant value occurs with 1.5 mg. of dextrose and here the difference from the other values is so slight, 0.03 mg., that no error is introduced by

¹ Loc cit

ignoring it. Although the author did not obtain the same figure with the smallest quantity of dextrose as he did with the larger ones, it is interesting to note that the average of the results with 1.5 mg. of dextrose in Tables I and II gives the value taken as the correct constant per cubic centimeter of thiosulfate.

Various modifications can be made in this method, such as adding the acetic acid, then the hydrochloric acid, and finally running in a known excess of iodine and titrating back with thiosulfate. Under carefully controlled conditions good duplicate results can be obtained in this way, but the dextrose-thiosulfate value is not constant.

While the method described may be modified, as outlined by Clark, and used for much larger quantities of sugar than those employed in the present work, still very accurate results may be obtained by diluting the sugar solution so that it will come somewhere near the limit employed in this investigation.

The same procedure may be used for reducing sugars other than dextrose.

SUMMARY

A method is described for the determination of reduced copper by iodimetry in a modified Benedict's solution.

The method is simpler than any previously reported.

The ratio of reducing sugar to thiosulfate is constant.

The results of duplicate determinations differ by less than 0.1 mg. of dextrose.

The method may be used for any reducing sugars.

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THE ANALYSIS OF ALLOYS OF TIN

By ARCHIBALD CRAIG

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Though the gravimetric method for tin has been largely superseded by volumetric methods, the analyst occasionally finds the older method of advantage, as, for instance, when the sample is very small. A discussion of the conditions of greatest accuracy of the analysis based on the nitric acid separation will therefore be of interest to some.

When an alloy of tin is treated with nitric acid, the precipitation is never complete, no matter what the precautions, and the precipitate is always impure. The elements which may be found with the tin in ordinary alloys are antimony, arsenic, phosphorus, copper, iron and magnesium. If sulfur is present in the alloy the treatment with strong nitric acid will cause the formation of lead sulfate, which may be avoided, if it is known in time, by the use of dilute acid. Sulfur will then separate without precipitating lead, and may be burned off without causing error. Lead is not held by tin to an appreciable extent, even in solders, though it may be found in the precipitate if not enough acid is used in washing to prevent hydrolysis. Coarse drillings of bronze are not easily decomposed, and may retain some of the original alloy. This difficulty may be overcome by boiling the strong nitric acid toward the end of the reaction, so

that the lumps are broken up and the acid can reach all of the alloy.

As most varieties of brass and bronze contain the same elements, differing, from the analytical point of view, mainly in the proportions of tin and zinc, the schemes for analysis differ only in the quantities used for the determination of those elements. In the bronze group as large a sample is taken as the tin determination will permit, and for brass, copper is the limiting element, the solution being finally divided to obtain a suitable quantity of zinc for titration. After the methods of decomposing the different varieties have been disposed of, therefore, the scheme of analysis is the same for all, until the zinc determination is reached.

The ignited tin precipitate should weigh less than 0.5 g. The copper content may be 2 g. or more. Samples often contain copper and lead segregations so marked that it is necessary to sample the sawings or drillings with great care, using the entire fraction delivered by the sampler instead of an even weight, or to sift the entire sample and use proportionate parts of fine and coarse. Mixed drillings may be sampled down to from 10 g. to 20 g., treated with nitric acid and filtered, the precipitate ignited and weighed, and an aliquot taken to correspond to the fraction of the solution taken with the pipette.

For ordinary bronze, sample about 3 g. and weigh into a 250 cc. beaker, add cautiously 20 cc. nitric acid (1.4 sp. gr.), and after violent action has ceased, boil gently until the alloy is entirely decomposed. This is easily seen by observing the disappearance of froth on removing from the hot plate. The residue should be fine and dense. Dilute to 150 cc. with hot water, stir well, warm half an hour, and filter.

White bronze, which is high in tin, is run on 0.5 g. using 5 cc. nitric acid (1.4 sp. gr.) and diluting to 75 to 100 cc. before filtering.

If sulfur is known to be present, treat 3 g. of the sample with 40 cc. nitric acid (1.2 sp. gr.) on the water bath, crushing the lumps if necessary to assist the decomposition and separation.

Brass may be run on as much as 5 g. if special attention is to be paid to small percentages of impurities. It should be treated with slightly dilute acid and not boiled. Generally tin, if present, has a tendency to run through, and evaporation to dryness before filtering may make a better separation; but as some tin goes through the filter in any case, and is recovered afterward, the writer does not consider that evaporation is ever worth while, except in the case of the nitric acid residues of large samples, which may clog the filter unless previously dried.

Select a funnel with a narrow stem and without internal enlargements, particularly near the top, so that the column will not break from below, and air bubbles accidentally forming will be carried down. Fold a 9 cm. filter at a little wider angle than that of the funnel, but not so wide as to form wrinkles at the top. Tear off the corner (single) of the paper which comes next to the glass. Set in this way the filter

will give the maximum stream, and the column will hardly ever break. Pour on a little pulp made by shaking up ashless paper with water. This will make the stream slower at the start, but it will prevent clogging by the slimy precipitate, and the filtration will be more rapid toward the end than without it.

Filter and bring the precipitate onto the paper, using cold or warm water, as hot water has a tendency to harden some of the precipitate on the sides of the beaker before it can be rubbed out. Wash the paper once with hot water, once with hot 5 per cent nitric acid, and 4 or 5 times with hot water.

When the filtration is finished, heat the filtrate, uncovered, almost to boiling until the solution equals about 7 cc. for each gram of the sample. Then add 10 cc. of sulfuric acid for the larger samples, or 5 cc. for the smaller, mix the solution well, and continue the evaporation on the water bath until copper sulfate separates and then carry, uncovered, at a low heat on the hot plate, to fumes of sulfur trioxide. After the acid fumes slightly, cool the beaker and add water equal to 5 cc. for each cubic centimeter of sulfuric acid, dissolving the copper sulfate, and set the beaker away for the lead sulfate to separate.

Meanwhile ignite the tin precipitate without loss of time. The writer prefers a broad round-bottomed crucible, of the kind variously known as annealing cups or combustion crucibles, of 25 cc. capacity. If a muffle, in which the heat can be accurately controlled, is not available, a fair substitute may be made for use with a blast lamp. Knock the bottoms out of two Denver 30 g. crucibles, and set horizontally in the middle of one of them a ring of heavy iron wire. Put a metal triangle without legs on the ring, and on it set a porcelain crucible whose top is about as large as the bottom of the one used for analysis. Set the whole in a ring stand, put on the other clay crucible for a chimney, and direct a moderate blast, with an oxidizing flame, vertically through the bottom.

In the meantime, set the weighed crucible containing the moist precipitate in another crucible to avoid cracking, and heat gradually over a Bunsen flame until the paper has been burned off. Then transfer to the hot muffle and blast for 5 min. uncovered. If the residue is not thoroughly calcined before the crucible is covered, some tin and much of the antimony will be volatilized. The Bunsen flame is not hot enough to do this. If the crucible is cooled after the first ignition and the residue moistened with nitric acid, dried, and ignited again, the oxidation will be more certain than by blasting uncovered, though the latter method is safe if carefully done, and much quicker.

After the oxidation, cover the crucible and blast to constant weight. 15 min. heating should do this, and less if the residue weighs less than 0.1 g. When the temperature is properly regulated the crucibles will be so softened that they will stick together slightly, and care should be taken in removing. Heat the tongs so as not to crack the crucible and lift it without removing the flame. Set the crucible on a clay

triangle to cool somewhat before putting it in the desiccator. Weigh, and blast again, if the method is not familiar, to make sure that constant weight has been obtained. The blast flame, once adjusted, is not changed, and any number of precipitates can be treated under identical conditions. The precipitate should be burned to the same color throughout and should not stick to the bottom. When a blast flame is directed on the bottom or side of a crucible in the ordinary way the heat is not uniform, and part will be heated too much and part not enough, while the Bunsen flame will not bring the stannic oxide (SnO_2) to theoretical weight. Perhaps some of the newer burners, which the writer has not tried with this method, may be found to give the required temperature more automatically than the blast lamp, which is capable of giving too high a temperature.

After weighing, cover the residue in the crucible with about twenty times its weight of sulfur fusion mixture. This mixture is made of 14 parts potassium carbonate, 10 parts sodium carbonate, and 10 parts sulfur. Cover the crucible with an inverted lid from which the handle has been removed, set it in another crucible, and apply full Bunsen heat for a few minutes, until the fusion is quiet. Leave the crucible covered until cool. Cover with water in a small beaker, and leach. If iron colors the solution green, it may be settled by the addition of ammonium hydroxide and ammonium sulfate, and it should then be filtered as soon as the solution shows yellow. Filter on ashless paper and wash well with ammonium hydrogen sulfide solution. Ignite in the original crucible, if it is not cracked. Brush out the residue and weigh it, return it to the crucible, cover with a little hydrochloric acid, and warm for a few minutes until the copper and iron are dissolved. A little tin will dissolve, in proportion to the amount present, but not enough to affect the result. Dilute in the crucible, filter on a very small paper, ignite the residue, and weigh as before. The first residue contains some stannic oxide (SnO_2) and silica (SiO_2), and possibly fragments of the crucible, which remain in the second residue. The difference between these is, therefore, the proper correction for oxides insoluble in the fusion.

Add a little sulfuric acid to the hydrochloric acid filtrate from the first residue, evaporate it to fumes, dilute, and filter it with the lead sulfate separation, thus combining all the lead, copper and iron before the electrolysis. Ordinarily, lead will not be found in the tin precipitate. Its presence may be due to sulfur in the sample.

The alkaline filtrate from the sulfur fusion contains all the antimony, if it is less than $\frac{1}{5}$ as much as the tin. Some arsenic will be lost in the ignition, but not all, so that the correction for arsenic in the tin residue must be made from the fusion of the residue itself. The total arsenic should be determined on a separate portion.

Add sodium chlorate in slight excess over the sulfur present, and then hydrochloric acid equal to half the volume of the solution, and boil down to small

bulk, just enough to keep all in solution. Dilute slightly, make just alkaline with ammonium hydroxide, add oxalic acid and ammonium oxalate each equal to 5 per cent of the solution, and pass in hydrogen sulfide until the arsenic is precipitated. A good alkali solution to dissolve antimony sulfide (Sb_2S_3) is 5 per cent potassium hydroxide into which some hydrogen sulfide has been passed. Sodium hydrogen sulfide is likely to cause the precipitation of antimony as antimonate.

Filter the precipitate of antimony and arsenic, dissolve in the least amount of the alkali solution, without dissolving much sulfur, oxidize the solution in a flask with sodium chlorate and hydrochloric acid, boil out the excess of chlorine, and titrate with thiosulfate. Success in this method depends on attention to details. The alkaline solution should be about 75 cc. and warm. Add 2 or 3 g. of sodium chlorate, just enough to give an excess of chlorine, and then add the acid a little at a time, with gentle shaking, until the free chlorine slowly develops, much of the sulfur is oxidized, and the rest forms whitish flakes which do not occlude antimony. Then add more acid, 125 cc. in all, and boil vigorously. The color of chlorine should be gone in 15 min. if the temperature is right. Then boil 10 min. more. Titrate as soon as the solution has cooled to 40° C. This titration can be considered accurate only if a standard is run under identical conditions, often enough to confirm the constancy of the operator.

After the titration, add 100 cc. of hydrochloric acid and pass in hydrogen sulfide, which will precipitate the arsenic at once. Make a plug of glass wool in a funnel, pour on asbestos pulp with plenty of water, so that a column will form and stay, wash out the water with a mixture of 3 parts hydrochloric acid and 2 parts water, filter, wash with the acid solution and then with water, dissolve through the filter with ammonium hydroxide, acidulate and reprecipitate, and weigh as arsenious sulfide (As_2S_3).

If one of the other volumetric methods for antimony is preferred, the arsenic may be separated as above described after the first oxidation with sodium chlorate and the antimony recovered from the filtrate, or the arsenic may be separated by distillation.

Phosphorus is best determined on a separate portion, but if it is necessary to use the main portion, there is a choice of two methods. Ammonium hydroxide may be added to the oxalate filtrate from the antimony, and the phosphorus precipitated with magnesia mixture. As phosphorus is generally either absent or present in considerable quantity, in bronze, this method will do for ordinary work.

If it is necessary to identify a trace in the main portion, the alkaline filtrate from the sulfur fusion may be acidulated, the mixed sulfides of tin, antimony and arsenic filtered, dissolved, and examined for arsenic and antimony, and the filtrate boiled free from hydrogen sulfide. About 0.1 g. of iron in ferric solution is added, an ammonia precipitation made, the ferric hydroxide dissolved in nitric acid, and the

phosphorus precipitated as molybdate in the ordinary way for phosphorus in steel.

The ignited tin precipitate may now be corrected. The oxides insoluble in the fusion are deducted without separating them from each other, as described above. Phosphorus is calculated to P_2O_5 , antimony to Sb_2O_3 , and arsenic to As_2O_3 . A further addition may have to be made of tin recovered from the electrolyte.

In the meantime, the filtrate from the tin precipitate has been converted to sulfate, boiled, and settled. Filter the lead sulfate with paper pulp, as under these conditions it is likely to be very fine, and run through the filter. Wash with cold water. This is safe when the lead is to be converted to chromate, as, while the lead sulfate is decomposed to some extent, the lead becomes basic and does not dissolve, while the washings show acid. Wash the lead sulfate back into the beaker, and fill the paper with ammonium acetate solution. This is conveniently made by mixing 80 cc. ammonium hydroxide, 100 cc. water, and 70 cc. glacial acetic acid. 25 cc. of this mixture will dissolve 0.5 g. of lead.

Boil the lead sulfate with the acetate until it dissolves, filter, wash once with water, once with about 5 cc. of acetic acid mixed with water to fill the filter, and several times more with water. Dilute the filtrate with hot water to a volume between 400 cc. for 0.5 g. of lead and 50 cc. for a trace. To the warm solution add from 2 to 10 cc. of cold saturated potassium dichromate solution. The precipitant should be in excess over the lead to the extent of about 2 cc. per 100 cc. of solution. Heat strongly on the water bath, stirring two or three times until the precipitate subsides rapidly after stirring, and cool somewhat. Fold close-fibered filters in pairs, let them stand in funnels for a few minutes to recover from the moisture of the hands, and cut them to equal weight, cutting the heavier one of each pair through the double corner, and the other at one of the single corners. In setting the filters, leave the first paper folded and open the other with one uncut thickness next to and slightly above the first. When set in the funnel, the folded filter will be entirely covered by one thickness of the other, and the two uncut sides will make the unbroken top of the filter. After moistening, the filters should be pulled up and loosened if necessary, so that the stream will be rapid without a column.

In filtering, pour off nearly all of the solution without disturbing the precipitate. Then take the beakers one at a time, if there are several, and transfer the precipitate to the filter, using cold water. This will prevent the formation of a dry pulverized portion which may run through the filter. Fill each filter with hot water from a beaker, and when that has run through, wash all visible colored solution out of the paper, being careful to avoid washing the precipitate over the top. When the filter looks clean from below, fill again with hot water and wash as much as before. Wash the top of the filter with alcohol. Allow the precipitate to keep its natural form on the filter, without stirring it or washing it down. Dry in an oven

surrounded by boiling water for 2 hrs. Remove, loosen the papers in the funnels, let stand for half an hour in the weighing room, and weigh. The empirical factor to lead is 0.6375. If any variation of this method is used, it should be standardized against pure lead and a factor calculated. The theoretical factor will give results too high when paper filters are used. If preferred, the lead sulfate may be separated by the use of alcohol and weighed as such.

The filtrate from the lead is electrolyzed for copper at about 200 cc., after adding 5 cc. nitric acid. This can be done best with a coil and cylinder, so that the electrolyte can be saved without dilution. In removing the electrodes more care should be used to avoid diluting or spilling the solution than to avoid dissolving the copper, for the copper can be recovered.

Pass hydrogen sulfide into the electrolyte and filter on an ashless paper, with a little pulp. In some cases it may be necessary to add sulfuric acid to prevent the precipitation of zinc. The precipitate will consist of copper and tin. In most cases it is accurate enough to burn and weigh, and guess at the proportion of each. Or the cupric oxide may be dissolved away from the stannic oxide in the crucible after ignition with a little hydrochloric acid, as described above. The weights of tin and copper are added to the major amounts found.

In some determinations, particularly when the tin is low and is found largely in the electrolyte, it is best to reserve the tin precipitate until this second portion is recovered, before ignition. The tin will then be weighed all at once, and the copper found with it can be determined separately. The separation is conveniently made with hydrogen sulfide, leaving the iron in condition to add to the main portion.

When the separation has proceeded thus far, the filtrates will contain all the manganese, iron, aluminum, nickel, and zinc. It is convenient to oxidize the iron by adding hydrochloric acid while boiling out the hydrogen sulfide, as some nitric acid is present. As the amount of nickel is small, the basic acetate separation can be made almost at neutrality. Bring the solution just to the acid side with ammonium hydroxide and hydrochloric acid, and then add 20 per cent ammonium hydroxide, using a wash bottle, until a slight cloudiness of iron remains after stirring. Add a gram or so of sodium acetate, boil, settle, filter, and wash well with water containing ammonium sulfate. Dissolve, and precipitate the iron and aluminum with ammonium hydroxide, mixing some ashless paper pulp with the precipitate before filtering. This makes the ignited oxide soft and easily fusible. As the aluminum is generally present only in traces, it is not safe to take it by difference. After weighing the combined oxides they may be fused two or three times with sodium carbonate and the aluminum precipitated by nearly acidulating the filtrate with hydrochloric acid, or the fusion may be made with acid potassium sulfate, the solution made just acid with sulfuric acid, using ammonium hydroxide to neutralize it, and the iron removed electrolytically, using a mercury cathode. The precipitate of iron and aluminum is likely to con-

tain silica, and expulsion before weighing, using a drop of sulfuric acid with the hydrofluoric acid, is a wise precaution. Titration of the iron is still better.

Precipitate the manganese in the filtrate from the iron by the use of ammonium persulfate, and determine it as usual.

The nickel may now be separated from the zinc by dimethyl glyoxime, and filtered and weighed on a Gooch filter. As the solution by this time contains too much interfering acid to titrate the zinc directly, it should be made just acid with acetic acid and the zinc precipitated with hydrogen sulfide. Filter, but do not wash. Put paper and all back into the beaker, pour in 10 cc. water and 8 cc. hydrochloric acid, warm for a few minutes, dilute, and titrate with ferrocyanide. In the case of brass it will be necessary to take a suitable aliquot before precipitating the zinc. Instead of the glyoxime separation, the zinc may be precipitated first by Treadwell's salting out method.

This method is laborious and tedious, but it makes possible a practically complete analysis of one weighed portion, and the results are very accurate, in spite of the multiplicity of corrections. Complete analyses generally foot up within a few hundredths of 100 per cent.

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THE ALKALIMETRIC DETERMINATION OF SMALL AMOUNTS OF MAGNESIUM

By P. L. HIBBARD

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A method for determining magnesium by titration of ammonium magnesium phosphate was published by Bruckmiller in 1917.¹ The principles of his method had been known for some time, but he improved the technique considerably. While endeavoring to use the method for determining magnesium in soil extracts, the writer has further changed the procedure so that it is now very convenient and exact for the estimation of quantities of 5 mg. or less, down to 0.1 mg.

The principal changes introduced are:

- 1—Use of the Gooch crucible for filtration whereby it is possible to wash the precipitate in the most efficient manner, with the least quantity of wash solution.
- 2—Use of neutralized alcohol followed by water solution of ammonium magnesium phosphate for washing.
- 3—Use methyl red instead of methyl orange as indicator, giving a much sharper end-point.

Nearly all of the experimental work was in connection with the second point, finding a suitable wash liquid. Among those tried were water, alcohol, ether, in various concentrations and mixtures, 1 per cent water solution of ammonium sodium hydrogen phosphate, and a water solution of the salt which was to be purified, ammonium magnesium phosphate. The last named and pure alcohol were the only ones permitting good results, so it is not necessary to give the results with others. Ordinary alcohol is not neutral, but when properly neutralized it has very little solvent effect on ammonium magnesium phosphate. However, if left in contact with the salt for some time ammonia is taken up by the alcohol so that

¹ "Titration of Magnesium," *J. Am. Chem. Soc.*, **39** (1917), 610.

the alkalinity of the precipitate is changed. It was to avoid this difficulty that other wash solutions were tried.

A saturated solution of ammonium magnesium phosphate in water has practically no effect on the precipitate so long as the temperature of saturation does not differ much from the temperature at which it is used. The alkalinity of this solution is so slight that the small amount of it remaining in the precipitate is negligible, or at any rate may be allowed for by a blank determination. The solution is easily prepared by agitating some of the salt with carbon dioxide-free water for several hours, then filtering. It must not be heated, as hot water hydrolyzes the salt and causes separation of a basic compound. Addition of ammonia to the solution again precipitates ammonium magnesium phosphate. For this reason it cannot be used to remove excess of ammonia from the precipitate. Hence the use of alcohol to remove the main portion of the excess of ammonia. Then the washing is completed with the ammonium magnesium phosphate solution. Precise details are given in the description of the method following.

The procedure is essentially the same as if the magnesium were to be determined by weight up to the operation of filtering. This and the titration require only a few minutes. No special apparatus is required, though it is well to use for the washing solution a wash bottle operated by a rubber pressure bulb in order to avoid the entrance of carbon dioxide.

The following table illustrates the degree of accuracy attained. The quantities are stated in milligrams of magnesium.

TAKEEN	FOUND
0.5	0.53, 0.55, 0.50
1.0	0.98, 0.98, 1.00
2.0	2.00, 1.98, 2.02

METHOD

The method is alkalimetric, depending for success on obtaining the magnesium in a definite compound, ammonium magnesium phosphate, the alkalinity of which may be accurately determined, by means of standard acid.

1. PREPARATION OF THE SOLUTION—The solution must be free from other bases precipitable by phosphate ion in alkaline solution. In most cases it is convenient to use the solution from which calcium has been separated as oxalate. The volume should be small in order to effect complete separation of the magnesium in case there is very little present.

For amounts less than 1 mg.	5 cc. volume
For amounts of 1 to 3 mg.	10 cc. volume
For amounts over 5 mg.	20 cc. volume

Other soluble salts increase solubility of the precipitate, hence should be absent if possible.

Ammonium salts should be removed by evaporation and ignition, or by evaporation with nitric and hydrochloric acids. The quantity of ammonium salts formed in making the separation of calcium as oxalate ordinarily will not interfere with precipitation of ammonium magnesium phosphate.

2. (a) PRECIPITATION IN THE COLD—The solution, in a 200 cc. Erlenmeyer flask, should contain one- to two-tenths of one per cent of ammonium chloride and

enough free ammonia to give the odor distinctly, but not strong. Add, dropwise, a 1½ per cent solution of ammonium sodium hydrogen phosphate, 1 cc. for 1 mg. of magnesium, shaking constantly. If there is much magnesium, the precipitate forms at once; if there is very little, it will not appear until after addition of ammonia. After 10 min., add one-third the volume of strong ammonia, cover, and let stand 2 hrs. or more.

(b) PRECIPITATION HOT (SCHMITZ METHOD)¹—If the solution contains much ammonium salts which it is not convenient to remove, this plan gives very good results. Acidify slightly with hydrochloric acid, heat to boiling, add the necessary amount of ammonium sodium hydrogen phosphate, then one-third the volume of strong ammonia, cover, let stand 2 hrs. or more. If there is much magnesium present, a flocculent precipitate forms at once. On standing and cooling this becomes crystalline and has the same composition as that formed by Method (a), ammonium magnesium phosphate.

3. FILTERING AND WASHING THE PRECIPITATE—Prepare a Gooch crucible with a moderate thickness of paper pulp as filtering medium. Asbestos is not so good. Filter with moderate suction. The principal part of the soluble salts may be washed out with 2 per cent ammonium hydroxide or this may be omitted and washing with alcohol begun at once. Wash two or three times with 95 per cent alcohol, neutral to methyl red. In order to prepare the alcohol, measure 10 cc. into 50 cc. neutral water and determine the amount of standard acid or alkali necessary to neutralize it. From this, calculate the acid or alkali required for the volume of alcohol to be used. It is impossible to neutralize the alcohol by titrating directly on account of failure of the indicator to ionize in strong alcohol. After washing with the alcohol, wash four times with 5 cc. portions of a saturated water solution of ammonium magnesium phosphate. Rinse inside of crucible once with the same wash. Each time the wash should be entirely sucked out before adding the next portion. Return the felt with precipitate to the flask, rinse crucible into flask with water, and titrate.

4. TITRATION OF THE PRECIPITATE—Add a few drops of 1 per cent alcoholic solution of methyl red indicator, run in acid, while shaking, until it turns red, then about 5 cc. in excess. Shake well to insure complete solution of the precipitate. If the crystals are large, considerable time will be required to dissolve them. If not entirely dissolved before back titration, the end-point will be unstable and results will be low. Titrate back with alkali of the same strength as the acid until the color changes through pink almost to yellow.

1 cc. N/50 acid = 0.24 mg. magnesium
1 cc. N/10 acid = 1.2 mg. magnesium

When more than 2 mg. magnesium are present, the color change is not sharp.

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¹ *Z. anal. Chem.*, 1906, 512. Method given in Treadwell's "Analytical Chemistry," 2, 67.

ADAPTATION OF THE MOHR VOLUMETRIC METHOD TO GENERAL DETERMINATIONS OF CHLORINE

By LESTER YODER

Received April 11, 1919

By the proper preliminary preparation of the chloride solutions many determinations of chlorine as usually carried out may be simplified and shortened by the use of Mohr's volumetric method. Other volumetric methods are less satisfactory as the following brief résumé will show:

The original Volhard method has been modified by Drechsel,¹ Rothmund and Burgstaller,² and Alefeld,³ to a short and accurate process. Excess of standardized silver nitrate solution is added to the chloride solution and the excess titrated with standardized thiocyanate. The precipitate of silver chloride must be rendered either more insoluble by flocculation with heat or reagents or filtered from the excess of silver nitrate for the titration with the thiocyanate.

Votocek⁴ recently reported a method in which the chlorides are titrated in about 250 cc. of slightly acid solution with mercuric nitrate solution using 0.06 g. of sodium nitroprusside crystals as the indicator. In this method nitrites and sulfites interfere.

The well-known method of Mohr in which alkaline or alkaline-earth chlorides react with silver nitrate in the presence of a few drops of potassium chromate solution as indicator is as simple, direct, and fully as accurate as the method of Votocek, provided the proper conditions for the titration are as easily attained. The conditions necessary for an accurate titration appear numerous and exacting because (1) the solution must be neutral, (2) no carbonates or phosphates may be present since the silver salts of these acids are less soluble than the red silver chromate indicator and would therefore be titrated as well as the chlorides, and (3) the solution of the chlorides must have a proper concentration to produce the most definite color change.

The object of the work herein presented was to develop and test modifications of procedure to meet these conditions so that the Mohr method would be applicable to rapid determinations of chlorine in various materials and particularly in organic products containing small amounts of the element.

In the preparation of a titratable solution of the material in which chlorine is to be determined the sample must be ignited (in the case of organic products, at a low heat), and provision made for the fixation of free chlorine. An excess of sodium carbonate is usually added with the result that the sodium salts fuse and thereby prevent even after repeated ignitions, the complete oxidation of the carbonaceous matter which will pass through the filter in the subsequent filtration. A large amount of carbonates will also be present in the solution and the removal of any excess of phosphates is not assured.

Since the modifications necessary for the use of the

Mohr titration must provide for the removal of carbonates and phosphates, calcium acetate solution was substituted for the solution of sodium carbonate and ferric acetate solution was subsequently added to the ignited residue.

The following procedure gave the best results:

To the sample is added 5 cc. of a 30 per cent solution of calcium acetate with sufficient distilled water to thoroughly saturate the material. The mixture is evaporated to dryness at 120° C. and ignited at a temperature not over 450° C. The cooled residue is thoroughly moistened with a few cubic centimeters of a 10 per cent solution of ferric acetate, and again evaporated to dryness and ignited below 450° C. The residue is triturated with hot water, filtered, and washed until free from chlorides. The filtrate is evaporated to dryness or nearly to dryness and taken up with just sufficient hot water to insure complete solution of the chlorides, when cooled. After the addition of 2 or 3 drops of potassium chromate, the solution is titrated with 0.05 *N* silver nitrate.

The calcium acetate fixes free chlorine and during the extraction of the ignited residue precipitates carbonates and neutralizes the filtrate for the titration. The ferric acetate precipitates the phosphates and is itself converted into the insoluble oxide and also removed by the one filtration. Two ignitions with organic materials have not failed in our work to give clear and colorless solutions. Fair examples of the results obtained in the above procedure are reported in the table.

	Calculated Weight of Chlorine	Weight of Chlorine Found	Error or Difference
10 cc. N/10 HCl 0.025 g. KCl	0.0472	0.0469	-0.0003
10 cc. HCl 0.025 g. N/10 KCl 0.25 g. Na ₃ PO ₄	0.0472	0.0473	+0.0001
	Weight of Chlorine by Gravimetric Method	Weight of Chlorine by Mohr Method as Modified	Difference
Feces No. 19, 2 g.	0.0037	0.0035	-0.0002
Feces No. 23, 2 g.	0.0051	0.0048	-0.0003
Feces No. 27, 2 g.	0.0049	0.0049	±0.0000
Mixed Grain, No. 1, 3 g.	0.0020	0.0022	+0.0002
Alfalfa Hay No. 2, 3 g.	0.0061	0.0063	+0.0002
Mixed Grain No. 5, 3 g.	0.0018	0.0015	-0.0003

The modified method was applied to two solutions, one containing known amounts of free hydrochloric acid and its potassium salt, and another containing in addition added soluble phosphate. These were evaporated and ignited twice and subjected to a temperature of 450° C. in one of the ignitions. The results show no loss of chlorine and only a negligible difference from the calculated weight of chlorine in the samples. Determinations of chlorine were also made in different kinds of cow feces and mixed grain and in alfalfa hay. The results differ only slightly from those of determinations made gravimetrically and are well within the limits of experimental error although the percentage error in the weights of chlorine found is large by reason of the low chlorine content of the materials.

With the procedure outlined and from the results obtained by its use it seems that the Mohr direct titration method could be used for determinations of total chlorine in most instances.

¹ *Z. anal. Chem.*, **16** (1877), 351.

² *Z. anorg. Chem.*, **63** (1909), 330.

³ *Z. anal. Chem.*, **48** (1909), 79.

⁴ *Chem.-Ztg.*, **42** (1918), 257-60.

STUDIES IN SYNTHETIC DRUG ANALYSIS. VII—ESTIMATION OF MONOBROMATED CAMPHOR IN MIGRAINE TABLETS

By W. O. EMERY

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INTRODUCTION

The estimation of monobromated camphor *per se* by means of its bromine content may be effected with greater or less facility by any one of several procedures, notably the classic one of Carius; more speedily, however, by that of Stepanoff¹ which involves reduction in absolute alcohol with sodium, or by modifications thereof as reported by Bacon,² Maryott,³ and Drogin and Rosanoff.⁴ The earliest recorded experiments dealing specifically with the quantitative elimination of the halogen in monobromated camphor were undertaken by Schiff,⁵ who, operating with sodium on a solution of the camphor derivative in toluene, showed the result of such action to be sodium bromide and sodium camphor. Taking advantage of this observation and subjecting the resulting products to titration *via* Volhard, Andre and Leulier⁶ report satisfactory results in the examination of several commercial samples of the drug.

In medicaments like migraine tablets, however, the problem of evaluating the camphor derivative becomes more complicated. In addition to vehicular and other more or less inert materials peculiar to such products, we have here a preparation consisting essentially of acetanilide, caffeine, and monobromated camphor, with sometimes salicylates and plant extractives. From mixtures of this character monobromated camphor, on account of its physical properties, is hardly susceptible of quantitative isolation by means of immiscible solvents, although a gross separation of the drug in solution, along with acetanilide, caffeine, and other extractable material eventually present, may indeed be made by a systematic treatment of the powdered tablets with alcohol, benzene, or toluene. Such procedure, however, almost invariably gives rise to solutions of so unwieldy and varying a volume as to render any subsequent reduction, with sodium for example, quite valueless, owing to the uncertain quantity of metal required and consequent unsatisfactory results. Even when operating with like volumes of solvent, and in strict accord with the latest approved method comprehending the Stepanoff principle,⁷ the amount of sodium required for complete reduction is generally variable and always relatively large, in fact, more than twenty times that of the bromine derivative involved. This comparatively low efficiency from the standpoint of sodium consumption arises from the phenomenon, familiar to most chemists, whereby metallic sodium when applied to heated alcohol immediately assumes the spheroidal state, moving about very actively on the surface of the

liquid, but separated therefrom by a film or cushion of hydrogen and alcohol vapor, all conditions clearly favoring incomplete reduction. Any objection to, or uncertainty attendant upon, the use of the free metal may be entirely eliminated by recourse to the procedure whereby the powdered tablet itself in alcoholic solution and suspension is subjected to the action of sodium in the form of its mercury amalgam, an effective reagent and at all times under complete control of the operator.

EXPERIMENTAL

The tabulated data are representative of numerous results obtained with both control and commercial mixtures. The monobromated camphor required for the controls was prepared by recrystallization of a well-known foreign brand carrying a slight excess of halogen. The purified product melted sharply at 76° and had a bromine content, as determined by Carius, of 34.6 per cent. In general, the treatment consisted in subjecting the powdered sample in alcoholic solution and suspension to the action of the amalgam at about the temperature of boiling alcohol, at first over a wire gauze and with appropriate reflux, finally on the steam bath to practical exhaustion of the amalgam, and with no attempt at condensation. The amalgam was applied in a strength of about 1 per cent of sodium, although in Expts. 5 to 8, inclusive (see table), a product containing only 0.6 per cent of sodium was employed. After quantitative separation of the liquid from the mercury, the halogen is precipitated by silver nitrate in acidified solution, and the insoluble bromide determined in the usual way. In general, estimation of the bromine *via* Volhard is not advocated, on account of possible interference from accompanying organic substances.

Expt. No.	C ₁₀ H ₁₅ BrO Gram	PhNHAc Gram	Caffeine Gram	Starch Gram	NaHg Gram	AgBr Gram	C ₁₀ H ₁₅ BrO Caled.	Per cent
1	0.2000	.....	.....	.....	25	0.1621	0.1994	99.7
2	0.1000	.....	.....	.....	25	0.0810	0.0996	99.6
3	0.2000	.....	.....	.....	25	0.1628	0.2002	100.1
4	0.1000	.....	.....	.....	25	0.0809	0.0995	99.5
5	0.2000	.....	.....	.....	25	0.1619	0.1991	99.6
6	0.2000	.....	.....	.....	20	0.1617	0.1989	99.5
7	0.2000	.....	.....	.....	15	0.1596	0.1963	98.2
8	0.2000	.....	.....	.....	10	0.1526	0.1817	93.8
9	0.2000	.....	.....	.....	13	0.1623	0.1996	99.8
10	0.2000	.....	.....	.....	19	0.1622	0.1995	99.8
11	0.2000	0.8000	0.1000	0.1000	25	0.1627	0.2001	100.1
12	0.1000	0.4000	0.0500	0.0500	25	0.0812	0.0998	99.8
13	0.0972(2)	0.3888	0.0486	?	25	0.0762	0.0937	96.4(2)
14	0.0972(2)	0.3888	0.0486	?	25	0.0768	0.0945	97.2(2)
15	0.1000	0.4000	0.0500	0.2000	25	0.0812	0.0999	99.9
16	0.1296(2)	0.1944	0.0648	?	25	0.1052	0.1294	99.8(2)
17	0.1296(2)	0.1944	0.0648	?	25	0.1056	0.1299	100.2(2)
18	0.1300	0.2000	0.0650	0.1000	25	0.1059	0.1303	100.2
19	0.1296(2)	0.6480	.....	?	25	0.1068	0.1314	101.3(2)
20	0.1296(2)	0.6480	.....	?	25	0.1065	0.1310	101.1(2)
21	0.1300	0.6500	.....	0.1000	25	0.1056	0.1299	99.9

In further explanation of these results, it may be stated that Expts. 1 to 10, inclusive, have to do primarily with the camphor derivative alone, 13 and 14, 16 and 17, and 19 and 20 with commercial mixtures, while 11 and 12, 15, 18, and 21 deal essentially with controls of the latter, in which the dominating ingredients were proportioned to agree with the manufacturer's label. Accordingly, any uncertainty existing relative to the quantities of such ingredients, notably monobromated camphor, actually introduced or present in the samples examined, would necessarily be re-

¹ Ber., **39** (1906), 4056.

² J. Am. Chem. Soc., **31** (1909), 49.

³ Am. J. Sci., **30** (1910), 378; Chem. News, **108** (1911), 1.

⁴ J. Am. Chem. Soc., **38** (1916), 711.

⁵ Ber., **13** (1880), 1407.

⁶ J. pharm. chim., [7] **2** (1910), 64.

⁷ Loc. cit.

fected in all computations based thereon—as in the calculation of percentages—and is so indicated. With the exception of Expts. 3 and 4, the period of reduction in all the experiments was uniform, consisting of a $\frac{1}{2}$ hr. treatment under reflux on the wire gauze and $\frac{1}{2}$ hr. on the steam bath. In the exceptions noted, the reflux period was doubled, thus making the entire digestion cover 2 instead of $1\frac{1}{2}$ hrs. While no material advantage in the longer treatment is observable there can be no objection thereto. A brief survey of the results presented will suffice to show the efficacy of the method.

METHOD

Ascertain the weight of 20 or more tablets, reduce to a fine powder and keep in a small tube or specimen bottle provided with a tightly fitting cork or glass stopper. On a metal or glass scoop weigh out an amount of the sample equivalent to not less than 100 or more than 200 mg. of the camphor derivative alleged to be present. Transfer quantitatively with 20 cc. of 96 per cent alcohol and 10 cc. of water, to a small (100 cc.) round-bottomed flask, containing 15 g. of 1 per cent sodium amalgam. Connect the flask, by means of a rubber stopper, with a short vertical reflux, preferably of the Allihn or of the worm type. Heat the mixture over a wire gauze just enough to cause the liquid to boil gently for a period of not less than 30 min. After cooling slightly, wash out the condenser tube first with 5 cc. of alcohol, then with 5 cc. of water, receiving the washings in the flask below. Remove the flask to the steam bath, heating for another hour, or until the evolution of hydrogen

has nearly or quite ceased. Toward the latter part of this operation, render the liquid about neutral with a few drops of acetic acid in order to further reduction. Transfer the contents of the flask to a separatory funnel, preferably of the Squibb type, withdrawing and washing the mercury in a second separatory funnel with at least two 50 cc. portions of water. Pass the several aqueous solutions quantitatively through a small filter, collecting the clear filtrate in a suitable beaker. Precipitate with silver nitrate after the addition of about 5 cc. of nitric acid, and proceed with the determination of the resulting silver bromide in the usual gravimetric way, employing, if available, a Gooch crucible in the operation of filtering. The weight of the silver bromide multiplied by the factor 1.23 will give the quantity of monobromated camphor originally present in the sample taken for analysis. A control should be run on the amalgam in order to determine whether any correction is necessary for the presence of halogen in material quantity.

SUMMARY

This method for the estimation of monobromated camphor in migraine tablets takes advantage of the fact that, when an aqueous-alcoholic solution of the camphor derivative, either alone or in admixture with other substances, is subjected to the action of sodium amalgam on heating, among other changes the bromine is split off quantitatively in the form of its sodium salt, which may then be determined gravimetrically in the usual way.

SYNTHETIC PRODUCTS LABORATORY
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LABORATORY AND PLANT

ACID TEST ON ENAMEL WARE

By W. D. COLLINS

Received February 8, 1919

The testing of enameled steel ware and of enamels for coating sheet steel has been discussed by Orton,¹ J. B. Shaw,² Landrum,³ Poste,⁴ and Frost⁵ in papers presented at meetings of the American Ceramic Society, and published in the *Transactions of the Society*. Much of the work of these authors was with special test pieces or vessels and the results of acid tests reported were largely based on loss of weight of the test pieces, or changes in appearance.

A recent article by Miller⁶ gives the amounts of antimony dissolved from certain enameled vessels by treatment with different agents. One gray sauce pan lost 26 mg. of antimony when 1500 cc. of 4 per

cent acetic acid was boiled in the vessel for $\frac{1}{2}$ hr. Food substances, grape juice, cider, cranberry pulp, spinach, and sweet milk, when cooked in the same vessel, dissolved proportional amounts of antimony. The results indicate that for the solution of antimony from enamel ware 4 per cent acetic acid may be considered fairly representative of a number of food products which will dissolve antimony from such vessels.

The test by boiling with 4 per cent acetic acid is comparatively old. Koerner¹ refers to a regulation of the German government, dated June 25, 1897, that vessels for cooking shall not give up any lead when 4 per cent acetic acid is boiled for $\frac{1}{2}$ hr. in the vessel.

The results reported in Table I were obtained during the examination of a number of enameled dishes to learn the extent of the use of antimony oxide as a substitute for tin oxide in white enameled ware, and in connection with a few tests of different wares as to their acid resistance. Altogether, tests were made on 32 samples of white ware from 21 manufacturers, 15 samples of gray ware from 9 manufacturers, 12 samples of blue ware from 4 manufacturers, and 2

¹ "Testing of Enameled Sheet Steel Wares," *Trans. Am. Ceram. Soc.*, **11** (1909), 320-41.

² "Testing Sheet Steel Enamels," *Ibid.*, **12** (1910), 463-93.

³ "Resistance of Sheet Steel Enamels to Acetic Acid," *Ibid.*, **13** (1911), 494-501; "Comparison of Ten White Enamels for Sheet Steel," *Ibid.*, **14** (1912), 489-509.

⁴ "The Relative Action of Acids on Enamel," *Ibid.*, **17** (1915), 137; *Ibid.*, **18** (1916), 762.

⁵ "The Action of Acetic Acid Solutions of Different Strengths on a Sheet Steel Enamel," *J. Am. Ceram. Soc.*, **1** (1918), 422-8.

⁶ "Solution of Antimony from Enameled Cooking Utensils," *J. Home Econ.*, **8** (1916), 361-7.

¹ "Bleihaltige, im Sinne des Gesetzes ungiftige Glasuren," *Sprechsaal*, **39** (1906), 2-4.

miscellaneous samples. As ware of more than one kind was tested from some manufacturers, the total number of establishments represented was only 26.

A number of the samples were purchased on the open market, some were obtained from the General Supply Division, Quartermaster Corps, of the Army, and a few were received from manufacturers.

The samples were treated with different acids of various strengths.

The effect on the appearance of the surface, and the amounts of total material, of silica, of antimony, and of lead dissolved were determined for different samples.

APPEARANCE

In most of the tests the appearance of the vessels after the action of the acid was noted.

Boiling 4 per cent acetic acid for 30 min. was the test used in the greatest number of cases. One per cent citric and tartaric acids were used in some tests. They had approximately the same effect on the glaze as 4 per cent acetic acid. A number of tests were made with 1 and 2 per cent acetic acid. In some of the tests the vessel with the acid was heated on the steam bath for 30 min., or for a longer time. Loss of glaze and deterioration in appearance cannot be expressed numerically with ease. Therefore all the observations have been summarized under the headings good, fair, and bad. When no effect on the glaze could be detected, or at most only a slight attack at the level of the surface of the liquid, the appearance was called "good." When the glaze had entirely disappeared where the liquid touched it, and the surface was left rough, the appearance was called "bad." Those neither "good" nor "bad" were called "fair." The results are summarized in the following table:

TABLE I—APPEARANCE OF SURFACE AFTER TREATMENT WITH BOILING ACETIC ACID FOR 30 MIN.

	Strength of Acid	Good ¹	Fair	Bad	Total
White ware.....	4	13	13	4	30
Gray ware.....	4	8	8	2	18
Blue ware.....	4	1	3	2	6
Blue ware.....	2	1	3	2	6
Blue ware.....	1	2	3	5	10

¹ Figures in this and following columns give the number of samples.

The loss of glaze detracted most from the appearance of the blue ware. The glass seemed to dissolve leaving the clay or other infusible constituents showing at the surface. Although some clay could be scoured off, the ware did not recover its original color. With white ware the only loss was the glaze. In nearly all cases a smooth, dull surface was left after the clay was washed away, and the appearance of the vessel was like new except for the glaze. The effect on the gray ware was intermediate between the other two.

The white and gray wares were not affected at all by treatment with 1 or 2 per cent acetic acid which attacked severely all but two of the samples of blue ware.

SOLUBILITY

A number of vessels were treated with 200 cc. of 4 per cent acetic acid on the steam bath for six or more hours. The acid solution was evaporated to dryness

in platinum and the residue heated approximately to constant weight in an oven at 110°.

The weight of material dissolved was determined for only 11 dishes—6 white, 4 gray, and one blue. The white and gray ware, of brands which are generally understood to give good service in use, lost from 0.05 to 0.08 g. when treated for 6 hrs. with 4 per cent acetic acid. Other samples of white and gray ware lost from 0.2 to 0.5 g. under similar conditions. The single sample of blue ware tested lost from 0.6 to 1.2 g.

On account of the difficulty of making strictly comparable tests, and the small value of the results when obtained, the subject was not pursued further. As would be expected, the amounts of material dissolved corresponded to the loss of glaze.

SILICA

Silica was determined in the material dissolved from 4 white dishes, 3 gray ones, and one blue bowl. The determination was made by adding hydrochloric acid, evaporating to dryness, taking up the residue in hydrochloric acid, filtering, igniting, and determining the loss of the ignited residue on treatment with hydrofluoric acid. The highest percentage of silica (about 30 per cent) was obtained from a special white cup made without tin oxide. Other commercial white and gray wares had from 7 to 20 per cent of silica in the dissolved material. The single blue bowl had only from 2 to 6 per cent of silica in the material dissolved in successive treatments.

ANTIMONY

Antimony was dissolved from the vessel in most cases by boiling 500 cc. of 4 per cent acetic acid for 1/2 hr. and also by boiling 500 or 400 cc. of one per cent tartaric acid for 1/2 hr. A few results were obtained with one per cent citric acid, which dissolved about the same quantity of antimony as did the one per cent tartaric.

From the solutions antimony was precipitated by hydrogen sulfide. The precipitate of antimony sulfide was dissolved in boiling concentrated hydrochloric acid. The solution was filtered, and after dilution and the addition of starch indicator, iodine solution was added to oxidize any reduced tin. The solution was made alkaline with sodium carbonate, tartaric acid was added to acidity, and then sodium bicarbonate until the solution was distinctly alkaline and contained an excess of sodium bicarbonate. The antimony was then titrated with iodine solution. In most cases the strength of the iodine solution was such that 1 cc. represented 0.606 mg. of antimony. The tartaric acid dissolved two or three times as much antimony as the acetic acid. For comparison the results were averaged and tabulated according to the number of samples losing different amounts of antimony.

The 51 samples examined represented the products of 25 manufacturers. The 17 samples with no antimony came from 9 manufacturers. Three of these furnished only one sample each, which was white ware. One blue sample without antimony was from a manu-

facturer whose white sample gave up about 1 mg. of antimony. Another blue sample was from a company which furnished white ware without and gray ware with antimony. Four samples from one company, 1 blue, 1 white, and 2 gray, failed to give any test for antimony.

TABLE II—NUMBER OF SAMPLES LOSING DIFFERENT AMOUNTS OF ANTIMONY TO SOLUTIONS OF ACETIC AND TARTARIC ACIDS

	None	0.5 mg.	1.0 mg.	2.0 mg.	Total
White ware.....	9	6	12	5	32
Gray ware.....	4	3	5	3	15
Blue ware.....	4	0	0	0	4

In general, as much antimony was dissolved from gray ware as from white. A white-coated cup which was made without tin oxide for use in these studies gave up less antimony than a number of the other white and gray vessels. The highest three values were obtained from gray vessels.

The results show that enamel ware can be bought, in white and gray, which is free from antimony.

LEAD

Lead was dissolved from the ware of only one manufacturer. Vessels treated with different amounts of acetic acid gave up from 2 to 9 mg. of lead.

The freedom from lead shows the desire of practically all manufacturers to keep their product free from such a well-known dangerous poison.

EFFECT OF TEMPERATURE CHANGES

Although no effort was made to test the resistance of the different vessels to changes in temperature, a number of the samples failed to hold their coating during the tests. Most of the tests with boiling acetic acid were made by placing the vessels over a Bunsen burner flame after the vessels had been filled with a cold solution of acid. In some cases the enamel cracked as soon as the flame was applied; in a few instances large pieces of enamel chipped off at once. In some other cases the coating seemed to be sound until the vessel was removed from the flame, when pieces of the enamel chipped off the inside of the vessel. In one case a dipper was removed from the flame, and placed on a tile table top at room temperature. Large pieces of enamel came off the inside at once. It is evident that considerable differences exist in the ability of the vessels to withstand sudden changes in temperature. Hardly any of the vessels which lost large quantities of enamel received any more harsh treatment than an ordinary cooking vessel must receive.

SUMMARY

Acid tests were made on 61 samples of enamel ware from 26 different American manufacturers. These included white, gray, and blue cups, bowls, and pans.

The test most used was made by boiling 500 cc. of 4 per cent acetic acid in the vessel for $\frac{1}{2}$ hr. Some tests were made with 1 per cent tartaric acid.

About half the samples of white and gray ware suffered no loss of glaze on treatment with 4 per cent acetic acid, while nearly all the blue ware was badly affected by 2 per cent acid. The amounts of material dissolved corresponded to the loss of glaze.

Seventeen samples from 9 manufacturers gave no antimony. There was no great difference between

the white and gray ware in the amounts obtained from the 34 vessels which gave from 0.5 to 2.0 mg. of antimony.

Lead was found in ware from only one manufacturer.

Pieces of enamel chipped off several vessels under heat treatment no more severe than might be received by any cooking vessel.

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CHANGES IN OILS UPON STORAGE

By HENRY A. GARDNER

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In various papers¹ the writer has called attention to the storage changes that may take place in oils when ground with pigments. For instance, when paints made with pure raw linseed oil having a certain iodine number are stored for long periods of time, subsequent analysis may show that the oil has a lower iodine number than that called for by the specifications upon which the paints were made. Reactions that are responsible for such changes are of course greatly stimulated at high temperatures. As a result of some investigations that have just been completed, it would appear that similar but less marked changes may take place in pure oils without the presence of pigments, and that such changes will depend to a very great extent upon the method of storing and certain other factors.

During the early part of 1911 the writer secured a quantity of a number of commercial oils for use in experimental paints that were to be exposed to the weather to determine the efficiency of various oil mixtures as paint ingredients. After the painting tests were made, samples of the pure oils were placed in pint glass bottles having ground glass stoppers. The bottles were well filled, an air space above the oil of more than one inch not being allowed in any instance. The oils were placed upon a shelf in the laboratory where they were exposed to indirect light and to ordinary room temperature (in the summer not over 105° F., and in the winter not less than 35° F.). In November 1914 portions of the oils were removed from the bottles and examined as a check against the original determinations. Air was, of course, admitted during this procedure. During September 1916 the oils were again examined, further quantities being removed for this purpose. The bottles were again placed upon the shelf and allowed to remain there until March 1919, when further quantities were removed for examination. The results obtained on these samples are given in Table I.

In Table II are shown the results on a series of oils obtained during 1914 and kept under similar conditions to those shown in Table I, the analyses being made in September 1916, and in March 1919.

¹ "The Effect of Pigments upon the Constants of Linseed Oil," *J. Frank. Inst.*, **1912**, 415-423; "Changes Occurring in Oils and Paste Paints. Due to Autohydrolysis of the Glycerides," *Ibid.*, **1914**, 533-540; "A Study of Some Curious Painting Phenomena," *Ibid.*, **1915**, 681-695.

TABLE I—1911-1919 OIL TESTS¹

Analyses were made when oils were first obtained and again at three later periods as shown below.

No.	Sp. Gr. at 60° F.	Iodine No.	Sapon. No.	Acid No.	Refrac. Index at 60° F.
1 Linseed Oil					
March 1911.....	0.931	186.0	188.0	2.0	
November 1914....	0.933	185.4	189.6	2.8	1.4867
September 1916....	0.936	..	190.2	3.3	1.4798
February 1919....	0.943	182.1	192.3	4.8	1.4870
2 Soy Bean Oil					
March 1911.....	0.924	129.0	189.0	2.3	
November 1914....	0.925	130.2	193.7	4.7	1.4813
September 1916....	0.937	122.0	192.1	7.0	1.4733
February 1919....	0.939	121.7	193.4	7.8	1.4721
3 Menhaden Oil					
March 1911.....	0.932	158.0	187.0	3.9	
November 1914....	0.934	156.3	193.7	16.1	1.4850
September 1916....	0.938	..	191.4	19.2	1.4768
February 1919....	0.940	156.9	191.5	21.3	1.4838
4 Tung Oil					
March 1911.....	0.944	166.0	183.0	3.8	
November 1914....	0.946	161.5	190.3	5.7	1.5050
September 1916....	0.944	158.6	188.7	5.6	1.5138
February 1919....	0.948	141.1 ²	191.6	6.0	1.5024
5 Perilla Oil					
March 1911.....	0.94	180.0	188.0	2.0	
November 1914....	0.94	172.0	195.4	7.4	1.4874
September 1916....	0.939	..	193.3	14.8	1.4767
February 1919....	0.941	168.9	192.1	10.5	1.4817
6 Perilla Oil (Special) ³					
March 1911.....	0.94	192.0	189.0	3.2	
November 1914....	0.981	123.8	219.4	20.8	1.4978
September 1916....	1.000	122.4	220.9	31.2	1.4840
February 1919....	..	..	..	..	..
7 Heavy-bodied Linseed Oil					
March 1911.....	0.968	133.0	189.0	2.8	
November 1914....	0.992	130.5	200.0	6.3	1.4966
September 1916....	..	124.4	206.3	9.0	1.4876
February 1919....	..	133.5	192.2	11.1	1.4892
8 Lithographic Linseed Oil					
March 1911.....	0.97	102.0	199.0	2.7	
November 1914....	0.96	103.4	150.9	13.4	1.4978
September 1916....	0.974	108.5	137.7	15.2	1.4890
February 1919....	..	100.2	131.5	18.3	1.499
9 Whale Oil					
March 1911.....	0.924	148.0	191.0	9.2	
November 1914....	0.926	138.2	191.2	17.4	1.4820
September 1916....	..	..	..	..	..
February 1919....	0.929	136.9	193.3	20.2	1.4793
10 Boiled Linseed Oil					
March 1911.....	0.941	172.0	187.0	2.7	
November 1914....	0.943	170.0	188.0	3.1	1.4895
September 1916....	..	..	..	..	..
February 1919....	0.948	172.7	193.7	10.9	1.4890

¹ All of the determinations were made at 60° F., except in the case of tung oil which had become so viscous by February 1919 that a temperature of 60° C. was required for the determination of its refractive index. In determining the iodine numbers of the oils, Hanus solution was used in every case except for the tung oil, in which case Hubl solution was used.

² Hubl at 60° C.
³ This is a special grade of bleached oil which has become highly viscous, possibly through oxidation, as result of exposure to air for long period.

In Tables III, IV and V are given the results on special oils, the history of which is given in each table.

Previous to the examination of the oils in March 1919 a record was made of the approximate contents of each bottle so that some information might be on record as to the amount of air space above the oil and the appearance of the oil. This record is given in Table VI.

It will be noted from a study of the tables that the ageing of nearly every oil causes a drop in the iodine number, which is accompanied by a rise in the specific gravity, saponification number, and acid number. Two special exceptions to the rise in saponification number are shown by Oils 8 and 13. It is probable that the highly over-oxidized condition of Oil 8 may be held responsible for the results shown. In the case of Oil 13, the low result may be due to the condition of the oil, a considerable amount of material having precipitated out. This precipitate was of a highly acid character and consequently may have been the means of lowering the acid value of the clear oil.

Special attention is directed to the rapid increase

TABLE II—1914-1919 OIL TESTS

Analyses were made when oils were first obtained and again at two later periods as shown below.

No.	Sp. Gr. at 60° F.	Iodine No.	Sapon. No.	Acid No.	Refrac. Index at 60° F.
11 Corn Oil					
November 1914....	0.921	124.8	190.1	4.1	1.4800
September 1916....	0.924	121.3	191.4	4.6	1.4707
February 1919....	0.926	127.2	191.4	5.3	1.4742
12 Cottonseed Oil					
November 1914....	0.920	111.7	194.3	0.9	1.4781
September 1916....	0.924	110.6	192.9	1.4	1.4681
February 1919....	0.925	109.4	193.0	0.82	1.4718
13 Rosin Oil (Low Grade 4th Run) ¹					
November 1914....	0.964	68.9	35.5	32.4	..
September 1916....	0.964	66.0	36.6	31.6	..
February 1919....	0.965	64.4	22.6	17.9	1.5202
14 Treated Tung Oil ²					
November 1914....	0.882	56.4	101.3	7.7	1.4764
September 1916....	0.884	53.2	103.2	8.0	1.4660
February 1919....	..	..	..	..	..
15 Lumbago Oil					
November 1914....	0.927	162.0	189.0	1.0	1.4789
September 1916....	0.926	164.0	188.9	1.9	1.4748
February 1919....	0.927	161.2	189.4	2.4	1.4749
16 Sunflower Oil					
November 1914....	0.924	124.6	189.3	7.5	1.4796
September 1916....	0.923	122.2	190.2	9.0	1.4712
February 1919....	0.922	130.1	194.2	8.2	1.4747
17 Hempseed Oil					
November 1914....	0.927	149.4	191.1	3.9	1.4822
September 1916....	0.930	146.1	191.0	5.0	1.4745
February 1919....	0.930	151.3	191.8	4.9	1.4777
18 Shark Oil					
November 1914....	0.910	132.8	158.9	5.2	1.4815
September 1916....	0.915	127.4	163.3	6.2	1.4722
February 1919....	0.918	121.4	168.9	8.9	1.4749
19 Sardine Oil					
November 1914....	0.919	134.6	177.3	10.4	1.4800
September 1916....	0.962	91.4	180.2	31.1	1.4755
February 1919....	..	76.5	188.7	..	1.4787

¹ Considerable matter of highly acid character settled out during 1917.

² Heat treated with driers and thinned with mineral spirits; as used in the liquid portion of interior flat paints.

in acid number shown by Oils 3, 9 and 19 (fish oils). It would appear that marine animal oils are very susceptible to changes which develop considerable percentages of free fatty acid. The subsequent drop in the acid number of Oil 19 may have been caused by the precipitation of matter during 1917.

TABLE III
A. S. T. M. AMERICAN-GROWN TUNG OILS

No.	Sp. Gr.	Iodine No.	Sapon. No.	Acid No.	Refrac. Index
20 ¹ Oil No. 3 A					
Dec. 1914.....	..	167.4	190.0	0.9	
Mar. 1919.....	..	168.6	193.6	0.6	1.5042 ²
21 ¹ Oil No. 4 A					
Dec. 1914.....	..	168.5	189.6	0.6	
Mar. 1919.....	..	163.3	194.8	0.5	1.5037 ²
22 ² Oil No. 1 B Commercial					
Dec. 1913.....	0.9395	168.7	192.1	3.8	1.5195
Mar. 1919 (in glass)	0.939	169.4	193.4	2.1	1.5177
Mar. 1919 (in tin) ³	0.945	160.6	192.9	2.0	1.5178
23 ³ Oil No. 2 B American Tallahassee					
Dec. 1913.....	0.939	169.5	191.0	0.9	1.5210 ⁴
Mar. 1919.....	..	166.9	193.0	0.6	1.5037

¹ Oils 20 and 21 were crushed by the Bureau of Chemistry from two lots of nuts grown during 1914 in Leon County, Florida. For data on character of nuts, percentage of oil contained therein, evaluation of kernels, etc., see report of Subcommittee III of Committee D-1 on Testing of Paint Vehicles, *Proc. Am. Soc. Testing Materials*, 1915, 211.

² Oil 22 was a portion of a sample submitted to the American Society for Testing Materials by L. P. Nemeck as representing a large commercial shipment of imported oil that had proved satisfactory in making paints and varnishes.

³ Oil 23 was crushed by the Bureau of Chemistry from nuts grown in China and obtained through the Agricultural Explorer of the Bureau of Plant Industry. For data on character of nuts, percentage of oil contained therein, evaluation of kernels, etc., see report of Subcommittee III of Committee D-1, on Testing of Paint Vehicles, *Proc. Am. Soc. Testing Materials*, 1914, 237.

⁴ Because of condition of oil, 60° C. required for determination of refractive index.

⁵ Oil in can streaked with fungus growth.

On Oils 1, 3 and 5 the September 1916 iodine numbers have been omitted, since they had been recorded as being lower than is shown in the 1919 examination. This result not being in accord with the progressive decrease in iodine number, would lead to

the conclusion that some error was made in these determinations rather than to the assumption that the iodine number of an oil may drop and then increase.

Special attention should be focused on the rather moderate changes in constants shown by corn oil, cottonseed oil, lumbago oil, sunflower oil, and hempseed oil (Nos. 11, 12, 15, 16 and 17, respectively). These oils were all received in excellent condition and were perfectly clear and apparently free from moisture. These factors may have had much to do with their keeping properties.

TABLE IV
RAW LINSEED OIL
Untreated and Sterilized

No.	Sp. Gr.	Iodine No.	Sapon. No.	Acid No.	Refrac. Index
24					
Original Oil Not Sterilized Examined 1911	0.931	186.0	188.0	2.0	..
Original Oil Not Sterilized Examined Nov. 1911	0.933	185.4	189.6	2.8	1.4867
Original Oil Not Sterilized Examined Feb. 1919	0.943	182.1	192.3	4.8	1.4831
Original Oil Sterilized Nov. 1914 ¹ Examined Feb. 1919	0.935	181.5	191.8	0.9	1.4816
25					
Original Oil Not Sterilized Examined 1911	0.932	158.0	187.0	3.9	..
Original Oil Not Sterilized Examined Nov. 1914	0.934	156.3	193.7	16.1	1.4850
Original Oil Not Sterilized Examined Feb. 1919	0.940	156.9	191.5	21.3	1.4802
Original Oil Sterilized Nov. 1914 ¹ Examined Feb. 1919	0.938	156.2	190.1	5.1	1.4802

¹ Heated to 105° C.

Most interesting results were obtained with Oils 20 and 21 (American-grown tung oils). These oils have shown but very moderate changes in acid value, although both developed rather high saponification numbers, and Oil 21 showed a substantial decrease in iodine number. A comparison of the value of glass and tin for storage purposes is shown in the cases of Oils 22 and 23. It seems rather curious that the oil stored in tins should have shown more change than that stored in glass. This may possibly be due to the action of the fungus growth that was in 1919 observed to be present in the tinned sample may have been inhibited by the action of light.

TABLE V—MISCELLANEOUS TESTS

Analyses made after allowing oils to remain in glass bottles for nearly three years. No determinations were made at start of test.

No.	Sp. Gr.	Iodine No.	Sapon. No.	Acid No.	Refrac. Index
26	0.916	87.1	192.4	3.5	1.4696
27	0.931	133.2	194.3	7.4	1.4767
28	0.926	152.1	186.4	3.8	1.4791
29	0.937	153.5	190.1	0.8	1.4995

¹ Source unknown. Very heavy, granular deposit settled out, streaked with fungus growth.

In Table IV some data is given on the effect of sterilization of linseed and menhaden oils by heat treatment. The rapid rise in acid value shown by the unsterilized sample of menhaden oil, and the very moderate rise in acid value shown by the sterilized oil would indicate that properly treated oils may be made more or less immune from changes of an undesirable nature. In the writer's opinion the changes that take

place in oil upon standing are due very largely to auto-hydrolysis caused by the presence of either moisture or, in some instances, fat-splitting enzymes. Whenever oil is heated to a temperature of 105° C. for a sufficient period of time to remove the moisture, and then filtered, a moisture-free, clear and sterile oil will result. Such oil will apparently keep for a long period of time without showing any marked changes.

TABLE VI—APPEARANCE OF OILS IN CONTAINERS IN MARCH 1919
PREVIOUS TO ANALYSIS

Oil No.	Appearance
1	1/4 full Very slight sediment
2	1/4 full Very clear
3	1/4 full White sediment at bottom. Globular-like oxidation at surface
4	2/3 full Completely solidified to white mass, crystalline at surface
5	1/2 full Very clear
6	1/4 full Highly viscous. Clear
7	2/3 full Clear. Slight film at surface
8	2/4 full Highly viscous
9	1/4 full White sediment at bottom. Globular-like oxidation at surface
10	1/2 full Clear
11	1/2 full Slight white sediment at bottom. Clear
12	1/4 full Heavy white sediment at bottom. Clear
13	2/3 full Dark sediment
14	2/3 full Clear. Film at surface
15	2/3 full Very clear
16	1/3 full Very clear
17	1/3 full Very clear
18	1/4 full Dark sediment at bottom
19	1/4 full Dark sediment at bottom
20	2/4 full Lower third of oil completely solidified to white mass. Upper part clear
21	1/3 full Completely solidified to white mass
22	2/4 full Clear. In can 2/3 full. Clear, but slight fungus streaks
23	2/3 full Completely solidified to milk-white mass
24	1/4 full Very clear
25	1/2 full Very clear
26	2/4 full Clear
27	2/4 full Lower third of oil black mass with white specks throughout and a blanket of milk-white granules at top

The precipitated foots and curious form of oxidation products at the surface of the fish oils was of a distinctive nature. The solidification of the tung oils to a white, granular mass is characteristic of these oils when exposed to light for long periods. This condition makes necessary the determination of refractive index at 60° C. The matter, settled out from the corn and cottonseed oils, was very flocculent and white.

There was unfortunately no analytical data originally obtained on the samples of oils shown in Table V, but at the end of nearly three years' storage the constants would indicate that but slight changes have taken place in the oils, with the exception of tung oil. This sample was from an unknown source and may have been adulterated.

THE INSTITUTE OF INDUSTRIAL RESEARCH
WASHINGTON, D. C.

WIRE CLOTH AND ITS ADAPTABILITY TO THE CHEMICAL INDUSTRY

By ALVIN ALLEN CAMPBELL

Received June 11, 1919

Under the heading of wire cloth there may be numbered over ten thousand different meshes, sizes, and grades. The term wire cloth even to the mind of large users is hardly appreciated to its full extent.

The wire cloth industry was started in Scotland many years ago, and the first plant in the United States was started at Belleville, N. J., some 100 years ago,

by some Scotch immigrants. There is still in operation one of the old original hand looms.

In order to give an idea of the possibility of weaving from wire a square mesh, the following comparisons are given: A mesh of $2\frac{1}{2}$ in. \times $2\frac{1}{2}$ in. can be made of as heavy rod as 1 in. diameter and can be made of as light a wire as 0.177 in. There are listed fourteen different sizes of rod and wire in between these two limits. The mesh then gets finer until it reaches 250 meshes to the linear inch, fabricated from a wire 0.0015 in. in diameter. The wide range of differences can readily be seen from the above statement.

In many instances perforated metals are used as backings for tank strainers, centrifuges, filters, malt floors, washers, etc. The heavier grades of wire cloth are fast replacing this material for the reason that the air space is greater in comparison to the area of the screen than that of perforated metal. The term "air space" is the technical term in the wire cloth industry for the opening in the mesh. Wire cloth has the advantage over perforated metals from other viewpoints. It is stocked in a greater variety of metals, and can be used for sizing materials, because of the very great range of openings and their uniformity.

Wire cloth has long been used in the paper industry, and the majority of manufacturers in the United States still confine their efforts to the manufacture of Fourdrinier wires or paper machine cloths. Fourdrinier wires range in mesh from 40 to 90, although some tissue mills use wires as fine as 100 mesh.

The manufacturers of the United States had been rather backward in the fabricating of wire cloths finer than 100 meshes to the inch until about 1912, when some experimental work was started in weaving a piece of 200-mesh cloth for the Edison laboratories. After overcoming many difficulties, a piece of 200-mesh cloth 34 in. \times 100 ft. was completed, using Monel metal wire of a diameter of 0.0021 in. This cloth was later used for filtering wax. From that time on Europe has had American competition.

The United States Bureau of Standards in their investigation of testing screens say that it had been impossible for American manufacturers to successfully manufacture meshes finer than 100 mesh to the inch, and that meshes of the finer nature had to be imported from Germany, France, England and Scotland. While all American manufacturers listed the fine cloths in their catalogues, they were not American-made goods, in fact, there are still foreign-made goods sold on the American market. Probably 80 per cent of all the wire cloth, especially the fine wire cloth imported from Europe, came from Germany, while the other three countries furnished the balance. A great number of the German manufacturers were located in Alsace-Lorraine, which will of course now be rated as French. The finest wire cloth on record is 350 mesh, but early in 1914 a firm in Elberfeld, Germany, started to make 400 mesh. If this was accomplished none of it ever came to this country. The finest square mesh manufactured in

the United States is 250 mesh. All finer is imported material.

All of these fine cloths are confined to a standard, as to size of wire, size of opening, etc. The standard is fixed by the United States Bureau of Standards. American manufacturers do their utmost to keep up this standard and are constantly in touch with the Bureau.

A word as to perfect cloth. If a wire cloth is sold as 200 mesh, it should measure, within the allowance specified by the Bureau of Standards, 200 mesh by 200 mesh, in other words, 200 each way. There are, however, cloths sold on the market as a given number, for instance, as 200 mesh, which may measure 200 one way but the other way may measure 185 to 190 mesh. This to the eye is not noticeable, but in work does not give the desired results. The exporters were very fond of sending fine wire cloth into this country, giving it a number which was mistaken by the American buyer as the mesh. For instance, French and German manufacturers would give the number 200 to a cloth which, when counted, would total only 190 each way, but was bought as 200 mesh. It cannot be said that this was a deliberate fraud, but in a great many cases the exporter would "get away with it."

As an example of the necessity of a cloth being perfect, the following test may be tried: Solder a piece of square mesh 200 \times 200 in the bottom of a funnel and pass some hydrocarbon mixed with a little water through it. The result will be that all of the water will stay on top of the mesh and the hydrocarbon will pass through. If, on the other hand, a piece of mesh 200 \times 180 is used, the water will pass through as readily as the hydrocarbon. The explanation is, that the water has a specific gravity different from that of the hydrocarbon; being heavier and globular in nature, it is held back by the square opening, while the lighter hydrocarbon readily passes through. In the second test, where the mesh is rectangular, the lighter hydrocarbon passes through as readily, while the heavier water, because of its globular nature, elongates and passes through quite as fast.

The user should remember that there is a wire cloth available for each individual use, and that some of the larger manufacturers maintain special testing laboratories in order to assist the user in finding the best mesh for his use.

As before stated, wire cloth covers many meshes, weights, etc., and in addition it can be said that no matter what the trade name may be, if it is a woven wire fabric, it is wire cloth. A few of the trade names follow: Metallic filter cloth, brass lawn-fly screen, metallic bolting cloth, wire gauze, platinum gauze, washer wires, Fourdrinier wires, Dutch cloth, centrifugal liners, wire mesh, etc.

It is well to investigate and know wire cloth to some extent before ordering. There are two different ways of measuring. If an operation calls for a $\frac{1}{4}$ -in. square opening, it would not be correct to order 4-mesh wire cloth, as 4 mesh is made of thirteen different diameters of wire, ranging from 0.135 in. as the heaviest size to 0.028 in. diameter as the lightest size. The term

"mesh" means the number of meshes or openings per linear inch each way, measuring from center to center of wire. In the heaviest 4×4 mesh the opening would measure 0.115 in., whereas in the lightest the opening would measure 0.222 in. In order to get a space of $\frac{1}{4}$ in. the size wire must be specified along with the size opening. For example, a wire cloth made of 0.083 in. wire with an opening of 0.250 in. would be a 3×3 mesh. It is well for users to write the manufacturers for their catalogue giving table of sizes, openings, etc. The choice of sizes increases in the heavier meshes and decreases in the lighter and finer sizes. There is very little difference in the size of opening and diameter of wire in the meshes finer than 100×100 . A difference of 0.0001 in. in the diameter of wire would make a considerable difference in the finished product, both from a manufacturing and working standpoint.

Under the heading of wire cloth, it should be noted that filter cloths and centrifugal linings are fast becoming leaders in the chemical industry. Wire cloth is and may be designed to meet specific purposes. Several patents have been issued on filter cloths, and in each case there have been reasons for their design. The latest patent issued by the United States Patent Office¹ was on a cloth designed to compete with, and overcome the deficiencies found in, other filtering mediums.

The factors influencing efficiency in filtration are rapidity, the life of medium, the cost of filtering the medium, the strength of cloth, the fineness of cloth, and the adaptability of the filter cloth to any make of filter press. It is not the filter cloth which does the filtering; the filter simply acts as a retainer or backing in order that a cake may be formed. This medium must be of a nature to permit the filtrate to pass through rapidly and to retain the precipitate. In pressure filtration the cake really does the work, and the quicker the cake forms the more efficient your filter becomes. However, if the cloth becomes clogged, filtration ends or is much retarded. The cloth described in the above-mentioned patent was designed to overcome the difficulties met with in cloths which must be rolled to get fineness of opening. In rolling a piece of woven wire fabric it is impossible to keep equally sized and uniformly shaped openings, and strength is lost in the rolling of wire cloth. When fine overlapping wires such as occur in wire cloth are rolled, these wires are distorted by crushing between rolls. Strength is then sacrificed in order to get fineness.

This cloth replaces the old type fabric filter cloths, such as jute, hemp, and cotton, being stronger, more readily cleansed, and when made of Monel metal or pure nickel, alkali proof and impervious to weak acid solutions. Monel filter cloths have stood the commercial use of solutions containing from 7 to 10 per cent sulfuric acid. The only case known to the writer where Monel metal did not stand up in commercial use was in a press using cast iron plates and Monel metal filter leaves for the precipitation of

potassium permanganate. In this case the filter leaves rapidly decomposed because of electrolytic action set up.

Microscopic examination of this filtering medium shows an opaque surface, when the cloth is parallel with the table of the microscope. If, however, the cloth be turned at an angle of 45° , small wedge-shaped openings are seen, the idea being to have the contact surface of the filtering medium a practically tight backing for the quick forming of the cake, the wedge-shaped opening permitting a rapid discharge of the filtrate. As stated before, when an opening or mesh decreases to microscopic size, water, because of its globular nature, must elongate in order to pass through it; if, however, the hole be rectangular, it will pass through more readily, and even better if the opening be wedge-shaped. In this weave it is possible to get twice the number of wires beaten up side by side that would be theoretically possible; for example, 250 wires of a diameter of 0.004 in. laid parallel and in contact with each other, would equal one inch of space. Because of the weaving principle employed 500 wires are put in this one inch of space. These wires are spirally overlapped, giving a smooth, opaque, double-surfaced filtering medium, the two sides of which are identical, and the openings in which are wedge-shaped, each one identical as to shape and size. A cloth of this nature is very strong and easily cleaned, with a weight of about 9 ounces to the square foot. This type of wire cloth is being used extensively as lining for centrifugals.

Wire cloth has been one of the most important materials in the chemical industry during the war-time emergency. It has been used extensively in ordnance manufacture; explosives mills, cement, paper, glue, and pottery manufacture; dyestuffs production, drug houses, color works; food production; and last, but not least, ammonia oxidation.¹

NEWARK WIRE CLOTH COMPANY
NEWARK, NEW JERSEY

DETERMINATION OF ANILINE IN DILUTE AQUEOUS SOLUTION

By WALTER G. O. CHRISTIANSEN

Received March 14, 1919

In plants where aniline is produced the chemist in the works laboratory has to determine the aniline content of the water from which the aniline has been separated in the rectifying house in order to ascertain how much aniline is being lost in the water. Some days a dozen samples may be brought in, and if each is to be analyzed by extracting a known weight of the sample with ether, drying the extract, evaporating off the ether in a weighed dish, and weighing the residue, considerable time is lost. It is somewhat shorter and more accurate to add two drops of concentrated hydrochloric acid to the undried ether extract in a weighed dish, evaporate the ether on a steam bath, and dry the residue of aniline hydrochloride in an oven at about 50°C . The residue must not be heated to a high temperature, as it decomposes readily. However, either of these methods takes between 3 and 4 hrs.

¹ U. S. Patent 1,288,504, December 24, 1919.

¹ THIS JOURNAL, 11 (1919), 468, 541.

In attempting to shorten the time factor, a colorimetric method, based on the production of Runge's violet when aniline is treated with a solution of calcium hypochlorite, was investigated. As the work was carried out in a poorly equipped works laboratory, the apparatus used had to be constructed from materials found lying about; this appears as an advantage now, for it taught us that the apparatus costs almost nothing and is available everywhere.

The colorimeter was made by supporting in front of a tungsten lamp a thick cardboard in which two slits $\frac{1}{4}$ in. \times 2 in. had been cut 1 in. apart. Above each slit was a wire loop large enough to support a 16×120 mm. test tube so that the latter hung directly in front of the slit. The test tubes used for the comparisons were 16×120 mm. and all of the same internal diameter; this was determined by putting 20 cc. of water into a number of test tubes of this size, and selecting those in which the water stood at the same height.

As Runge's violet is not a permanent color a set of standard colors had to be prepared, each of which would correspond to the color produced by a certain concentration of aniline in water. In eight of the selected test tubes were put 5 cc. of aqueous solutions of aniline containing, respectively, 0.5, 0.4, 0.35, 0.3, 0.25, 0.2, 0.15 and 0.1 per cent of aniline. To each tube 1 drop of dilute sodium hydroxide, 3 drops of saturated aqueous phenol solution, and 4 cc. of fresh saturated filtered bleaching powder solution were added. After shaking, the tubes were allowed to stand for $\frac{1}{2}$ hr., each sample was diluted with 50 cc. of water, and the tubes half filled with the diluted solutions. Permanent colors corresponding to the colors resulting from these solutions of known concentration were prepared as follows: A tube containing one of the above tests was hung in front of one slit and another of the selected test tubes containing 15 cc. of water was hung in front of the other. To the water, red and blue ink and powdered C. P. calcium carbonate were added until the depth and opacity of the Runge's violet were exactly matched. This was done for each of the above samples, and a set of permanent colors was secured corresponding to the above eight concentrations of aniline. The inks used were Stafford's Commercial Bright Blue and Carter's Carmine Red Non-copying Ink, the latter was diluted with an equal volume of water before use.

To determine the concentration of aniline in an unknown aqueous solution, take 5 cc. in one of the selected test tubes, add 1 drop of dilute sodium hydroxide solution, 3 drops saturated aqueous solution of phenol, and 4 cc. of fresh bleaching powder solution. After letting stand $\frac{1}{2}$ hr. dilute with 50 cc. of water, and compare a sample of the diluted solution with the standard colors in front of the electric light. If the resulting color is deeper than the darkest standard solution, 5 cc. of the unknown solution is diluted with an equal volume of water, and this diluted sample is tested as above and the per cent obtained multiplied by two.

Anybody intending to use this method of analysis ought to make his own standard colors, following the method outlined above. Below is a table showing how much ink was used in making up the standards in my work.

Per cent of Aniline	15 cc. of Water plus		CaCO ₃ ¹
	Blue Ink ¹ Drops	Red Ink ¹ Drops	
0.5	3 $\frac{1}{2}$	30	...
0.4	2	18	...
0.35	1 $\frac{1}{2}$	11	...
0.3	1	6 $\frac{1}{2}$	...
0.25	0	6 $\frac{1}{2}$	...
0.2	0	4 $\frac{1}{2}$	...
0.15	0	3 $\frac{1}{2}$	...
0.1	0	3	...

¹ One drop of the blue ink = 0.0545 g.

² One drop of the diluted red ink = 0.0541 g.

³ I did not weigh the CaCO₃ added to secure the required opacity.

PRECAUTIONS—To secure the correct color the bleaching powder solution must be fresh and saturated. The tubes of standard colors must be shaken before using.

ADVANTAGES—This method is rapid (a dozen samples can be analyzed in an hour), is easy, and accurate enough for plant control work.

The following are check analyses run on samples of aniline water from an aniline rectifying house:

Colorimetric Method Per cent	Aniline Hydrochloride Method Per cent
0.30	0.32
0.35	0.39
0.35	0.38
0.76	0.84
0.07	0.08
0.08	0.09
0.70	0.69

419 MAGEE AVENUE
ROCHESTER, NEW YORK

AN IMPROVEMENT IN CASEIN MAKING¹

By J. L. SAMMIS

Received April 9, 1919

Large amounts of casein are now used in the manufacture of water-proof glue for aeroplanes and other purposes. Lack of uniformity in casein as it comes from the creamery has been found to cause irregularities in the finished glue, or to necessitate variations in the glue-making process, which it is desirable to avoid if possible.

In July 1918 a request was received by this department from the Forest Products Laboratory, Madison, Wisconsin, that aid be given by the Dairy Department of the University so far as facilities would permit, in the study of these casein problems.

THE FAULTS TO BE OVERCOME AND THEIR CAUSE

Variations in ash and acid contents in the dried casein appear to be the main causes of trouble in casein for glue making. The high acid and ash contents of many commercial caseins appear to be due to use of excessive quantities of acid or to insufficient pressing or washing of the curd before drying. The older methods of precipitation were such as to make thorough washing difficult. The curdling temperature commonly used (120–130° F.) was so high that the precipitated curd quickly gathered into large masses

¹ Published by permission of the Director, Wisconsin Agricultural Experiment Station.

having the consistency of dough through which wash water could not be made to penetrate with any ordinary amount of manipulation.

Our first experiments were directed to find a method of treating the curd thus made, so that the wash water could readily penetrate it. For this purpose the precipitated curd was run through a grinder placed under water in the precipitating vat. This method of operation proved quite successful in reducing the impurities in the product, but the inconvenience and cost of putting the entire curd through an extra grinding led to a search for modified methods of precipitation which would permit thorough washing without the necessity of grinding the curd under water.

APPLICATION OF WELL-KNOWN PRINCIPLES TO PROBLEM

1—It was pointed out in 1907 in the 24th Annual Report of the Wisconsin Station, pp. 188-189, that milk can be curdled at different temperatures by slightly different proportions of acid.

2—Curd formed at low temperatures is fine grained, and has little or no tendency toward flocculation, but precipitated at a moderately high temperature, the curd collects in larger or smaller flocculent lumps, and at yet higher temperatures, at or above 125°, it forms large doughy masses, sometimes melting or softening to the consistency of a thick syrup due to the heat.

In view of these well-known facts about casein, it appears necessary only to select suitable temperature and other conditions of precipitation in order that the curd when formed may be slightly coherent so as not to be readily lost through the strainer in the form of a fine powder, but yet sufficiently loose and open so that wash water can readily penetrate it for the removal of acid and ash.

Some printed directions such as were formerly issued by casein buyers for the guidance of casein makers are reprinted here for reference by the reader.

DIRECTIONS FOR MAKING COOKED CURD CASEIN

All that is necessary for making cooked curd is a metal or wooden vat to hold the milk which is heated by turning live steam directly into it. This vat should have not less than 1/4 in. steam pipe to heat the milk and a water pipe so as to run cold water on the curd. You would also need an ordinary wooden hay rake to stir the milk while you are curdling it.

For each thousand pounds of milk contained in the vat, measure out one pint of sulfuric acid. Dilute the acid by adding it to double the amount of water. (Always add acid to water, never water to acid.)

Heat the skim milk to about 130° by turning steam directly into it.

When the milk is at the proper temperature, add the acid throughout the milk, stirring it as fast as possible with an ordinary rake.

When the curd has separated, drain off the whey, rinsing the curd by throwing several buckets of water over it.

Cover the curd in the vat with one or two inches of water.

Heat the water to 170° by turning steam directly into it.

When heated, stir the curd in the warm water several times, then draw off the water, after which turn the curd over several times with a shovel until it has matted together and is thoroughly drained.

Place in bags or barrels while warm and ship to the buyer.

Some other published directions call for the addition of an extra amount of acid after the coagulation is complete.

BUREAU OF AIRCRAFT PRODUCTION SPECIFICATIONS

Specifications No. 14018A of the Bureau of Aircraft Production, U. S. A., for casein intended for casein glue making, include the following:

MATERIAL—The casein shall be made of straight skim milk of low fat content, and shall be free from starch, dirt, and other foreign material or adulterants.

MANUFACTURE—The casein shall be precipitated by either the lactic acid, sulfuric acid, or hydrochloric acid methods. Casein precipitated by different methods shall not be blended.

The precipitating temperature should be about 120° F. and in no case shall exceed 130° F. Only sufficient acid to secure a clear separation shall be used.

The curd shall be well pressed and dried quickly to prevent molding. With the hydrochloric or sulfuric acid methods of precipitation the cooked curd method is preferred, the temperature of cooking to be about 190-195° F.

FINENESS—The casein must pass entirely through a 50-mesh screen.

ACID—The free¹ acidity shall not exceed the equivalent of 3.0 cc. of N/10 sodium hydroxide per gram of moisture-free casein.

FAT—The fat shall not exceed 1.5 per cent of the moisture-free casein.

ASH—The ash shall not exceed 3 per cent of the moisture-free casein for natural sour, and 4.5 per cent for sulfuric acid or hydrochloric acid caseins.

MOISTURE—The moisture content of the casein shall not exceed 8 per cent.

NITROGEN—The nitrogen content shall not be less than 14.25 per cent on a moisture-, fat-, and ash-free basis.

EXPERIMENTAL

I. EFFECT OF USING A LARGE EXCESS OF ACID IN CURDLING MILK—Two 10-lb. lots of skim milk in separate pails at 125° were curdled by adding, respectively, 25 cc. and 50 cc. of dilute (1:5) sulfuric acid. After the two lots of curd had been stirred 5 min., the whey was decanted, and the curd washed 10 min. with 4 lbs. of water in each pail at 125° F. The curds were then drained, cooled, and pressed in cloth bags. The 25 cc. curd was gummy in the whey, while the other was loose and flocculent in the whey. Addition of a larger proportion of acid to the milk than is actually necessary to cause coagulation tends to make the curd loosely flocculent, and prevent it from becoming doughy and gummy. This has been noted repeatedly.

However, the use of a larger proportion of acid simply to secure a loose curd, would seem to be an expensive way of accomplishing this result.

Two other effects of using larger proportions of acid are (1) the acid content of the finished casein is increased, and (2) the ash content of the finished casein is decreased as shown in Table I.

TABLE I—EXCESS ACID REDUCES ASH AND INCREASES ACIDITY OF CASEIN

EXPT. No.	Amount of Acid Used, Cc.	Ash in Dry Casein, Per cent	Total Acidity of Dry Casein, Cc.
6.1	25	4.87	9.2
6.2	50	2.85	15.2

¹ 3 cc. free acidity + 8.9 cc. casein acidity = 11.9 cc. total acidity.

In so far as an excess of acid reduces the ash content, and tends to make the curd loose, instead of compact and gummy, it is an advantage, but in so far as it increases the cost and the acidity of the finished casein, it is a disadvantage. As the percentage of ash is within the standard limit in both cases, a minimum amount of acid appears satisfactory for casein making.

II. EFFECT OF VARIOUS TEMPERATURES OF PRECIPITATION—Four 10-lb. lots of skim milk in pails at 80°, 90°, 100°, and 110° F. were curdled by adding dilute sulfuric acid slowly from a graduate. The physical properties of the curd thus formed without excess of acid were observed with reference to ease of washing and draining at these temperatures. Formed at 80° F., the curd was fine grained, settled slowly, and did not tend to collect in lumps. At 90° F. the curd grains showed a slight tendency to flocculate into small lumps. Neither of these two curds settled rapidly so as to be readily drained and washed. The curd formed at 100° F. was slightly gummy and coherent, flocculating to a sufficient degree so that it settled readily, and drained easily without loss, and could be washed without difficulty. The curd formed at 110° was quite gummy and collected rapidly into large lumps of such coherence that it was impossible to wash the curd inside the lumps.

The results of the 90° experiment and the 100° experiment indicated that the most suitable temperature lay between these figures. After a number of trials, 95° was selected as the proper temperature for precipitation, giving curd of suitable texture for most convenient draining and washing. A number of experiments were made which confirmed this choice.

III. EFFECT OF ADDING ACID SLOWLY OR RAPIDLY—Using 10 lbs. of skim milk in a pail, and adding acid slowly from a graduate, while stirring vigorously, the smallest amount of dilute acid which would cause clear coagulation was determined. With 10 lbs. of the same milk in other pails, but adding the same quantity of acid at one instant, it was often found that the milk was not fully coagulated, but that the curd was surrounded by milky whey. This experiment, repeated several times, indicated the desirability of adding acid slowly in making casein, while mixing the milk by vigorous stirring. When all the acid is added at once, mechanical inclusion of part of the acid in the curd first formed may deprive the last portion of the whey of the quantity of acid necessary to make it clear, unless an excess of acid is used.

SUGGESTIONS FOR AN IMPROVED METHOD OF MAKING CASEIN

The plan adopted as a result of our experiments is to heat skim milk to about 95°, stir vigorously while adding dilute acid slowly until a clear whey is obtained, avoiding excess of acid. The curd obtained at this temperature is just coarse and coherent enough to settle rapidly and permit draining the whey, but sufficiently loose and open to permit ready washing with water, with a minimum expenditure of labor and time.

After settling in the whey for a minute or two, the curd is pushed away from the gate with a rake, and the whey is drawn out through a strainer. Water at 95° equal to one-quarter the volume of the milk used is added to the curd, and after a few minutes' stirring the water is drained out and the curd put to press in the usual manner. Thorough pressing to remove as much water as possible is recommended.

It has not seemed necessary or desirable to use a test for the acidity of the skim milk employed for casein making, or to prepare a table showing the amounts of acid required, as this will vary with the acidity of the skim milk to start with, and other conditions, such as the temperature of precipitation.

Trials of the method described above have been made as follows, with entirely satisfactory results.

CASEIN 14—1900 lbs. of skim milk of 0.16 per cent acidity were heated to 95° in the vat. Dilute sulfuric acid (1 : 5) was poured in a small stream while stirring the milk vigorously with a wooden rake. No more acid was added than was necessary to produce clear whey. The 4.6 lbs. of concentrated sulfuric acid diluted in 20 lbs. of water required 3½ min. for its addition to the milk in the manner described.

The acidity of the clear whey was 0.37 per cent by the acidimeter. This is stated here as a matter of record, but the use of the acidimeter is not required in practice. The curd was pushed away from the gate and the whey was drawn out without clogging the strainer in the least. Sample 14.1 was then taken from the curd, and pressed in a cloth bag without any washing.

The curd in the vat was washed by adding water at 95° F. equal to one-quarter of the volume of the milk used. After vigorously stirring up the entire mass of curd in the wash water with the teeth of the rake turned downward, the wash water was drawn out through the strainer. A sample of the curd was taken and marked 14.2. Another sample of the curd was taken and given a third washing in a pail with water at 95° F., and this was then drained and pressed, and marked 14.3. The main bulk of the twice-washed curd was pressed as dry as possible, milled, and dried in a commercial sized casein dryer recently installed in the Dairy Building. Caseins 16 and 17 were made by the same method as described above.

The analyses of the products are given below, showing that they come well within the standard limits of ash and acidity.

TABLE II—ANALYSIS OF CASEINS MADE BY NEW METHOD

No.	Moisture-free substance Ash Per cent	Acid Cc.	Moisture Per cent
14.1	2.80	9.6	5.65
14.2	2.28	9.5	5.48
14.3	1.98	9.4	6.17
16.2	2.36	8.6	5.12
17.2	2.80	8.33	5.74

Casein 14.2 gave excellent results when used for making water-resistant glue according to three formulas at the Forest Products Laboratory.

The chemical analysis of about thirty-five samples of experimental casein for ash, acid, moisture, and in some cases nitrogen, as well as the glue-making tests were made by the Forest Products Laboratory, U. S.

Department of Agriculture, at Madison, Wisconsin, for which acknowledgments are due.

The card of directions for making casein reprinted above may be revised as follows:

REVISED DIRECTIONS FOR MAKING CASEIN

A metal or wooden vat is needed to hold the skim milk which is heated by turning steam directly into it. This vat should have not less than $\frac{3}{4}$ in. steam pipe. Some arrangement for heating the water to be used in washing the casein should be provided. An ordinary wooden hay rake is used to stir the milk while curdling it.

For each 1000 lbs. of milk in the vat, measure out one pint of sulfuric acid. (Muriatic acid may be used with equal success.) Sulfuric acid when used must first be diluted by adding it to double the amount of water. (Always acid to water, never water to acid.)

Heat the skim milk to 95° F.

Add the acid in a small stream or streams to the milk while stirring the latter as vigorously as possible with one or more rakes. Use no more acid than necessary to obtain clear whey.

When fully curdled, let the curd settle for a few minutes, then push it slowly with the rake away from the gate toward the upper end of the vat. Put in the strainer and draw out the whey. Have ready in cans, water at 95° F. equal in weight to one-fourth of the milk used. Add this at once to the curd in the vat and stir up thoroughly with the rake, teeth down, so as to break up all lumps and wash every particle of curd.

Draw off the wash water, and press the curd as thoroughly as possible, if pressed curd is to be made for immediate drying.

If cooked curd is to be made, cover the washed and drained curd with hot water and run in steam to heat it to 180–190° F., until the curd unites into a single large mass which can be shoveled into barrels or boxes for shipment.

SUMMARY

In this paper, it is shown that by modification of the former factory process as to temperature, washing, etc., casein can be uniformly obtained which is suitable for making water-resistant glue.

MADISON, WISCONSIN

SOME NOTES ON PAINT ANALYSIS

By GEORGE J. HOUGH

Received May 9, 1919

The methods described in this paper were devised by the writer to meet particular cases occurring in the course of regular work on the testing of paint supplies; and it is hoped that they may prove useful to those engaged in paint analysis who may have to deal with similar problems. Of course it is understood that with mixed paints, the paint vehicle must be extracted, and the pigment dried, before they can be analyzed.

DETERMINATION OF CUPROUS COPPER IN COPPER PAINTS

This method was devised for ship-bottom paints specified to contain a certain amount of copper in the form of cuprous oxide. The method is as follows:

To 0.5 g. of sample add 10 cc. of concentrated hydrochloric acid, stir well, heat gently for several minutes to dissolve all copper, dilute with cold water to about 200 cc., add 5 cc. of phosphoric acid, and titrate at once by potassium permanganate. The results are good except when the sample contains much unextracted matter, which causes a slight error in the titration.

EXAMPLES—(1) 0.5 g. of sample required 12.8 cc. of permanganate, equal to 28.8 per cent copper. (The same sample titrated one year later gave the same result.) Taking 0.5 g. of the same sample, separating the copper as copper sulfocyanate (CuCNS), and determining it by titration of the sulfocyanic acid gave 28.9 per cent copper.

(2) In another sample the cuprous copper titrated by permanganate was found to be 24.5 per cent. In the same sample, the copper separated by aluminum and determined by the iodide method was found to be 24.8 per cent

To prove the accuracy of this method for commercial purposes, a sample of dry commercial cuprous oxide was taken, and 0.5 g. samples were dissolved and titrated as above; 0.5 g. of pigment used 27.3 cc. of permanganate with a value of 10 mg. iron per cc. equal to 11.66 mg. copper, showing the copper content to be 63.6 per cent; 2 more duplicate tests gave the same result. It will be noted that the factor 1.166 is used, instead of the theoretical factor 1.125, to change the iron value of the permanganate to the copper value; this factor was found by standardizing the permanganate against a carefully prepared sample of cuprous oxide.

Then samples of 0.2 g. were each treated with a solution of silver sulfate made by dissolving 1.3 g. of silver nitrate in 100 cc. of water and adding 10 cc. of concentrated sulfuric acid; the tests were made with cold solutions, and were allowed to stand for 1 hr. with occasional stirring; they were then filtered and washed, and the metallic silver that had been reduced by reaction with the cuprous copper was dissolved in nitric acid, and the silver titrated by Volhard's method, using a standard solution of ammonium sulfocyanide. In the reaction between cuprous copper and silver sulfate, one part of silver is reduced by one part of cuprous copper. The results of 4 determinations were, 63.85 per cent, 63.55 per cent, 63.85 per cent, 63.55 per cent of copper; this proves that the method is within allowable limits for commercial work. This test with a solution of silver sulfate cannot be made on an extracted pigment, as it is almost impossible to free the sample from oil and organic matter, which interferes seriously with the reaction between the copper and silver.

A RAPID METHOD FOR LIME IN WHITE LEAD

It is sometimes desirable to test white lead for lime, especially in putties, to ascertain how much lime has been added in the form of whiting. The following method depends on the solution of the white lead in a hot dilute solution of caustic soda, and it is removed by filtration from the insoluble whiting:

To 0.5–1.0 g. of sample add 50 cc. of 5 per cent caustic soda and heat to boiling for several minutes, decant on filter, add a little more caustic soda and then hot water, and decant; wash well by decantation with hot water and wash filter about four times; dissolve the residue in hot hydrochloric acid (1 : 2), dilute, neutralize with ammonia (filter off any lead precipitate), boil, and precipitate lime with a saturated

solution of ammonium oxalate; determine lime by titration with permanganate, or as desired.

When much lead is present (more than 50 per cent of the sample), boil a second time or even a third time with caustic soda. If the residue is well washed, no lead will remain with the lime.

EXAMPLES—(1) 0.5 g. of white lead and 0.5 g. of whiting (CaO present, 54.3 per cent) gave 54.2 per cent CaO.

(2) 0.1 g. of white lead and 0.5 g. of whiting (same amount of CaO as above) gave 54.2 per cent CaO.

(3) 0.8 g. of white lead and 0.2 g. of whiting (CaO present, 10.8 per cent) gave 10.3 per cent CaO.

(4) 0.9 g. of white lead and 0.1 g. of whiting (CaO present, 5.4 per cent) gave 5.6 per cent CaO.

CHROMIUM IN MIXED PIGMENTS

Much trouble is experienced in detecting small amounts of chromium in mixed pigments where chrome yellow has been used to slightly modify an olive or drab shade of color. The following test is quickly and easily made, and gives good results:

Treat the pigment with a few cubic centimeters of dilute nitric acid (1 : 5), stir well, let stand a minute or two, filter, and to the filtrate add a few cubic centimeters of hydrogen peroxide. A purple color indicates chromium, the chromic acid being oxidized to perchromic acid by the hydrogen peroxide. The color is not permanent and soon fades out, especially with small amounts of chromium. This test shows the presence of a very minute quantity of chromium, and it works equally well with chrome green pigments; but for the reaction to proceed successfully, the chromium must be present as chromic acid, and the solution must not be heated.

IMPROVED METHOD FOR CHROMIUM IN CHROME YELLOW

Dissolve 0.5 g. of sample in 15 cc. of 20 per cent caustic soda, warming until dissolved, dilute to about 200 cc. with cold water, add 2 g. of ferrous ammonium sulfate (previously dissolved in a little water), stir well, let stand a few minutes, acidulate strongly with dilute sulfuric acid, dilute cold to nearly 400 cc., and titrate by permanganate.

EXAMPLES—(1) 0.5 g. portions of chrome yellow used; titer of the permanganate was 10 mg. iron per cc.

Found 29.5 per cent, 29.6 per cent, 29.5 per cent, 29.6 per cent CrO_3 .

Same sample titrated by potassium dichromate gave 29.6 per cent, 29.5 per cent CrO_3 .

Same sample by the old standard method (treatment with ferrous ammonium sulfate) gave 28.9 per cent and 29.0 per cent CrO_3 .

EXAMPLE	NEW METHOD		OLD METHOD	
	Per cent		Per cent	
2.....	26.8		26.3	
3.....	19.0		18.8	
4.....	28.8		28.4	
5.....	17.4		16.3	

This method is better than the old standard method using hydrochloric acid to dissolve the chrome, as some chromes are partly insoluble in acid, but readily decomposed by the caustic soda as in Test 5 above.

PREPARATION OF STARCH INDICATOR

Finally, I wish to call attention to a very convenient way of preparing starch indicator, which I devised several years ago. It depends on the well-known fact that starch is soluble in a dilute solution of salicylic acid. Indicator thus prepared keeps indefinitely; a solution put away in a well-corked bottle in a dark cupboard and kept for 2 yrs. was found at the end of that time to be unaltered and as good as when first made up.

METHOD—Dissolve 1 g. of salicylic acid in 100 cc. of distilled water, boil, pour into it 1 g. of potato starch mixed with a little water, boil gently till starch has dissolved, let cool somewhat, and then dilute with cold distilled water to 1 liter. This solution is clear and transparent, and gives a fine, deep blue color with iodine.

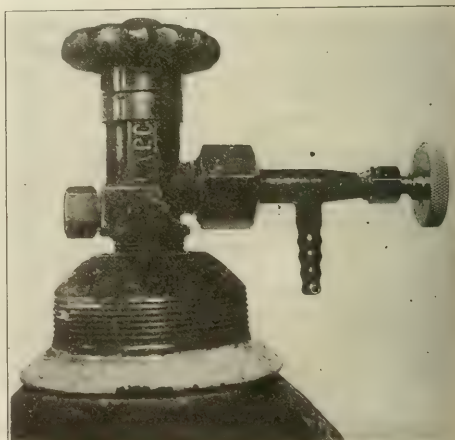
BUREAU OF SOILS
U. S. DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

A NEEDLE VALVE WITH DELICATE ADJUSTMENT FOR HIGH PRESSURE GASES

By S. W. PARR

Received May 23, 1919

Oxygen on tap is an essential feature of every present-day laboratory but the ordinary valve for opening and closing the steel cylinders is an unwieldy affair. Moreover, a standard connection interchangeable with all



cylinders by a ground metal joint was found to be a necessary feature in the designing of a calorimeter outfit of the oxygen bomb type. By slightly modifying the valve thus designed it has been made available for service under all conditions. The essential feature aside from the metal joint and lock-nut attachment is the possibility of definite control to the extent that by operation of the needle valve alone the gas may be taken directly from the cylinder to a com-

bustion train. Adjustment of the current of gas may easily be made to the ordinary speed where the bubbles passing an absorption bulb may readily be counted. The illustration shows the device as supplied for the purpose indicated.

DEPARTMENT OF CHEMISTRY
UNIVERSITY OF ILLINOIS
URBANA, ILLINOIS

NOTES ON SODIUM PRUSSATE

By LOUIS S. POTSCHMAYER

Received February 3, 1919

Since the war has made us dependent upon our own resources it has become necessary to foster many chemical industries.

In 1917 the writer had the opportunity of studying and correcting the production of sodium prussiate from gas mass. The process presented below is new primarily in the following parts:

- 1—Recovery of tar and sulfur
- 2—Separate treatment of fine and coarse material
- 3—Direct causticization

The outline is presented for the benefit of those who have not had these thoughts presented to them and as a suggestion for further experimental work.

When the German supply of prussiate was cut off from the manufacturers of blues they were forced to look to the local markets. The supply in that field was very limited and measures were at once taken to assist the blue manufacturers. Some gas plants had already begun the manufacture of sodium prussiate, and those which had not and had no intention of entering that field were only too glad to cooperate with the color makers by supplying gas mass. This latter material, which for years had been a drug on the market, had at last come into its own. A material heretofore fit for the dump heaps had suddenly risen from \$5.00 to \$10.00 per ton, dependent upon location. It was therefore only natural that the gas producers should cooperate with the color makers, and that the sodium prussiate market should boom.

Gas mass, composed of hydrated iron oxide so spread through wood chips as to allow of the free passage of gas in scrubbers, accumulates various chemicals, of which the following is a fairly representative list:

Tar	Ammonium salts
Sulfur	Ferro- and ferricyanides
Sulfocyanides	Double ammonium cyanides

The problem before the manufacturer is the separation of these chemicals on a paying basis. The following is a brief report of the recovery processes:

RECOVERY OF TAR AND SULFUR

In all manufacturing processes it is necessary to have a minimum waste, and for this reason it is necessary to remove tar. The removal of sulfur gives the prussiate manufacturer a by-product of value. If the tar is allowed to remain in the mass it will cause the mass to "ball" in a later lixiviating process. Un-

der the original methods of prussiate recovery the sulfur contained in the mass caused a loss due to the formation of sulfocyanides from the ferrocyanides.

Tar and sulfur may be removed in one operation by extraction with a sulfur solvent such as carbon bisulfide. The details of the operation are simple and the time element is of small consequence if the operation is one of a battery. As a result of careful control the sulfur and tar are dissolved in hot carbon disulfide and stored for recovery from the solvent at leisure. When the final extraction is made, the remaining solvent is driven off by blowing the extractor with live steam.

The desulfurized mass remaining in the extractor is of such nature that it would be difficult to extract with water unless separated into fine and coarse material. This may be done by any of the standard methods.

REMOVAL OF WATER-SOLUBLE SULFOCYANIDES AND AMMONIUM SALTS

In the separation mentioned above the fine material will contain about the same percentage of prussiate as will the coarse material.

The extraction of "fines" is hastened by steam boiling with water. The usual countercurrent operation can be used here to good advantage, remembering that after each successive boiling the material must be allowed to deposit from the solution. The liquors obtained here may, in turn, be used for the extraction of the "coarse" material.

The extraction of "coarse" is less hasty in that the washes are made at about 24-hr. intervals, the water being run on from below into false bottom tanks. The wash is drawn off, and may be added with the washes obtained from the "fines."

These washes contain the ammonium and sulfocyanide salts, from which the ammonia may be obtained by causticization and distillation. The ammonia which is driven off may be caught in distilled water and is then ready for market. The remaining sulfocyanide liquors are of value to the producer if they contain over 2 per cent sulfocyanide salts, in which case they are concentrated and recovered.

EXTRACTION OF SODIUM PRUSSATE

There are two good methods for extracting prussiate from "fines" and "coarse," namely,

- (a) By hydrated lime
- (b) By causticization

(a) The hydrated lime method is the older, and either fresh or commercial hydrated lime may be used.

The material is thoroughly mixed with the lime and allowed to stand in open bins for several days. It is then carried to tanks where the calcium salts are extracted, which salts form as a result of the reaction of the lime with the mass together with its resultant heat of reaction. Following the water extraction the solutions are treated with soda ash to precipitate the

calcium⁷ and form soda salts in solution, which are then concentrated in open pans to crystallization gravity. The solutions are then allowed to crystallize, and the crystals are either recrystallized to increase the purity or freed of excess mother liquor by centrifuging.

(b) Direct causticization relieves the plant and reduces the cost by increasing the speed of output. This may be accomplished either by the use of caustic soda or soda ash acting directly on the lixiviated mass. Of course the "fines" are kept separate from the "coarse." In direct causticization the counter-current system may be employed so as to minimize caustic losses and reduce concentration costs.

The "coarse" material remaining after this treatment could be resold to the gas producers as it is practically revived⁸ mass.

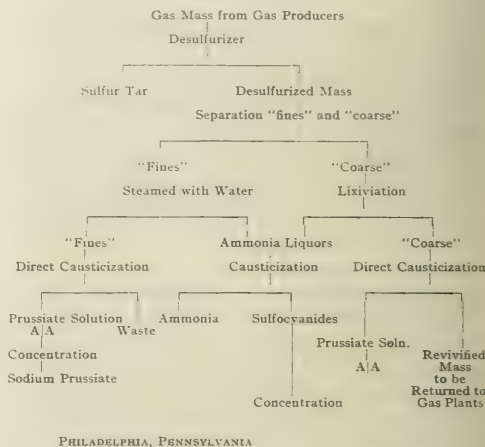
CONCENTRATION AND CRYSTALLIZATION OF SODIUM PRUSSATE

The prussiate liquors obtained above are concentrated either in the old-fashioned open evaporating pans, steam-coil heated, or in vacuum evaporators. In the former case, it is preferable to use steam coils rather than direct heating because of the formation of sodium sulfate, which precipitates out during the concentration. Steam forming under such a precipitation often causes an "explosion," throwing out the hot liquors. From a battery of evaporators the liquors may be run into crystallizers and allowed to

cool slowly. The later prussiate crystals carry sulfates.

SUMMARY

The above is merely intended as an outline of procedure in a manufacturing process strengthened as a result of our war needs. The flow sheet following may serve to make the process more clear.



ADDRESSES AND CONTRIBUTED ARTICLES

THE RELATION OF THE CHEMIST TO THE BRASS INDUSTRY¹

By WILLIAM B. PRICE

At the present time, when the importance of the chemist and a properly equipped laboratory to the average industry is beginning to be appreciated, it may be of interest to outline the growth and development of the Chemistry and Test Department of the Scovill Manufacturing Company for a period of thirteen years.

In the fall of 1902, when the writer first became associated with the Scovill Company he was the only chemist employed.

The work was principally routine in character and consisted of the analysis of brass, bronze, nickel silver, coal, etc., for the casting shops, rolling and wire mills, and did not take in the manufacturing departments.

In September 1915 the laboratory force consisted of twenty-seven and the work had expanded so that the nine lines of work described herewith were carried on.

In August 1917, the Chemistry and Test Department moved to a new laboratory especially designed and equipped to give increased facilities for work along the lines outlined in this paper. Just previous to the time when the armistice was signed, ninety-four people were employed in the laboratory. This force included forty girls who were employed solely on routine brass analyses and two night shifts of ten men each on this same work. The average daily samples totaled about twenty-five hundred, equivalent to at least eight thousand determinations which included analyses of brass, bronze, nickel silver, cupronickel,

steels, oils and greases, copper, spelter, etc., and physical and microscopic tests.

At the present time, May 1919, the laboratory force numbers fifty-nine and the average daily number of samples is about one thousand, equal to three thousand two hundred determinations.

I—GENERAL ROUTINE WORK

A—Complete analyses of brass, bronze, nickel silver, cupronickel, and other alloys from the mills, casting shops, and manufacturing departments.

The number of daily analyses on this class of material averaged thirty-five.

A report was rendered on the same day that the samples were received and the work was done by one man. This rapid analysis was made possible by the simultaneous deposition of the lead and copper on gauze electrodes.

B—Outside samples. This included samples submitted by customers, our New York, Boston, and Chicago Stores, and any new alloys which might be put on the market.

C—Analysis and control of the pickle tubs in the rolling and wire mills. Weekly determinations of the free sulfuric acid in the pickle was made, and the pickling of the metal was under the supervision of a chemist, whose duty it was to see that the proper amounts of oil of vitriol were added and a proper temperature maintained. This procedure has resulted in a large reduction in the amount of acid formerly used and has cut down the time required to pickle the metal.

D—Analysis of raw materials such as zinc, copper, nickel, manganese, phosphor-copper, tin, lead, antimony, coal, etc.

¹ Address before the New York Section of the Society of Chemical Industry, May 23, 1919.



FIG. 1—LABORATORY

E—Analysis of steels, greases, oils, lacquers, paints, acids, and chemicals used by the manufacturing departments.

F—Analysis and control of plating and finishing solutions and dips in the plating room.

One chemist was stationed in the plating room, whose duty it was to analyze all copper, brass, and nickel plating solutions, dips, coloring solutions, cleaning solutions, and make a weekly report expressing the results in ounces per gallon. He was also expected to see that all anode and cathode connections were kept clean, figure out the necessary chemicals to be added, and find substitutes for materials not available or too high priced on account of the war.

II—CONTROL AND ANALYSIS OF SUPPLIES FOR THE PLANT

Under this head comes the drawing up of specifications for the purchase of materials to be used throughout the plant, and co-operation with the purchasing and requisition departments to see that shipments conformed to the specifications.

In making a specification it has always been our aim that it should represent in its final form the result of coöperation between the producer and consumer. In 1915 we had about a hundred specifications.

Below is given a list of some forty-six which we consider to be among the most important, together with the form of specification used.

Aqua Ammonia
Sulfuric Acid
Amyl Acetate

Benzine
Sodium Bichromate

Copper Carbonate
Gasoline
Glycerin
Wool Grease

Kerosene

Double Nickel Salts
Shot Nickel

No. 2 Lard Oil
Unfiltered Cylinder Oil
Crude Cotton Seed Oil
Refined Cotton Seed Oil

Light-Pressed Fish Oil

Black Oil
28° Paraffine Oil
Turpentine
Tetrachlorethane
Acidless Tallow

Rapeseed Oil
Red Engine and Machine Oil
Linseed Oil
Corn or Maize Oil (Crude)
Corn or Maize oil (Refined)

Air Compressor Oil
Fusel Oil
Beta Pitch
Chilled Cast Iron Rolls

Spelter

Tallow Stearin
Cotton Seed Stearin
Caustic Soda
Pure Orange Shellac
Refined Bleached Bone-dry Shellac
Sodium Silicate

Tack Steel

A. S. T. M. Standard for Steel Castings

A. S. T. M. Standard for Cold-Drawn Steel

Steel Strip for Cartridge Chargers
Platers Compound or Soap
Carbon Tetrachloride
Turmeric
Lead Oxide, Yellow (Litharge)



FIG 2 OFFICE



FIG 3 LIBRARY

THE SCOVILL MANUFACTURING COMPANY
Waterbury, Conn.

Specification No. 46. Issued December 1, 1915.

PRIME SULFURIC ACID 66° (Oil of Vitriol).

Material—This specification calls for pure sulfuric acid.

General Requirements—(1) It shall have a gravity Baumé of 66°.

(2) It shall contain not less than 91.19 per cent sulfuric acid.



FIG. 4—METALLURGY DEPARTMENT

NOTE—According to the latest tables of equivalents approved and published as standard by the Manufacturing Chemists Association of the United States, 66° oil of vitriol contains 93.19 per cent sulfuric acid, and an allowance of 2 per cent under this is allowed.

- (3) It shall be free from selenium.
- (4) It shall contain no more than a trace of arsenic.
- (5) It shall be free from chlorides or hydrochloric acid.

Information to Manufacturers and Dealers—Prices and all quotations to be per 100 lbs. in tank cars, delivered f. o. b. cars, Dublin Street Station, Waterbury, Conn. Terms 30 days, or less 1 per cent for cash in 10 days from date of invoice.

Each tank car shall be accompanied by invoice giving the gross and net weights of the acid. When received, all shipments will be promptly weighed and a reduction will be made in final settlement for all deficiency in net weight as compared with the net weight charged in the bill, provided this deficiency exceeds 1 per cent. Parties failing to send invoice giving gross and net weights on their tank cars must accept Scovill Manufacturing Company's weights without question.

Firms desiring to bid on these specifications must, if requested, submit to the Scovill Manufacturing Company, Waterbury, Conn., a gallon sample of the acid which they propose to furnish, this sample to be kept as a standard and shipments must in no important respect differ from sample.

When a shipment is received, a sample will be taken from the bottom, middle, and top of tank and the mixed sample will constitute sample taken for analysis. This sample will be examined according to the above requirements and the shipment accepted or rejected on these tests.

Terms of Rejection and Replacement—All condemned material will be returned to the manufacturer or dealer for full credit at price charged, f. o. b. point of delivery specified by the purchaser.

If the material is to be replaced, a new order will be entered at prices, terms, and conditions acceptable to the purchaser.

Remarks—All specifications for prime sulfuric acid 66°, previously issued, are hereby cancelled.

The purchase of goods under specifications and chemical supervision insures pure chemicals and materials and has resulted in a large annual saving.

III—CALIBRATION OF PYROMETERS AND THERMOMETERS THROUGHOUT THE PLANT

All pyrometers used in the annealing or heat treatment of metals and the control of different operations requiring an accurate temperature were calibrated against a standard pyrometer certified by the Bureau of Standards.

Pyrometers were brought to the Chemistry and Test Department on the 15th of every month for calibration.

Thermometers were calibrated on the first of every month against a certified Bureau of Standards thermometer, and any errors noted on the monthly report.

Pyrometers were also adjusted and repaired in cases where they were not so badly damaged that it was necessary to send them back to the maker.

IV—PHYSICAL TESTING

Tensile strength, elastic limit, elongation, reduction of area, compression and transverse tests are made on brass, bronze, steel, and cast iron.

All building materials, such as cement, cast-iron floor plates, bolts, etc., raw and finished materials, either purchased or sold on physical test specifications were tested to see if they were up to requirements.

V—COMPOUNDING OF OILS AND GREASES AND BUFFING COMPOSITION

In 1910 we started to mix our own oils and greases. At the end of 1915 we were successfully compounding the following oils, greases, cutting solutions, etc.: Belt dressing, cup greases, cutting compounds for automatic screw machines for both steel and brass; cutting and drawing compounds for shell work; high and low pressure cylinder oils; gear grease; typewriter oil; lantern oil for watchmen's lanterns; metal oil used on the metal when rolling brass, nickel silver, etc.; mould oil for dressing the iron moulds in which the brass, bronze, nickel silver, and other metals are cast; tool hardening and tempering oils.

In addition to the above we have substituted for high-priced engine oil, a lubricating oil for half the price that goes farther and give better lubrication.



FIG. 5—MICROSCOPE

This oil is also used for lubricating light shafting, counter shafts, and light jack shafts, motors, and high speed machines. One or two examples will give an idea of the possible saving:

Formerly we purchased a well-known brand of high pressure cylinder oil for which we paid 54 cents a gallon. Compounding this oil ourselves it cost 15 cents a gallon.

Mould oil that we paid anywhere from 50 cents to \$1.00 a gallon for, we made for 12 cents.

The first year that we started compounding our own oils we saved fifteen thousand dollars (\$15,000).

This large saving was made possible, not only by compounding but by the fact that we purchased our base and mixing oils in tank car lots.

After ascertaining the composition of the different oils we were buying, it required considerable research to find out the proper base oils to use and how to compound them with the necessary ingredients.

Since 1912 we have been manufacturing our buffing compositions. Below are given the different kinds together with the amounts of each made during the year of 1915.

No. 30 Cut & Color Composition, X and XX size cakes, 133,000 lbs.

No. 30 Special Cut & Color Composition, X and XX size cakes, 69,000 lbs.

S. O. B. Composition for producing old brass finish, 2,060 lbs.

3 B. F. Color Composition, 15,000 lbs.

This gives a total of 219,060 lbs., or nearly 110 tons, of which the greater proportion (100 tons) consisted of cut and color composition.

When we first started experiments to ascertain whether we could make our own composition cheaper than we could purchase in the open market, we were paying \$2.98 per hundred pounds, f. o. b. Waterbury.

Considering the relatively high price of raw materials, such as stearic acid, tripoli, petroleum grease, etc., this did not give us much leeway.

At this time we were experiencing considerable trouble in procuring properly seasoned composition, so the advantage of making the composition under our own supervision and of being able to give it the proper seasoning outweighed a possible slight increase in price.



FIG. 6—DARK HOUSE, PHOTOGRAPHY DEPARTMENT

After six months' experimenting we were able to produce a composition equal to the one we were buying, at practically the same price.

Our experience had demonstrated the fact that the duplication of the composition from the analysis of the material we were purchasing was the simplest part of the research and that we could not produce a cheaper composition until we had procured the proper machinery and were able to buy the raw material in carload lots on the same basis as the manufacturers of buffing composition.

It required another 6 months to accumulate the necessary data and with this in hand we made rapid progress, until finally we were able to make a better composition for nearly a cent a pound cheaper than we could buy it.

This, together with the saving on the other compositions, amounted to a saving of over \$4,000 per annum.

The manufacture of the oils, greases, and buffing compounds was done under laboratory supervision, which includes the analysis of the raw and finished products and practical testing before sending out the finished articles.

VI—METALLURGY AND METALLOGRAPHY

A—Included visual examination of chilled cast rolls upon arrival by means of a small portable micrometallograph, and the grading and marking of the rolls as follows: O. K. F. for

finishing, O. K. B. for breaking down, and O. K. R. for running down.



FIG. 7—FURNACE ROOM

Every broken roll was examined, the depth of chill noted, photograph taken, analysis and photomicrograph made. Reports containing all this data are sent to the roll manufacturer and his cooperation and inspection has resulted in a great reduction in the number of broken rolls.

Finishing rolls that were taken out of their housings for defects, such as holes, were inspected and a report made as to whether they should be scrapped or placed in the racks for future use in breaking or running down; or whether or not it would pay to have them redressed.

B—Articles submitted by the mills and manufacturing departments were examined under the microscope, photomicrographs taken, and by this means it was possible to tell whether the metal had been properly annealed, rolled, or drawn.

Much valuable information was gained in this way which could not be detected by chemical analysis. When a customer sent in metal and desired to have it matched as to temper as well as chemical composition, the metal was examined under the microscope, the crystal count taken, and scleroscope tests made.

By a proper combination of these methods it was possible to match the temper exactly, and many times one could say with reasonable certainty how competitors rolled and annealed their metal.



FIG. 8—POLISHING ROOM

C—Determinations of the recalcant and decalescent points on steels were taken in cooperation with the Tool and Hardening Department.

By means of this information the proper hardening and tempering temperatures for steel were ascertained.

Steel that had been fractured in service or in hardening was subjected to both microscopic and macroscopic examination to determine the cause of the failure.



FIG. 9—BALANCE ROOM

D—By coöperation with the Hammond Laboratory of Yale University we trained one of our chemists to be a specialist in metallurgy and metallography.

During his course of study he worked upon the standardization of our different mixtures, which included complete physical tests, scleroscope tests, and crystal counts of all our different anneals.

This enabled us to match very closely, as to temper and physical properties, any metal that was submitted to us.

It also gave us an insight into the reasons for metal fractures and failures in manufacturing operations, and enabled us to apply the proper remedy to avoid these failures in the future.

No hard and fast rules can be laid down for standardizing metal in brass manufacture because of the fact that different mills use different rolling and annealing schedules.

Therefore, each manufacturer will have to prepare his own standards.

VII—PHOTOGRAPHY

A—Photographs of machines and machine parts.

B—Photographs for half-tones for catalogs.

C—Photographs of buildings and machines in the course of construction.

D—Photographs of accidents in connection with hospital work. This also included prints from X-ray photographs.

VIII—INSPECTION AND CONTROL OF FACTORY

A—Control of annealing problems. An example was the control of the anneal on gilding metal used for primers.

Samples were taken from every lot of strip gilding that was run through the gilding furnace and the crystal count taken and compared with a standard, in order to ascertain if the proper temper was attained.

If the crystals were not of the proper size the furnace was regulated until it produced metal of the proper temper.

B—Circulating drinking water system.

This was controlled by taking daily samples and determining the alkalinity before and after filtration, the color, and the amount of alum used.

The washing of the filters and the amount of alum necessary to maintain the color in the water was under the supervision of the Chemistry and Test Department. Daily samples were also taken of the ditch water used for power purposes, and alkalinity, color, and turbidity determinations made in order to control the properties of the ditch water that tend to scale formations in the boilers.

The treatment and filtration of the water used in the boilers was also taken care of by Chemistry and Test Department.

C—Analysis of flue gases in coöperation with the steam department on boiler tests.

IX—RESEARCH WORK

This included the improvement of existing factory methods and the development of new ones. I will give you a few typical examples of what has been accomplished in the past.

In introducing these changes the financial gain is not the only thing taken into consideration. Improvement of working conditions and the health of the workmen are given careful attention.

It is self evident that well lighted workrooms, suitable apparatus, and healthy employees are the best kind of an investment. The following will serve as an illustration:

Prior to 1913 we always experienced more or less trouble with our fire gilding. Matters reached a climax when the fire gilder who had done our fire gilding for some twenty years was forced by ill health to seek some other occupation.

Fire gilders were scarce at that time and we were unable to get one to take care of the work which had accumulated in ten days. As a last resort the fire gilding was turned over to the Chemistry and Test Department.

A thorough investigation was made and for a period of two weeks the fire gilding was done by the writer. I found that a lot of the operations were unnecessary and that the conditions were unhealthy.

The first thing done was to substitute a gas furnace, properly equipped with suction blower to carry off the mercury fumes, for the old coal furnace.



FIG. 10—MAIN LABORATORY

A pyrometer and clock were installed and a new mercury condenser put in.

The old one saved less than 30 per cent of the mercury while the new one saved 75 per cent.

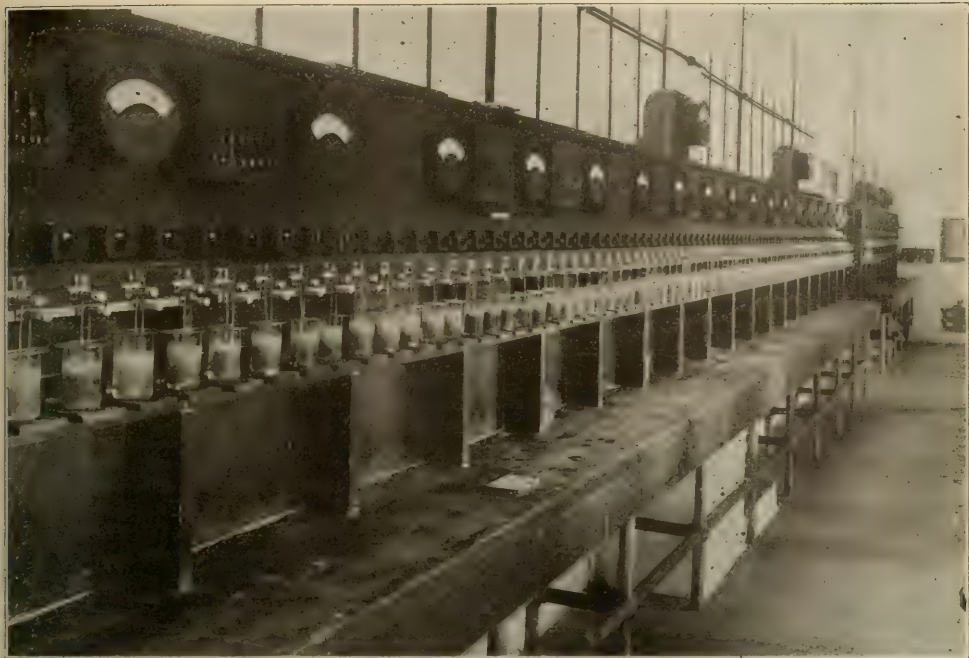


FIG. 11—ELECTROLYSIS BOARD

The methods of cleaning the work and making the amalgam were changed, with the result that in the last six years we have experienced very little trouble, produced better work, and increased our output at half the cost. The present fire gilder was a clerk who knew nothing about fire gilding but was trained by the writer.

Rules to avoid mercury poisoning have been posted in the fire gilding room, and the fire gilder has been given rubber gloves and all necessary precautions have been taken to make this a healthy occupation.

How effective the change in methods and the new mercury condensers have been is shown by the fact that during 1915 we did 25 per cent more fire gilding than in 1914, and yet we only used two flasks of mercury where we formerly used five.

In finishing brass articles that have a dip finish it is necessary to remove the scale by dipping in a scaling dip, consisting of a mixture of muriatic acid, oil of vitriol, and aqua fortis. Considerable metal is lost in this operation.

Formerly the baskets filled with brass articles were taken from the scaling dip and rinsed in running water, which ran down the sewer. Experiment showed that it would pay to save the copper in solution.

Instead of rinsing in running water, the baskets were rinsed in still water and when the solution had become concentrated enough, it was drawn off, and rotated in a set of stone crocks with an iron and coke couple, and the copper precipitated as cement copper.

We obtained about 1500 lbs. of this material per month, which ran between 66 and 70 per cent copper.

In the plating room we have succeeded in speeding up the brass, copper, and nickel plating solutions, and in cutting down the maintenance by analyzing all solutions once a week for metal contents, free cyanide, etc.

The solutions were all run at a certain concentration expressed in ounces per gallon and the amounts of chemicals to be added were all figured out and added under chemical supervision.

This scientific control instead of the old rule of thumb method has made for a better and cheaper product.

Results obtained on our nickel plating illustrate this point.

By toning up the old nickel baths containing sulfuric acid and double nickel salts with single salts, boric acid, and common salt we have been able to reduce the time of deposit very materially and obtain a whiter and better nickel.

On certain articles the time of deposit on the old solution varied from forty-five minutes to an hour and a half. In the new solutions the same articles were plated in ten to twenty minutes.

Before we speeded up the nickel solutions the plating room was using a battery of seven tubs to plate the articles and were obliged to work thirteen hours a day and then could not fill the orders. With the new solutions we used four out of the seven tubs, worked ten hours a day, and had no difficulty in keeping ahead of the work.

Sometimes considerable opposition is met in developing substitutes. It is then advisable to await a more favorable opportunity. The following will illustrate this point:

About two years ago experiments were carried out with niter cake as a substitute for oil of vitriol in pickling brass, bronze, etc. It was found with the proper temperature and concentration the niter cake was just as cheap and effective as the oil of vitriol. Being a radical change and contrary to the usual practice, it did not meet with general approval.

It was, therefore, decided not to adopt it at that time but to wait for the psychological moment. This arrived in the last part of December 1915, with the freight embargo, and the shortage of oil of vitriol.



FIG. 12—STEEL AND CARBON ANALYSIS DEPARTMENT

During the winter and spring of 1915 we were pickling all our metal with niter cake.

Without our knowledge of the merits of the niter cake as a pickling agent we would have been obliged to shut down our plant, as it was impossible to obtain sufficient oil of vitriol for our purposes.

COOPERATION

Coöperation between the management and the chemist on the one hand, and between the chemist and the superintendents, foremen, and employees on the other are absolutely necessary to the successful carrying out of research work.

In a great many instances the attitude of executives to changes and improvements advanced by scientific men has been one of hostility and disbelief. The Scovill Manufacturing Company is fortunate in having at its head men who thoroughly understand and sympathize with scientific research.

Coöperation is the ability to organize, to get together. This coöperation should be founded on a sane basis. The following story will illustrate this:

A visitor to a state asylum for the insane was walking over the grounds half a mile from the main building when he came across an attendant in charge of twenty patients. This attendant was a small man, many of the patients were big men. The comparison aroused the visitor's curiosity. He joined the attendant in a stroll and among other questions he asked, "What is to prevent those men getting together and overpowering you? You admit that you are unarmed and there is no help within a mile."

The attendant smiled and replied, "Why if those men could get together with anybody or anything they wouldn't be here."

You must get together with the other fellow.

In introducing these changes in the plant, the chemist must be prepared to meet more or less opposition. It is one of the natural tendencies of human nature to resent the introduction of any new ideas that tend to modify or replace processes of long standing.

After the change is made if anything goes wrong in that department the new idea is invariably blamed for it, whether or not there is any direct connection. To overcome this natural resentment and introduce changes with the least amount of friction requires considerable tact, patience, and knowledge of human nature.

The most satisfactory means in our experience has been the power of suggestion. When about to make changes in a process or to introduce a new one, one should talk over with the foreman or superintendent in charge, as well as the workmen, the benefits of the change, and get their ideas on the subject, and if possible get them to make the suggestions. It is well known that by continued reiteration a statement eventually becomes more or less fixed and magnified in the mind of the person who makes the reiteration, until the person really believes that the condition said to exist does exist.

In this way the interest in the new change is aroused and once get a man or group of men to believe the idea is theirs and they will work as hard for the success of the undertaking as they would against it if their coöperation was not sought.

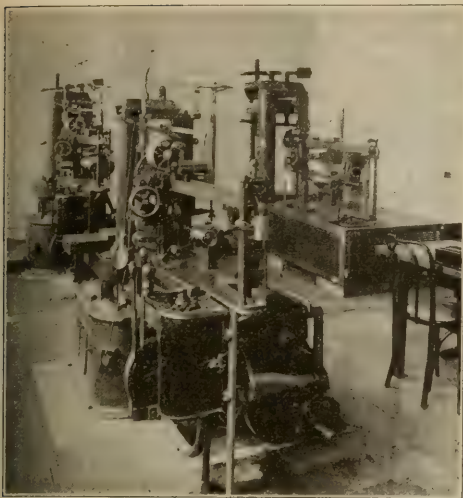


FIG. 13.—PHYSICAL TESTING DEPARTMENT

Before sending a chemist out into the plant, I try to impress upon him the fact that he must be humble, and that it is far better to adopt the attitude that he knows nothing about the subject to be investigated than that he knows it all. In this way he will gain the confidence of the workmen and in many cases often be able to obtain a valuable practical suggestion.

If this paper has succeeded in starting a train of thought showing the possibilities open to the brass chemist, and the urgent need of coöperation between the chemist and the management and in turn the coöperation between the chemist and the superintendent, foremen, and workmen throughout the plant, it will have served its purpose.

SCOVILL MANUFACTURING COMPANY
WATERBURY, CONNECTICUT

GERMANY'S INDUSTRIAL POSITION

By RICHARD D. ZUCKER

Received June 20, 1919

This paper covers in a broad way Germany's entire industrial position, from before the war to the present time, and also includes a brief consideration of the future. The sources of the information are several, the principal ones being my personal observations of mail censorship reports, of Germany's industrial position, of which I prepared daily summaries for a period of several months, and also my personal observations in various parts of the occupied territory. I have hesitated in making any fast, prophetic statements regarding the future, and have confined myself principally to the various possibilities.

For the purpose of comparison, certain facts must be given in regard to Germany's former industrial position. All industries being closely related in many ways, what applies to one directly will usually have its effect on another. Therefore, although the facts set forth here deal partly with the chemical industry, they also apply to the entire industrial field, and cover the situation in a general way.

The pre-war supremacy of Germany along industrial and commercial lines is too well known to us to necessitate any details being mentioned regarding it. And the fact that, in a large degree, this war was waged with a view to increasing their com-

mercial connections and extending their control over a greater amount of territory, cannot be denied. It has, however, resulted in their great industries being brought to a practical standstill. This, indirectly the result of the war, was directly brought about by three main causes: (1) The ever-increasing shortage of raw materials, (2) the great difficulties offered to all lines of transportation, (3) labor troubles.

All three of these are very closely related, in so much as the existence of one is capable and in many instances did produce both of the others. For example, one of the great shortages, which has caused so many plants to shut down, is that of coal. Although there are immense deposits of coal in the Ruhr district, Saar Valley, and Silesia, nevertheless, labor troubles, started by Spartacists, Bolsheviks, etc., caused transportation and production to be stopped, which, in turn, closed the supply of fuel and what little raw material there was available to the various industries.

Germany's dependence upon other countries for so much of her raw materials has placed her in a precarious position. She has no important copper, tin, or nickel deposits. Whereas, before the war she led the world in the production of aluminum, now the United States alone produces over one-half. We, and Canada, have a natural advantage over her in our large deposits of bauxite. Previously, Germany imported vast quantities of it from the Province district in France. It is doubtful if she will be able to do this in the future, because agitation is already on foot in France for the government to make stricter export laws on this material. She can obtain lead in fairly large quantities from galena deposits in the Harz mountains, Mechnich and Call in the Eifel district. Zinc is very plentiful in the Upper Harz and in Upper Silesia and Aachen. Formerly Sweden exported about three million tons of steel every year to Germany. Naturally this was greatly diminished during the war. Now even the production of Germany's own mines amounts to very little.¹ Cotton, rubber, gums, essential and vegetable oils must also be imported in large quantities. Flax is cultivated to some extent in Germany, but at the present time only about 5 to 6 per cent of the mills of the linen industry are in operation. This year's crop of flax will amount to practically nothing. Seed is difficult to obtain and the farmers are not planting much because they can see no method of disposal, and in many cases no labor can be had.

I read in one trade journal that, on account of the great oversupply of copper, cotton, rubber, textiles, etc., in the United States, we would be compelled to export them to Germany in order to dispose of them. They evidently expect the exports to commence with the lifting of the blockade, and also look for a big reduction in prices. They particularly mention that they want to import the raw materials and not the manufactured goods. This is so that their idle plants may once again be set in operation and employment given to those out of work.

Transportation difficulties arose from many different sources. The blockade between the occupied and the unoccupied territories, enforced by the Allied Armies of Occupation, played a big part, especially during the first months of occupation, when it was extremely difficult to obtain permits to export and import necessities, etc., from the left Rhine territory to unoccupied Germany, and *vice versa*. Later on the restrictions on certain raw materials and special classes of goods were made lighter, and it was possible for some plants to keep in operation through these means. For example, at one time a large quantity of raw beet sugar was permitted to be sent from the unoccupied zone to the left Rhine territory, where most of the refineries are located. It was on the condition that a certain large per cent should be kept for distribution in the occupied country. Another factor in the transportation trouble was that of the diminu-

¹ Details regarding this will be found in a contribution from Corporal Zucker concerning German industries in *THIS JOURNAL*, 11 (1919), 487.

tion in the amounts of rolling stock. Owing to the conditions of the armistice, 5000 locomotives and 150,000 cars had to be turned over to the allied authorities; and the shortage produced thereby added greatly to the already existent difficulties. It is claimed, however, that after the industrial plants start up again, the shortage of locomotives could be alleviated in as short a time as three months by means of spare parts on hand, outstanding contracts, etc. This seems to me to be a very optimistic statement.

The spread of Bolshevism and Spartacism caused considerable turmoil among the laboring classes. Naturally the leaders of these new parties sought the districts where labor was most concentrated, and therefore the mining regions around the Ruhr River, Upper and Lower Silesia, and other industrial centers suffered the most, thereby further paralyzing the arteries of commerce. The demands for higher wages, better hours and conditions were in some cases just; but the harm done to industry alone by their injudicious methods certainly adds the final touch to their discredit. For many months, in Berlin alone, there have been well over 200,000 unemployed. The government itself is greatly to blame for this, because, by law, they are compelled to pay those out of work 8 marks per day, I believe; and when a man is unable to earn much more than that by working, there is certainly little inducement to make him hunt a job, if he can get his living free and by thieving or plundering. A readjustment of these unfavorable conditions can be partially obtained by suppressing the Bolshevik menace by the cooperation of all, and with the course of time. It can be safely said that the majority of the workers are not in favor of the radical methods used, but were intimidated and compelled to adopt them.

Many movements have been on foot for the past months to socialize the different industries. The German government is making investigations concerning the benefits of it; and some branches of industry, I believe, have already decided to adopt the socialistic administration. Others are putting up a violent opposition to it, so the outcome of it will be interesting to watch. There has been existent in Germany for a long time a type of organization which, until comparatively recently, we have not had to any extent in our own country. Every little branch of industry has its so-called "Verein" or "Verband," which seems to be made up more from the manufacturers themselves than from the laboring classes. They are not similar to our trade unions, but are more along the order of our "chambers of commerce." They aim mainly to standardize commerce regulations, determine prices, establish cooperation with the employees, protest against unfair legislation, and to look out generally for the particular interests of their own branches of industry. They are in a large degree responsible for Germany's previous commercial success. Since the armistice was signed they have also played an important part in endeavoring to keep industry going and in making plans for the future. It might be mentioned here that another feature that played a part in Germany's former success was that of the elimination of "cross shipping," *i. e.*, the shipping of some class of goods from one part of the country to another distant part when it is possible to obtain the same in close proximity. This avoids unnecessary congestion of freight and affords cheaper prices, quicker delivery, etc. Of course, Germany being of much smaller area than the United States, can more easily practice such a principal; nevertheless, I believe that we should make attempts to eliminate this drawback as much as possible in the United States.

At the present time the immense syndicates and their vast plants are shut down exactly as those of smaller capacity are. Probably among the best generally known is the famous "Kali" syndicate, which controls the potash deposits of the Stassfurt region. During the first quarter of 1919, on account of coal shortage, transportation troubles, and labor difficulties, they

were able to deliver only 60,000 tons compared to 150,000 tons in the same period of 1918. The value of deliveries decreased from 77 million marks to 35 million marks. Now that the United States has become practically independent of large imports of potash, whereas in 1913 it is said that she imported about one million tons of potash salts from Germany, it can be seen that this important branch of Germany's export trade is doomed to suffer. In like manner, through the industrial independence which we have obtained in other lines during the war, especially in medical preparations, dyestuffs, optical glassware, etc., her position is greatly jeopardized. One plant of the Höchst Farbwerke in French-occupied territory is now in operation under French supervision. Medicinal products are produced, the stores and production are first used for the purposes of the Allies, and any remainder can be shipped by special permit into the unoccupied territory. Along the Rhine, in the American Zone, practically the only factories in operation are those manufacturing "Schwemmstein," a sort of porous concrete building brick made from gravel and clay found in the immediate vicinity. Being on the river, a coal supply is fairly easily obtainable. These plants have been making shipments with fair regularity, especially to Holland, which is also accessible by the water route. It is interesting to note here that after the American Army of Occupation had been here some time the numbers of unemployed among the Germans in the occupied zone decreased continually until at the present time it is very nearly nothing.

In the hills along the Lahn River, which terminates in French-occupied territory just below the American Zone, there are a few silver, lead, and iron mines. These have been in operation to some extent, but with no regularity and with only a small production. The great Krupp works at Essen, while having made plans to reestablish themselves on a peace basis, are at the present practically idle. It is interesting to note that the Krupp people claim that before the war the proportion of finished war materials (artillery, armor plate, shell cases, etc.) to that of peace materials which they manufactured, was only 1 to 20. It is not within the scope of this article to argue along these lines, but I have definite proof that the Krupp people cause false statistics to be given to the public and reserve the correct ones for their own internal administration. The addition that they will soon put onto their 1912 Jubilee Book concerning their experiences, production, etc., during the war will not be the same one that they will distribute to their own officials, and which will contain the true facts, figures, their great errors, etc.

The majority of the plants are in condition to start manufacturing again on short notice if the factors that closed them down are removed, that is, with a regular coal supply, which would of course necessitate open lines of transportation, and the labor trouble quieted, Germany will be able to manufacture on a scale in proportion to the supply of her own raw products and the disposal of her goods. Here her total dependence on other countries for such products as rubber, copper, etc., comes into effect. She is also largely dependent upon other countries for the disposal of much of her manufactured goods, and will no doubt make every effort to introduce her wares to the world once again, whether it be by open methods or unscrupulous ones, depending upon whether the former are successful or not. Importers are already sending out smooth business letters, seeking to renew connections and dismiss the "unfortunate occurrences," as they call it, of the past four years. English firms have their representatives in a portion of the occupied territory, where they are aiming to establish business connections. I understand also that a large American exchange company has offices in Berlin, and will handle imports of raw materials and exports of finished products to the States. It is doubtful if the antipathy against Germany will remain strong

with many in the commercial world, especially if there is anything to be gained by overlooking it.

The length of time required before Germany can even approach her previous standing is dependent upon many things. If the amount of indemnity that she has to pay should prove to be excessively large, the country would be placed in a condition of economic slavery for many years. If a commercial boycott of any extent should be placed upon her, this will certainly be a tremendous restraint upon her recovery. There is little doubt, however, but what these people will exhaust every means and source to reestablish themselves as rapidly as possible. Being naturally industrious and making application of science as they have heretofore, they will doubtless endeavor to regain the respect of the world again by new and possibly surprising means, especially if they should be fortunate enough to have the proper kind of leaders to guide them. Plans for the future are already being considered in detail. If attempts to place their goods in the large countries of the world cannot be made directly, they will resort to agencies which they have established in the so-called neutral countries, such as Holland, Switzerland, Sweden, Norway, Denmark, etc. Many firms already have their representatives in these countries and are making preparations for importing and exporting as soon as the blockade restrictions are lifted.

One thing which Germany fears in a commercial way is the competition of Japan. Since 1913, Japan's exports to Australia alone increased eightfold. There is a bitter feeling against them on account of the strides that Japan has taken in the export of toys, fancy wares, etc., to the United States, South America, Australia, and Europe. The fact that Germany, being closely engaged in warfare, gave Japan an excellent opportunity to expand her business connections, now causes Germany to apply the term "Yellow Peril" to the menace to her toy industries, etc.

A fact which must not be lost sight of in the future is the well-known ease by which a plant manufacturing dyestuffs can be converted, in a very short space of time, into a source for the most powerful explosives that the world knows of. It will be well to watch this formerly highly-developed branch of Germany's industry and not allow it to reach too extensive proportions.

One thing that impresses the foreigner in Germany is the great number of "Ersatz" or substitutes, which their chemists and inventors developed during the war to supply the demands for wares which were impossible to obtain, or could not be had in large enough quantities. The quality of most of them is easily seen by the quickness which the public gives them up when the genuine article once again presents itself. Leather, rubber, fats, cotton, and various foodstuffs were the principal materials for which substitutes were developed.

I have seen large 3 1/2 ton German trucks with the tires of solid synthetic rubber, and it seemed like a fair imitation, being of the same appearance but much harder than genuine solid rubber. However, the cost of production is said to be extremely high and no doubt it is, because the majority of the large trucks that one sees have nothing but the solid steel tires.

The leather substitutes, which many times would deceive one, even at close range, have absolutely no durability. They are usually made from a vegetable fiber, and are practically nothing more than a form of paper and stand up as such under wet conditions.

Fats proved a difficult class of goods for which to find an "Ersatz." We have occasionally heard gruesome tales of the extraction of fats, etc., from the bodies of the dead; but they have never been definitely proved as far as I can find out, and certainly are difficult to accept without a substantial foundation. Edible fats were one material for which no new substitute could be found, other than the various forms of "margarine"

and hydrogenated fats. Oils and fats for the soap and glycerin industries were mainly of animal origin, recovered from garbage and refuse; and small quantities were also obtained from fruit kernels and small nuts by pressing them.

Following are the analyses of several typical wartime soaps as given by the *Oil and Color Trade Journal* of London. These show how great the scarcity of fats was, and how all glycerin was recovered first and the fatty acids alone used in the manufacture of the soap.

MARK	Weight Grams	Color	Insoluble Per cent	Fatty Acids Per cent	Na ₂ O Per cent	Soap Per cent
K. A. Soap.....	90	Gray	75.30	14.77	1.62	23.5
Liliput.....	58	Brown	76.00	76.08	9.54	Toilet
Ideal.....	76	Bright Gray	92.44	5.30	0.55	8.5
Eureka.....	79	Bright Gray	92.70	5.40	0.72	8.5

¹ The insoluble substance is clay, which was apparently kneaded in the dissolved soap, cut, pressed, and dried. The analyst found no glycerin and concluded that fatty acids were used. These were in a state of decomposition and were free from gum.

I believe that the process for producing synthetic glycerin from sugar, as was developed in the United States during the war, was also in practice here, but on account of the quantity of sugar being less than that needed to supply the demands for food purposes, it was only used for the most important needs. For certain uses in the pharmaceutical trade, a solution of sodium lactate was used, but I know very little about its success.

It is rather hard to believe, but true, that at the beginning of the second year of the war, when Germany was becoming short on nitrates, the following advertisement appeared in the German newspapers:

The women of Germany are commanded to save their chamber lye, as it is very needful to the cause of the Fatherland in the manufacture of niter, one of the ingredients of gunpowder. Wagons, barrels, and tanks will be sent to the residences daily to collect and remove the same.

(Signed) VON HINDENBURG

Indeed, they must have been in narrow straits to make them adopt such peculiar ideas of resourcefulness as this. Whether it ever amounted to much, I am unable to say.

Textiles were in many cases manufactured from the same materials as were the substitutes for leather, producing a coarse material which, upon becoming wet to any degree, became useless. This "paper yarn fabric" was very expensive and in the future will be used only for special purposes.

Substitutes for gasoline were widely sought, but nothing of a startling nature was produced. Experiments with acetylene gas from calcium carbide, while successful in some ways, still showed several dangerous drawbacks, among them being its explosive property upon reaching a temperature of around 400° C. Ethyl alcohol produced somewhat better results, one run of about 5000 miles being made and the motor being in excellent condition at the end of the run.

Foodstuffs also were an important necessity to develop. During the war over 600 artificial honey factories were established, which made a fairly good imitation by the inversion of beet sugar with formic acid and the addition of coloring and flavoring substances. Miserable coffee substitutes were made from acorns, horse chestnuts, and carrots. Dehydrated vegetables and potato flour played an important part in the feeding of the nation.

Research continued throughout the entire war along extensive lines, both in matters of pure science and the practical applications of it. Many important medical discoveries were made and new medical preparations developed. According to a medical census taken some months ago, there is still plenty of salvarsan in Germany, and, incidentally, the conditions in the country at the present time certainly demand large quantities of it. Agar-agar and iodine were products for which there was great need, and for which importation had previously been

resorted to. The *Chemiker-Zeitung* for March 19 publishes the results of an investigation for producing these products and also potassium salts from certain kinds of seaweed found off the coast of Heligoland and in the North Sea. It is extremely doubtful if it would be of much avail for Germany to foster such an industry as this, especially as she considers in the article the production of potash for the purpose of export to the United States, whereas we already have the same idea working on a commercial scale on our western coast.

It is perfectly possible, although perhaps difficult for some to understand, for Germany to rebuild herself and become once more a nation of commercial importance and holding the recognition of the great nations of the world. It will take many years and an entirely different type of leaders from what she formerly had, and at the present time it does not appear as if her new leaders had lost sight of their old ideas of world domination in the future. So far as the United States is concerned, we have been very magnanimous to her on the whole, which is entirely in keeping with the principles for which we fought. If Germany, in her strides for recovery, shows herself worthy, I believe it would still be in accordance with our principles to assist her in certain ways; but if, on the contrary, she should show any intent of pursuing her old designs, forces to prevent it cannot be taken too soon. Present internal indications in Germany certainly indicate that she is anxious to reestablish her business connections, start up the factories, feed her people and put herself on a firm basis. Germany's future rests wholly with herself and, by watching her carefully, the rest of the world will be able to determine what new means to adopt towards her, judicially, commercially, and if necessary, physically.

HEADQUARTERS TROOP, 3RD ARMY
A. P. O. 927, GERMANY

PRODUCTION COSTS OF CHILEAN NITRATE

By J. MARCO

Received May 24, 1919

As the synthetic processes for the fixation of nitrogen are causing world-wide interest and discussion in regard to the possibility of their competing with the deposits of Chile, it is of interest to ascertain economic conditions which will affect the future of the Chilean nitrate industry. Of these, cost of production is the most important. As Chilean nitrate furnishes approximately 58 per cent of the total fixed nitrogen used in the world and the producers have always had conditions in their favor, many of the factors influencing cost of production to them have been overlooked. It is, therefore, desirable to study the possibilities of lowering this cost of production under commercial competition.

It is traditional that the nitrate industry in Chile has not been administered according to principles of scientific management, and the great savings in cost made in other lines of production by the adoption of business economies lead one to believe that savings could also be made in the mining, extraction, and transportation of nitrate. The managers of the nitrate plants in Chile in obtaining statements of the profits and losses in their business have heretofore depended entirely on the annual or semi-annual balance obtained by the accounting department when the books were closed and an inventory taken. As a result, no one knows the itemized costs of the various details of the business and it is not possible to determine at any time the advantage or disadvantage which any modification in methods might produce. A system of cost accounting is, therefore, of great importance to the improvement of the industry. The facts given below are not, therefore, the result of accurate statistics from the books of the companies, as the books would not

give such precise information; they are rather the result of observations made upon the ground, the figures being in accordance with the conclusions arrived at by many observers. The cost of Chilean nitrate on board ship may be divided into the following items:

A—Cost of mining and transportation of the caliche (raw material) from the deposit to the extraction plant.

B—Plant costs of manufacture (product, 95 per cent NaNO_3).

C—Cost of transportation from the plant to the ship.

D—Administration expenses.

We will consider these items in the above order.

A—This cost varies from \$0.79 to \$1.40 per short ton of caliche delivered at the Oficina (extraction plant).

The mining of the caliche is practiced in a very primitive manner, most of the time without knowing the quality of the material dug. This makes it impossible to maintain a uniform extraction cost on account of the variation in the quality of the material and the distance to the plant. If profits are to be realized the composition of the mineral taken from the ground should be followed and it may be possible in times of high prices to extract poorer material at a profit than could normally be done. Furthermore, most of the mining is hand labor and there is, naturally, a broad field for development in the use of mechanical devices. Transportation from the deposits to the plant is also now done by means of wagons drawn by mules, and the cost of production can undoubtedly be lowered by the use of trucks or other mechanical devices.

Labor is at present 70 per cent of the expense. A decrease in wages cannot be expected as only first class labor can be used. Such labor now obtained gets from \$1 to \$3 per day.

B—The cost of extraction of one short ton of caliche is now \$0.90 to \$1.37. The principal factors of costs are labor, 30 per cent; fuel, 60 per cent; and technical control, less than 1 per cent. Technical control and advice have been practically forgotten in the Chilean nitrate industry on account of the control of the nitrate markets which the Chilean industry has heretofore maintained. There is no question but that technical advice and control will lower costs. Some plants, for example, now extract no more than 55 per cent of the nitrate contained in the material, while others, in exceptional cases, get as high as 72 per cent. There is, however, a change taking place in this respect. Chemists and other technically trained men are being engaged in research which will undoubtedly lead to an increase in the percentage extracted and to a reduction in the amount of fuel used. Indeed, toward the close of 1918, El Instituto Tecnico del Nitrato was established in Chile with this object in view.

Of the total fuel used, 20 per cent is devoted to the production of power and 80 per cent to the production of heat. The installation of the Diesel type of motor in power plants has given good results and many central thermoelectric power plants are being planned to serve a number of Oficinas collectively. Under the present method of heating, 65 per cent of the fuel is not utilized, but it is expected that with the adoption of new models of boilers and evaporators, and new methods of chemical procedure these losses will decrease. Lately a process devised by Manuel Prieto, chemical engineer, has given satisfactory results for extraction, obtaining during the test made an extraction as high as 75 per cent even with poor raw material.

C—The costs of transportation from the Oficinas and placing on board ship are about \$18.00 a short ton of commercial nitrate. The export tax paid the Chilean government forms the chief item of this expense or 65 per cent of the total (56 c. a quintal = 101.6 lbs.). The government has under consideration a more rational principle of applying this export tax, the adoption of which will make it possible to exploit poor fields of ni-

trate. The construction of up-to-date docking facilities at the port of Antofagasta has already been begun and improvements in railroad facilities throughout the nitrate zone are continually being made.

D.—The costs of administration are approximately 38 to 60 cts. per short ton of caliche. This item probably cannot be reduced, but the adoption of better systems of management should increase the efficiency of production. Last year, under the auspices of the Chilean government, all the manufacturers of nitrate joined together in an attempt to solve many of these important commercial problems.

The following table gives the actual results obtained in four Oficinas:

	I	II	III	IV
Production, short tons of commercial nitrate.....	39660	73800	34200	85200
Average per cent of sodium nitrate in the caliche.....	17	21	16.5	18
Efficiency of extraction, per cent.....	64	70	62	65
Lbs. of nitrate extracted per short ton of caliche.....	213	294	204	234
Cost per short ton of commercial nitrate at the plant, A. B. D. factors, dollars.....	18.00	13.40	20.60	14.60

¹ The exchange value of the Chilean peso was equivalent to 12 d.

It is, therefore, hoped and expected that economies may be made in the mining and marketing of sodium nitrate and that it will for some time pay to compete with the synthetic nitrogen.

DETROIT, MICHIGAN

FOREIGN INDUSTRIAL NEWS

By A. McMILLAN, 24 Westend Park St., Glasgow, Scotland

TRIPLEX GLASS

A pamphlet received from the Triplex Safety Glass Company of 1, Albemarle Street, London, gives some details about the uses to which their material has been put during the war. This glass, which is the invention of a Frenchman, M. Benedictus, consists of two pieces of glass between which is introduced a transparent sheet of xylonite, adhesion being effected by the use of a special cement and high pressure. The result is a strong and tough material which does not splinter like ordinary glass, and which, in the thicker qualities, will even resist a rifle bullet. In the air it has been used for goggles and for the wind screens of fighting aeroplanes, and many pilots attribute the saving of their eyes and even their lives to its employment. On the water it has been adopted for bulkhead-door illuminators and portholes, in view of its power to remain air-tight and water-tight in spite of being badly smashed by a blow, and in submarines it has found its place in periscopes and instrument cases. On land, again, it has been fitted in the observation windows of armoured cars and in other vehicles, and has been employed in military hospitals. A further field of use is in field glasses and spectacles.

CUTTING TOOLS

A difficulty with cutters is to get them of sufficient strength and rigidity to withstand the strain of constant hard work. For the sake of economy many firms have experimented with special steel tips fixed to wild steel shanks by means of a fux, but the economy of this method is doubtful owing to the constant breaking of the tool at the joint when subjected to twisting strain for any prolonged period. To meet this difficulty a process has been introduced by the J. B. R. Tool Works, Longsight, Manchester, England, whereby the tools are made with a carbon steel shank to which is dovetailed and welded a piece of special high-speed steel which is subsequently hardened and ground in the manner of an ordinary high-speed steel tool forged from the bar. The tips last till they are ground off by use, and when they are used up the tools can be retipped by the same process. The cost of these tools, which can be supplied in a number of standard shapes to cover the whole field of regular machining operations, is stated to be about one-fifth of the ordinary cutters, and their life even under the hardest conditions about 6 weeks. In a test recently made in the machine shop of a Clyde shipbuilding yard with a No. 3, small-size, 1 in. by 3/4 in. section roughing tool in a large lathe on a bar of high-tension steel 8 in. in diameter and about 2 ft. long, a cut was put on the full size of the cutting edge, about 3/4 in., the tool traverse being 2 in. a minute. The tool traversed sweetly along the job, and was in perfect condition when the third cut down stopped the lathe.

LARGE LAUNDRY MACHINES

Since 1914 military requirements have obliged laundry engineers to give special attention to the production of machines which are not only capable of handling huge quantities of work with a minimum of labor, but also are as simple in design as possible, to fit them for operation by unskilled men. An example is afforded by a multiple-roller ironing, drying, and finishing machine, which was extensively used in military laundries during the war. It consists of a series of six cast-iron rollers 108 in. long by 12 in. in diameter, which are arranged on the flat and are curved with woolen blanketing and cotton covering. They revolve in a like number of cast-iron steam chests or "beds," concave in form and semi-circular, which are heated by steam at a pressure of 65 lbs. per sq. in. and serve to dry the articles which pass between them and the rollers. After this operation the goods are fed round a 12 in. roller, also of cast-iron and steam heated, and then go to a 30 in. steam-heated roller by which they are finished, and from which they are delivered at the opposite side of the machine from which they entered. A ribbon feed is provided, which not only obviates risk of accident to the attendant's fingers, but also permits much quicker feeding than would be possible without it. The articles are laid on traveling feed bands which convey it under the first roller, and the feeding speed is as high as 52 ft. per min. Six attendants are required—two feeding, two receiving, and two folding.

WELDING OF ALLOY STEELS

Many steels are considered practically non-weldable. To facilitate their welding, welding powders containing both iron filings to supply a fusible medium and borax to prevent oxidation are sometimes used. In the *Z. Ver. deut. Ing.*, Feb. 19, 1919, Dr. N. Czako claims to weld various nickel, chrome, and tungsten steels to a mild steel, and also to a high-speed tool steel with the aid of a powder which contains neither iron filings nor borax but which he does not describe. He was anxious to weld his high-speed steel (1) containing 4 per cent chromium, 4 per cent molybdenum, and 9 per cent tungsten; (2) containing 12 per cent chromium; (3) containing 12 per cent manganese; (4) containing 3 per cent nickel, 0.5 per cent chromium; (5) containing 1 per cent chromium, 2 per cent silicon; (6) containing 1.6 per cent carbon; and (7) a gray cast iron. Photographic reproductions of sections of his welds are given in the journal mentioned. He welded No. 1 of his specimens in an ordinary coke fire, but his tests were merely made with plates 4 cm. X 2 cm. up to 1 cm. thick which were welded to rods of the other material. In some cases, the demarcation between the welded portion and the alloy was distinct and not all of his welds stood the hammer test.

TYPE CASTING TRADE

In this industry, says *Times Trade Supplement* for April 26, the Germans in the past held the premier position. Now they are being ousted everywhere. Italian foundries, which before the war had done considerable business, have now doubled their plant and output. In France, on the other hand, the turnover was comparatively insignificant, but now no efforts are being spared to work up the trade and travelers are being sent out in all directions and elaborate publicity schemes initiated in all areas formerly worked by Germans. In Spain and South America, the Germans had introduced their "normal systems" and thus monopolized these markets with characteristic energy. English and American foundries have rearranged their works under considerable expense and great difficulties and are gradually capturing the trade of these countries. English agents have worked systematically and circularized every Spanish and South American printing works requesting them to give full particulars of prices asked and discounts and terms allowed by the Germans before the war.

IMPORT RESTRICTIONS WITHDRAWN

The restrictions on importation into the British Isles on the following goods are to be withdrawn: hand cultivator, hand drills, seeders, potato planters, furrow and root weeders, pea harvesters, manure scoops, hay rakes, planters, malleable tube fittings, pressure regulators, lubricators, grease cups, injectors and ejectors, pump and machinery governors, pressure and vacuum gauges, expansion joints of iron or brass, pressed steel union couplings, water gauge fittings, steam traps, metallic steam packing, brass wire, copper wire, phosphor wire, steel spring wire, wire-rope sockets, drop-forged steel, copper rods, steel and iron rods, antimony, ampoule files, lead capsules for bottles, mathematical instruments, oil cans, hand stamps for numbering and dating, rat and mouse traps, electrotypes, zinc plates for the manufacture of printing plates and zincos, also copper plates and brass plates.

SOAP FROM BROWN COAL

According to *Z. angew. Chem.*, a fat soap is being made in Germany from substances obtained from brown coal-tar oil. At first such soap had the defect of absorbing water from the atmosphere and becoming in consequence soft and gradually liquefying. This defect, which would have seriously limited its use, has been remedied, and the soap, as now manufactured, preserves its requisite consistency. It is probable that some of the oil shales afford the material required. In any case, the manufacture is likely to be set on foot on a large scale.

TRADE CATALOGUES FOR PALESTINE

The Chief Administrator, Occupied Enemy Territory, South Palestine, writes *Chemical News* of May 9, that he desires to obtain as many catalogues as possible upon numerous import lines, all of which should find a profitable market in Palestine. The idea is to replace by allied goods those formerly sent by enemy countries. Catalogues in the three principal languages of the country, English, French, and Arabic would be extremely useful, and were a great feature in the German pre-war trade propaganda. The following are the principal imports: Agricultural machinery and implements, flour-mill installations, all kinds of motors, furniture, bedsteads, enamel ware, pottery, glassware, lamps, stationery, hardware, ironware, articles of construction, book-printing and book-binding machinery, boots and shoes, drugs and chemicals, brushes for painting and household, traveling bags and necessities, locks, musical instruments, typewriters, all kinds of tools, engines for petroleum and gas, and perfumery.

OIL REFINING IN ITALY

A fair amount of machinery, says the *Times Trade Supplement*, will be required in connection with the development of the Italian oil industry, as the workings at Lugagnano, at Gropperello, in the province of Piacenza, and at other centers are to be exploited on as large a scale as possible. The report of the Società Petroliera Italiana states that all the preliminary operations and arrangements have been completed and that on their properties boring and productions will follow as quickly as possible. In this latter case the machinery, cables, tools, etc., for the preliminary work were ordered from England and the United States in fairly equal proportions. On the properties of this company, some 18 borings are already in progress. Borings are also being investigated at Milano. The hydrocarbon wells at Parma are also receiving attention and in the vicinity of Valozza Neviano there are such promising evidences of oil that borings will be undertaken in the course of a few weeks.

JAPANESE IRON AND STEEL TRADE

A proposed combine of the larger firms in the iron and steel trades in Japan who have stocks for disposal has apparently failed to realize. The Imperial Steel Works at Yawata has for disposal some 200,000 tons of steel made at high cost. Should the works wish to dispose of this steel at its cost price, buyers will be asked for an unreasonable figure, on the other hand, should the works lower their selling price to that approximating the current market price, the difference between manufacturing cost and selling price will have to be adjusted at the expense of the tax-payer. According to a report by the British Commercial Secretary at Yokahama, English pig iron is stated to be being offered in Japan considerably below Japanese cost of production. With a view, however, to protect the iron and steel industry in Japan, the Tokio Chamber of Commerce has recommended that the customs duty be raised and subsidies granted. It has been suggested that the present rate on pig iron, which is 5 cents per 132 lbs., be raised to 25 cents per 132 lbs. It is also proposed that in the case of pig iron produced in Manchuria, China, and Korea, a subsidy should be granted to such an extent as to counterbalance the import duty imposed. This proposed increase is opposed by shipbuilders in the country.

PHOSPHATES AND AMMONIA FROM SEWAGE

The dearth of phosphate fertilizers throughout Germany has set chemists looking around for new sources of phosphate. In the *Chemiker-Zeitung*, J. Gonné, of Berlin, suggests the recovery of phosphates from sewage. Without giving any figures showing the probable yield, he admits that the sewage treatment for phosphates alone would be unprofitable but claims that it is possible to gain the ammonia at the same time and further to utilize the residue. Such claims, says *Engineering*, 107 (1919), 703, are familiar from workers dealing with sewage problems. It is further pointed out that where ammonia is recovered from gas water, this process may be worked in similar apparatus. No definite description either of apparatus or process is given. The chief point in the paper is that phosphoric acid is precipitated as calcium phosphate by sodium phosphate, when ammonia is present, from solutions of calcium chloride and other calcium salts. He separates the liquid from the solid sewage in special apparatus which prevents the escape of ammonia and also prevents the explosion of any explosive gas mixtures. The clarification is facilitated by adding certain refuse or by-products of the process to the sewage. Calcium salts and some sodium phosphate, if necessary, are then added to the liquid and the mud precipitated is filter-pressed or centrifuged. The settled liquid passes into the distilling apparatus, more mud is obtained and the precipitation and distillation are repeated.

THE STILL ENGINE

As quoted in the *Electrical Times*, 55 (1919), 362, Capt. F. E. D. Acland recently gave an account of the Still engine before the Royal Society of Arts, London. Mr. W. J. Still has invented a combination of the internal combustion engine and the steam engine. It is not the first time, of course, that attention has been given to the steam-raising possibilities of the explosion engine and many proposals are on record. This special method of Mr. Still seems an advance on anything yet achieved and he has actually reached an efficiency of 47 per cent with an early model specially designed with an eye to economy. Mr. Still makes his cylinder jacket part of a boiler system, and the cylinder is cooled by converting water into steam without raising the temperature. The mean temperature of the cylinder walls is higher than in ordinary explosion engines but the changes in temperature are limited, so are the stresses. A cylinder liner only one-quarter or one-third of the usual thickness is used and is ribbed externally. The exhaust gases first do a little steam raising, then pass on at a reduced temperature to a device for preheating the water required in the jacket-boiler system. So the heat losses are circumvented at every point and terminal stack temperatures as low as 150° F. are recorded. During compression, the walls being at steam temperature, the incoming charge picks up heat instead of losing it and, last but not least, steam is used on one side of the piston. With these refinements very high efficiencies may be reached, and from a thermodynamic point of view it is a fascinating proposition, but the cost of the steam generating paraphernalia will, doubtless, prove a decided drawback.

MICROSCOPIC EXAMINATION OF ALUMINUM

A paper contributed by S. L. Archbutt and D. Hanson at a recent meeting of the Institute of Metals describes in detail the methods found most suitable for the preparation of specimens of aluminum alloys for microscopic examination. Particular care must be given to the grinding and polishing operations since the successful development of the microstructure depends to a very large extent on the condition of the prepared surface. Hand grinding on graded emery papers, which have been previously soaked in paraffin, is found to give excellent results, while, for the polishing operation, a motor-driven disc covered with smooth surfaced woolen cloth is employed. Magnesia is used as the polishing powder, but for soft alloys the final stages are carried out on a wet pad practically free from magnesia. With regard to the etching both of aluminum and its alloys, the authors recommend a 10 per cent solution either of caustic soda or of hydrofluoric acid in water. Methods for the identification of the various impurities occurring in aluminum and of the different microscopic constituents found in the commoner aluminum alloys are also described. These have been investigated in great detail with the object of finding reagents which will distinguish between the different constituents when they occur in the same alloy. Alloys of aluminum with silicon, iron, copper, zinc, nickel, magnesium, and manganese are considered in this connection.

MONAZITE SAND

The continued investigations of the Mineral Survey in Ceylon, says *Engineer*, 127 (1919), 559, have resulted in the discovery of beach deposits of monazite sand in that island and the government of Ceylon has made arrangements for working them. The Ceylon sand has been investigated by the Imperial Institute which has also conducted trials of concentrating machinery and finally selected plant which has been erected in Ceylon for working the sands. The deposits are less extensive than those of Travancore but they will make an effective contribution to British sources of supply of this important material.

MONOMETHYLAMINE

Monomethylamine being a synthetic reagent of considerable importance, a new method for its preparation will be of interest to organic chemists. The reduction of chlorpicrin yields different products according to the reducing agent used. When chlorpicrin is reduced with stannous chloride and hydrochloric acid, cyanogen chloride is produced; if, however, iron filings and acetic acid or tin and hydrochloric acid are used, monomethylamine is the chief product. In an article in the *Journal of the Chemical Society*, February 1919, p. 150, the reaction is discussed and the following method of procedure recommended: Iron filings (500 g.) are gradually shaken into water (2500 cc.) containing hydrochloric acid (60 cc.) and contained in a large earthenware jar which is fitted with a stirrer and placed in a little cold water. The chlorpicrin (250 g.) is then gradually added, with very efficient stirring. The temperature rises and should be maintained at about 50° C. The smell of chlorpicrin disappears after 3 hrs., and the mixture is then gradually added to a boiling solution of sodium hydroxide into which steam is blown. The methylamine is absorbed in hydrochloric acid, the solution evaporated, and the residue dried to a constant weight. In this way, a yield of 95.5 per cent of the amine hydrochloride is obtained. When reduced with a hot alkaline solution of ferrous sulfate, chlorpicrin gives a considerable amount of ammonia. The method described for methylamine should prove valuable now that large quantities of chlorpicrin are readily available.

NEW USE FOR OXY-ACETYLENE FLAME

A French company, says *Acetylene*, 16 (1919), 85, has for some months past used an oxyacetylene blowpipe of special construction to effect the cutting of steel under water. The apparatus consists of a cutting blowpipe based on the same principles as the ordinary one but supplemented with a small diving bell to which compressed air is admitted to expel the water. The pressures of the oxygen and acetylene required are much higher than usually employed, the pressure of the compressed air depending upon the depth at which the blowpipe is worked. At the trials now being carried out, ships' plates have been cut at a depth of 27 ft. under water. The application to marine purposes of this system of cutting plates has obvious advantages. By its aid the salving of torpedoed vessels may be facilitated and rapid repairs to lock gates can be effected. The electric arc can be manipulated in the same manner but requires special electrodes.

DIFFERENT EXPLOSIVES

The relative merits of different explosives, as quoted in *Engineer*, were given by Prof. J. Young in a recent lecture as follows: When material is to be displaced but not shattered, a slow-acting explosive is required, black gun powder with a velocity of 300 m. per sec. is good. Blasting powder is still slower in action and is suitable for quarrying where stone has to be obtained in large blocks. Bobbinit, still slower in action, is much used in coal mines with soft coal. All these comparatively weak explosives and large charges are used where great power and rending effect with a moderate shattering effect are required; there is little to choose between the ammonium nitrate and the perchlorate explosives except that the former are the safer to handle but most susceptible to moisture. Some grades of amatol made for military use would also be suitable and vast quantities should now be available. Where the greatest power in the smallest bulk is required, and this is the case where hard rocks are to be blasted and small drills are used, the nitroglycerin explosives are decidedly best, as they have a high density, great power, and high velocity of detonation.

FALL MEETING AMERICAN CHEMICAL SOCIETY

PHILADELPHIA MEETING TO HAIL DAWN OF NEW ERA

By JOHN WALKER HARRINGTON

American chemical independence will be proclaimed this autumn within sight of that historic hall where the people of these United States declared their national autonomy.

Philadelphia, birthplace of industrial chemistry on this side of the Atlantic, on September 2 to 6 welcomes the AMERICAN CHEMICAL SOCIETY which in the last five years has done so much to arouse America to the value of chemistry as a national asset.

The fifty-eighth meeting which next month convenes in the City of Penn undoubtedly will be the most significant which has ever been held. It will be one which none can afford to miss, because it will be the starting point of important new movements and the rallying place for leaders in the era of reconstruction now upon us.

Scores of processes and discoveries which were the direct outcome of war emergency measures will now have their application to the arts of peace. Officers of the Chemical Warfare Service of the United States will be present to tell of developments which came under their personal observation and many new applications of new-found knowledge will be suggested.

So much impressed is the Honorable Newton D. Baker with the relation of chemistry, science of sciences, both to the military and industrial strength of the country, that he has accepted an invitation to address the meeting. Several other government officials may also be present, including Mr. A. Mitchell Palmer, Attorney General of the United States. The occasion will have as its keynote the recognition of the services of chemistry in all branches of commerce and industry.

The Provisional Program which has been issued from the office of the Secretary contains many indications of the far-reaching interest of the discussions and papers.

The recently organized Dye Section will have its first meetings. The revolution which has come upon chemical and color industry of the nation it is expected will be exemplified in many ways during the sessions of this young and vigorous organization. The taking over of 4500 patents by the Chemical Foundation, Inc., the development of new processes, and the general policy with regard to this industry into which suitable legislation will breathe the breath of life, will draw the attention not only of the members of the profession but of all divisions of manufacturing and chemistry.

Prominent speakers will discuss reforms in our patent laws in a symposium which has been arranged in which the newly formed Dye Section and the Pharmaceutical Division will unite with the Division of Industrial Chemists and Chemical Engineers. One of the objects of this interchange will be to devise means to exterminate the patent pirates who for years have been preying upon inventors. The files of the Patent Office show that it is burdened with all manner of patents granted to men who have never used them and have never intended to employ them except to prevent others from using them. It is proposed that the requiring of an annual renewal fee would prevent this unwelcome class from levying tribute.

The recently organized Rubber Division will also have many new developments which will interest the technical men in many industries.

A special topic will be "Refractories" taken up by the Division of Industrial Chemists and Chemical Engineers.

An elaborate program is under consideration by the Division of Agricultural and Food Chemistry, for the chemist in these days, when the high cost of living must be put down in some way, will be called on for suggestions and advice.

The indications are that there will be at least two thousand members present, for Philadelphia is so close to the chemical center of the Union, that all roads will lead to it. As the greatest of the applied sciences enters upon its enlarged mission, the opportunities for conference and for getting in touch with the newest ideas both in theoretical and industrial chemistry afforded by this fall meeting are likely to be grasped by a large number of the SOCIETY membership. The fact that the Philadelphia meeting is held in the vacation time of chemists who are also instructors in schools and colleges, will make it unusually attractive to educators, many of whom have declared they will attend.

The local committee, therefore, urges that all who are planning to go will see to their hotel reservations as soon as possible. The official headquarters will be the Bellevue-Stratford, the entire first floor of which has been engaged by the SOCIETY for its deliberations. As the Knights Templar are holding their annual convention in Philadelphia the following week, and some are likely to appear before the formal conclave, the sooner members of the SOCIETY get into communication with the hotels the better.

Dr. Charles L. Parsons, the Secretary of the SOCIETY, before he left for Europe made a survey of the rooms at the Bellevue-Stratford with the local committee. The general meetings will be held in the grand ballroom and on the same floor are commodious apartments which can be employed by the various sections. The Red Room, the Clover Room, the Green Room, and similar rooms will accommodate from 60 to 200 persons each and will thus serve excellently for committee and divisional and sectional sessions.

When Dr. William H. Nichols delivers his annual address he will stand in the auditorium of the museum of the University of Pennsylvania. The going of the SOCIETY to this historic university where great leaders of modern industrial chemistry labored for the cause of science and industry is significant. The eminent historian of American chemistry, Provost Edgar F. Smith, has told the scientific world of the great work done in this institution by such leaders as Dr. Benjamin Rush, Dr. de Normandie, Robert Hare and other chemists of renown. Here the visitor may trace the footsteps of such pioneers of the profession as Priestly and Silliman.

The tremendous strides which American chemistry made during the war and its ability to maintain itself against all foreign competition under fair conditions, will be visualized in visits to the great chemical plants in the vicinity, all of which will be open to visiting delegates.

Among the excursions planned is a trip by boat down the Delaware so that visitors may get a good view, not only of the important chemical establishments there, but also of the Hog Island Shipyard and the League Island Navy Yard.

There will also be a trip by automobile to Valley Forge and the scenes hallowed by the ragged Continentals under Washington.

The social side of the Philadelphia meeting will be most attractive. Members bringing their wives and daughters will find many ways devised by a city famed for its hospitality to make their stay enjoyable. Mrs. Harry F. Keller has accepted the chairmanship of the Ladies' Committee.

For the men, the smoker to be held at the Scottish Rite Hall at Broad and Race streets, will have diverting features besides the appearance of Princess Nicotine.

The clubs of the city and various social organizations are seconding the efforts of the entertainment committee of the local section to make the Philadelphia meeting a calendar of red letter days.

PROVISIONAL PROGRAM

FALL MEETING AMERICAN CHEMICAL SOCIETY, PHILADELPHIA
SEPTEMBER 2-6, 1919

Tuesday, September 2

4.00 P.M.—Council Meeting, Bellevue-Stratford
6.30 P.M.—Dinner to the Council at the Bellevue-Stratford, tendered by the Philadelphia Section

Wednesday, September 3

10.00 A.M.—General Meeting, Bellevue-Stratford Ball Room

Address of Welcome
Response
Business Meeting
General Addresses

2.00 P.M.—Divisional Meetings

8.00 P.M.—Smoker, Scottish Rite Hall, Broad and Race Streets, Philadelphia

Thursday, September 4

Morning: Divisional Meetings

Afternoon: Excursions

8.30 P.M.—President's Address, Museum of the University of Pennsylvania

Friday, September 5

Morning: Divisional Meetings

Afternoon: Divisional Meetings

7.00 P.M.—Banquet, Bellevue-Stratford Ball Room

Saturday, September 6

Morning: Excursions

Afternoon: Automobile Trip to Valley Forge

NEWS SYNOPSIS

As a direct outgrowth of the important services rendered by the chemists of the United States both in the European War and in these days of reconstruction, the newspaper press is showing a deep interest in all chemical matters. The Philadelphia Section, in order to assist the lay press in the preparation of reports of the approaching Philadelphia meeting which will be complete, accurate, and dignified, is financing the publicity work. The Press Room to be established at the Bellevue-Stratford will be in charge of Mr. John Walker Harrington, an experienced newspaper man who is also connected with the A. C. S. News Service.

Members presenting papers which are likely to be of a special interest to the general public would greatly facilitate the work of the press bureau if they would furnish synopses in non-technical language or send such upon request. Carbon copies of the entire paper may also be sent from which condensations can be made and submitted to the authors for revision, if desired. These synopses are for distribution in advance to press associations and newspaper representatives subject to release after their delivery. They may be sent either to the office of the Secretary or forwarded to Dr. C. H. Herty, Director, A. C. S. News Service, 35 East 41st Street, New York City.

SCIENTIFIC SOCIETIES

TENTATIVE STANDARD METHODS FOR THE SAMPLING AND ANALYSIS OF COMMERCIAL SOAPS AND SOAP PRODUCTS

To the Division of Industrial Chemists and Chemical Engineers of the American Chemical Society:

Your Committee on the Methods of Analysis and Specifications of Commercial Soaps and Soap Products begs leave to report as follows:

Tentative standard methods for the sampling and analysis of commercial soaps and soap products were unanimously adopted April 8, 1919, and typewritten copy of the same is herewith submitted for publication in the *Journal of Industrial and Engineering Chemistry*.

The purpose of publishing these tentative methods is to elicit suggestions and criticisms from the soap and soap products industry. All such communications should be addressed to Archibald Campbell, *Chairman*, care of the Globe Soap Company, Cincinnati, Ohio, and will be referred to the Committee.

The personnel of your Committee is at present as follows:

C. P. LONG	DERBY H. WALKER
J. R. POWELL	ARCHIBALD CAMPBELL,
ROBT. E. DIVINE	<i>Chairman</i>

Your Committee has been unable to agree in several instances on one method of analysis and has reported alternative methods; and it proposes to do more coöperative work to test out the relative merits of these various methods as well as any others suggested, preparatory to adopting standard methods for the sampling and analysis of commercial soaps and soap products and of recommending the same to the Supervisory Committee for adoption by our SOCIETY.

Your Committee therefore recommends that it be continued in existence by the Division until this work is completed.

SAMPLING

Take samples from at least 3 per cent of the containers, taking one bar, or package, or in bulk goods, at least $\frac{1}{4}$ lb., or $\frac{1}{2}$ pt. in case of liquid soap, from each container. In quantities of less than 100 containers, take at least three samples. Wrap bar samples tightly in paraffined paper at once, and seal by rubbing edges with a heated iron. If possible, place the wrapped bar in an air-tight container, in which it should fit very closely.

Chip soap and powders are to be sealed air tight in completely filled containers. Liquid soap is to be placed in clean, dry bottles or cans which should be completely filled and securely stoppered with new corks. All samples should be kept cool until tested. In drawing sample of bar, cake, or package goods, the gross weight of final sample to be sent to any one laboratory shall be recorded at the time of taking and sealing.

PREPARATION OF SAMPLE

BAR SOAP—Run complete separate analyses on 25 per cent of the individual bars taken and in no case run less than two analyses. The average of these analyses is to be taken as that of the lot. For these analyses, quarter the bar by cutting at right angles in the center and shave equally from all freshly cut surfaces sufficient soap for the analyses. In case of soaps that can be easily powdered, the entire sample may be run through a suitable food chopper.

LIQUID SOAP—No preparation of the sample, other than thorough mixing, is necessary unless it is received during very cold weather, when it should be allowed to stand at least 1 hr. after it has warmed up to room temperature (20° to 30° C.) before it is noted whether it forms a satisfactory lather.

POWDERED AND CHIP SOAPS—Rapidly disintegrate and mix the sample and weigh out all the portions for the analyses.

Unused portions of the original sample shall be preserved in sealed air-tight containers in a cool place.

ANALYSIS

COMBINED ALKALI, NEUTRAL SOAP, FATTY ANHYDRIDE—Dissolve 10 g. of soap in about 100 cc. of water in a weighed 400 cc. Erlenmeyer flask. When solution is complete, add dilute sulfuric acid in slight excess, insert a small funnel in the neck of the flask, and heat the flask on a steam bath until the fatty acids float on top in a clear, oily layer. Avoid a higher temperature than 80° C. Allow to cool. For the extraction of the fatty acids, redistilled gasoline of boiling point below 65° C. should be used. Pour the contents of the flask, both fatty acids and acid water, into a 300 cc. Squibb's separatory funnel, washing out any adhering fat from the flask with gasoline, and make the first separation, saving the acid water for further extractions, using 50 to 75 cc. gasoline. Wash the gasoline solution in the separatory funnel two or three times with small amounts

of distilled water (15 to 25 cc.) avoiding too violent agitation to prevent emulsifying. The last washing should be free from sulfates. Draw off the wash water and emulsion down to the gasoline layer into the acid liquor. Filter the gasoline solution through a filter wet with gasoline into a 500 cc. beaker flask, care being taken to introduce no water into the filtering funnel. The filter should be $\frac{3}{4}$ to 1 in. below the rim of the funnel when in place. Now extract the acid water using 50 cc. gasoline for the first extraction. Wash as before and filter the gasoline into the flask. For the two succeeding extractions of the acid water smaller quantities of gasoline suffice, but at least 25 cc. should be used. Wash the filter free from fatty acids. This is best done by allowing to drain well, then tucking in the upper edges of the filter and washing with a spray from a wash bottle. Save the acid water for chloride determination.

Add 100 cc. freshly boiled neutral 95 per cent alcohol to the solution in the flask and titrate with standard sodium hydroxide to exact neutrality, using phenolphthalein as indicator. Transfer without filtering to a tared 150 to 200 cc. Soxhlet flask on the steam bath. Evaporate the gasoline and the alcohol as much as possible. A small stirring rod should be tared with the Soxhlet flask to be used for breaking up the soap to insure complete drying. Dry to constant weight in the oven at not over 105° C. Weigh as soda soap. This fatty matter naturally includes any mineral oil, neutral fat, and rosin acids, which, if determined separately, must be deducted from the result to obtain the true fatty soap. Calculate the combined sodium oxide (Na_2O) and deduct from weight of soda soap, giving the fatty anhydride. If original soap was potash soap, proper calculation must be made to reduce to potassium oxide (K_2O). In case the soap shows an excess of free fatty acid, proper corrections must be made in calculating the combined alkali in the original soap.

NOTE—A blank test should be made on the sodium hydroxide solution for neutral salts and the proper corrections made if necessary.

CHAIRMAN'S NOTE—In view of some recent cooperative work by the Total Fatty Acid Committee of the Society of Cotton Products Analysts, it will be well to check the drying of the soap in a vacuum oven or in an atmosphere of inert gas, especially where a drying oil is present in quantity in the soap.

FREE CAUSTIC OR ACID, FREE CARBONATE, SILICATE, WATER, INSOLUBLE MATTER, BORAX, PHOSPHATE, STARCH, ETC.

Digest hot a 10-g. sample of soap with 200 cc. high proof (94 per cent or higher) ethyl alcohol, freshly boiled and neutral to phenolphthalein, in 250 cc. beaker. Filter with suction through a neutralized counterpoised filter paper and protect the solution during the operation from carbon dioxide and other acid fumes. Wash the residue on the filter with hot neutral ethyl alcohol until free from soap. Titrate filtrate, using phenolphthalein as an indicator, and calculate the alkalinity to sodium hydroxide or potassium hydroxide, and acidity to oleic acid. Dry the filter papers and weigh as alcohol-insoluble.

NOTE—If starch is present, remove water-soluble in warm water without heating above 60° C. Determine starch¹ as follows:

Stir a convenient quantity of the sample (representing from 2.5 to 3 g. of the dry material) in a beaker with 50 cc. of water for an hour. Transfer to a filter and wash with 250 cc. of water. Heat the insoluble residue for $2\frac{1}{2}$ hrs. with 200 cc. of water and 20 cc. of hydrochloric acid (sp. gr. 1.125) in a flask provided with a reflux condenser. Cool, and nearly neutralize with sodium hydroxide. Complete the volume to 250 cc., filter, and determine the dextrose by the gravimetric method for determination of dextrose given under method of determining sugar in soap. The weight of dextrose obtained multiplied by 0.90

¹ Method A, Bureau of Chemistry Bulletin 107, p. 53; given also in the "Handbook of Sugar Analysis," C. A. Browne, 1912 Ed., p. 439.

gives the weight of starch. If sugar is also present, a correction must be made for the starch found. Refer to method of determining sugar in soap.

ANALYSIS OF ALCOHOL-INSOLUBLE—*Water-Insoluble*—Take up with hot water, filter, wash with hot water, dry and weigh residue as water-insoluble. (Make qualitative test on residue to determine its nature.)

Water-Soluble—Dilute filtrate from water-insoluble to 250 cc. In aliquot parts of this solution determine:

1—Total alkalinity by titration with methyl orange as indicator.

2—Borax by using the solution from 1. Boil under a reflux condenser several minutes to remove carbon dioxide. Wash out the condenser with water. Render the boiled solution exactly neutral to methyl orange. Cool and add 20 cc. glycerin. Titrate with $N/2$ sodium hydroxide, using phenolphthalein as an indicator, until the end-point is reached. Add 10 cc. more of glycerin and note if the red coloration disappears. If it does not disappear, as is usually the case, sodium hydroxide is added until the red color reappears. Another 10 cc. of glycerin is added, and the process repeated until a sharp color change takes place which does not disappear on the addition of more glycerin. Figure as boric oxide or borax as required.

3—Carbon dioxide by absorption method.

4—Silica (SiO_2) by any suitable method.

5—Phosphates by any suitable method.

MOISTURE AND VOLATILE MATTER

Weigh out 10 g. of the sample. Dry to constant weight in oven at a temperature not exceeding 105° C. Report loss in weight as moisture and volatile matter.

NOTE—After drying for an hour, time can be saved by adding 50 cc. absolute alcohol and then continuing the drying process in the oven.

CHLORIDE

The acid water from which the fatty acids have been separated is carefully saved and neutralized with chlorine-free alkali. The chloride is titrated with standard silver nitrate solution, using potassium chromate as indicator and the results calculated to sodium chloride or potassium chloride as the character of the soap indicates.

UNSAAPONIFIED AND UNSAPONIFIABLE

NOTE—The Committee has been unable to agree upon a single solvent for unsaponifiable and invites comparisons and criticisms of the two methods given.

ETHYL ETHER METHOD—Weigh 5 g. of the soap into a beaker and dissolve in about 100 cc. of 50 per cent alcohol on the steam bath. If the sample has been found to contain free fatty acid, add just enough aqueous alkali to neutralize this. Evaporate off the bulk of the alcohol, take up with about 200 cc. of hot water and transfer to a separatory funnel of about 500 cc. capacity, designated as No. 1. When cool, rinse out the beaker with about 50 cc. of ether and add it to the soap solution. Shake thoroughly for one minute. By the addition of small amounts of alcohol (5 cc. portions and the total not to exceed 25 cc.), a clear and rapid separation of the aqueous and ether layers is effected. After adding each alcohol portion, the separatory funnel is not shaken but merely given a whirling movement. The aqueous portion is drawn off into another separatory funnel, designated as No. 2. The ether solution is washed with 10 cc. portions of water until this water is no longer alkaline to phenolphthalein. All these washings are added to funnel No. 2 and this solution is extracted with 20 cc. portions of ether until the ether is absolutely colorless (3 or 4 extractions should be sufficient). These ether extracts are combined in a third separatory funnel (No. 3) and washed with 10 cc. portions of water until the water is no longer alkaline to phenolphthalein. The ether in Funnel No. 3 is now added to that in Funnel No.

1, a small amount of ether being used to rinse out Funnel No. 3. The ether solution is now washed with 20 cc. of 10 per cent hydrochloric acid solution and then successively with 20 cc. portions of water until the water is no longer acid to methyl orange. The ether solution is then filtered through a dry filter paper into a weighed beaker or flask. The ether is evaporated or distilled off on the steam bath and the residue is heated with alcohol and, when cool, it is neutralized with standard alkali, using phenolphthalein. Any appreciable amount of fatty acid found is deducted from the weight of the residue. This residue consists of the unsaponifiable and any neutral fat that may have been present in the soap, in which case, saponification of the residue is necessary and a second residue is obtained which will represent the unsaponifiable matter only. The difference between the weights of the two residues is, of course, the neutral fat.

GASOLINE METHOD—Dissolve 5 g. of soap in 20 cc. 70 per cent ethyl alcohol, transfer to a Squibb's separatory funnel, using 20 cc. 30 per cent ethyl alcohol to wash out the first vessel used. Cool to room temperature and extract with 5 portions of 50 cc. gasoline (boiling point below 65° C.), in same manner as under fatty anhydride. Wash the gasoline extracts with three portions of 25 cc. each of 10 per cent alcohol. Transfer the gasoline solution to a weighed beaker, evaporate on the steam bath under a current of air, dry in oven at 105° C. to constant weight.

NOTE—Test unsaponifiable for soap.

ROSIN

NOTE—The Wolf method is much more convenient and rapid than the Twitchell. The committee requests cooperative work to compare the accuracy of these methods before making a choice.

TWITCHELL'S METHOD—Weigh out accurately into a dry filter flask from 3 to 5 g. of the filtered and dried fatty acids prepared from soap. Dissolve this sample in ten times its volume of absolute alcohol, place the flask in ice water and pass a current of dry hydrochloric acid gas through the solution until there is no further absorption of gas. Cork tightly and let stand for 2 hrs., shaking occasionally. During this time, the esters of the fatty acids and the rosin acids will separate as oily drops on the surface of the liquid. Add about 400–500 cc. of water and a small piece of granulated zinc to prevent bumping and boil until the solution is clear. Transfer to a separatory funnel and make repeated extractions with ether as in the determination of fatty acids. The ether extract is washed repeatedly with distilled water until washings are neutral to methyl orange. About an equal volume of freshly boiled alcohol, neutral to phenolphthalein, is then added to the ether extract and the whole is titrated with standard sodium hydroxide solution, phenolphthalein being used as an indicator. Each cubic centimeter of *N* sodium hydroxide solution corresponds to 0.346 g. of rosin in the sample of fatty acid weighed out. Check by evaporation to dryness and weigh as rosin soap. Calculate percentages on original sample.

WOLFF'S METHOD (*C. A.*, 8 (1914), 2495)—Dissolve 3 g. of the dried fatty acids as above in 20 cc. of absolute alcohol. Then add 10 cc. of a solution of one volume of concentrated sulfuric acid (sp. gr. 1.84) and four volumes of absolute alcohol, and boil for 4 min. under a reflux condenser. Add to the liquid about five times its volume of 7 to 10 per cent of sodium chloride solution and extract with ether. Shake out the aqueous portion two or three times with ether. Unite the ether solutions and wash with sodium chloride solution until the washings are neutral. Add 30 cc. neutral alcohol. Titrate the rosin acids with standard sodium hydroxide solution (1 cc. normal alkali = 0.346 g. rosin). Calculate percentage of rosin in original sample.

SUGAR

REAGENTS (a) *Copper sulfate solution.* 34.639 g. of crystallized copper sulfate are dissolved in water and made up to

500 cc. (b) *Alkaline tartrate solution.* Dissolve 173 g. of Rochelle salts and 125 g. of potassium hydroxide in water and dilute to 500 cc.

Place 10 g. of soap in a 500 cc. Erlenmeyer flask and dissolve in 100 cc. of distilled water. Cool the solution down to 68° C. Add 11 cc. concentrated hydrochloric acid and maintain at this temperature for 15 min. By this treatment the sugar in the soap should have been completely inverted, the soap being decomposed, and the free fatty acids floating on top. Cool until the free fatty acids are completely solidified. Filter and wash into a 250 cc. graduated flask. Before flask is filled neutralize the solution with a strong caustic solution, using methyl orange as indicator. Bring to room temperature and make up to volume. The sugar is determined in an aliquot part of this solution, Allihn's method¹ being used as follows:

Place 30 cc. of the copper sulfate solution, 30 cc. of the alkaline tartrate solution, and 60 cc. of water in a beaker and heat to boiling. Add 25 cc. of the invert sugar solution which must be so prepared as not to contain more than 0.250 g. of dextrose, and boil for 2 min. Filter at once, without diluting, through a Gooch crucible which has been previously prepared and weighed. Wash with hot water and dry to constant weight at 105° C. By referring to Allihn's table for the determination of dextrose,² the corresponding amount of dextrose can be obtained. This, multiplied by 0.95 and divided by 10, gives the percentage by weight of the sugar in soap.

NOTE—If starch is present, it must be determined upon alcohol-insoluble, and correction made.

The acid liquor from the fatty acids determination is neutralized with barium carbonate and the whole evaporated over a steam bath to near dryness. The mass of barium sulfate and carbonate containing glycerin is now extracted with a mixture of absolute ethyl alcohol and ether (one part ether to three parts of ethyl alcohol by volume). The alcohol-ether solution is filtered directly into an acetylation flask. The extractions should be made by the use of numerous small portions of the solvent. Care should be taken to see that all lumps are broken, and the whole mass and filter well washed before the acetylation flask becomes filled. (Note: If flask will not hold filtrate, evaporate in a large flask. Boil up the concentrate with water, transfer to acetylation flask, and evaporate down.) The flask is now put on the steam bath with a current of air blowing on the liquid and so evaporated until all the alcohol and ether is driven off. Care must be taken that all alcohol is completely removed, also that the evaporation is not continued unnecessarily long, as glycerin is more or less volatile under these conditions. To this is added 7.5 cc. of acetic anhydride and 3 g. anhydrous sodium acetate and the mixture boiled for 1 hr. under a reflux condenser. After cooling to below the boiling point of water, 50 cc. of water at about 80° C. are added through the condenser and the mass in the flask completely dissolved. The solution is next filtered into a flask of about 1000 cc. capacity, the filter carefully washed with carbon dioxide-free water, and the solution cooled to room temperature.

Phenolphthalein is added and the free acetic acid neutralized with *N* sodium hydroxide solution free from carbonates. Care must be taken that no portion of the solution becomes at any time strongly alkaline or that the end-point is passed, as either will cause the saponification of the tri-acetin formed, causing low results. 5 cc. of *N* sodium hydroxide free from carbonates are added. The solution is boiled for 1/4 hr., cooled quickly, and the excess of alkali titrated with *N* acid. A blank on the reagents is run under identical conditions. From the difference between the two titrations, the alkali required to saponify

¹ Bureau of Chemistry, *Bulletin* 107, pp. 49–53.

² *Ibid.*, p. 50. Also in the "Handbook of Sugar Analysis," C. A. Browne, 1912 Ed., Appendix, p. 30.

the tri-acetin is determined.¹ (1 cc. *N* sodium hydroxide = 0.03069 g. glycerol.)

CAUTIONS.—Tri-acetin is volatile with water vapor. Avoid boiling of solution of tri-acetin. Solutions should be free from carbonates as they introduce serious errors with phenolphthalein. Great care must be taken in approaching the end-point when neutralizing the free acetic acid as it is not possible to titrate back.

Sugars affect the acetin method in proportion to the number of hydroxyl groups present.

THE GLOBE SOAP COMPANY
CINCINNATI, OHIO

ARCHIBALD CAMPBELL,
Chairman

AMERICAN CHEMICAL SOCIETY ADVISORY COMMITTEE MEETING

The Advisory Committee of the AMERICAN CHEMICAL SOCIETY met at the residence of President Nichols in New York City at 5 P.M., June 24, 1919, with Messrs. Nichols, Herty, Hesse, and Parsons present.

President Nichols added Dr. Frederick Bates and Dr. Charles A. Browne to the Committee to Formulate Specifications for the Construction of a Polariscope for Laboratory Use.

The Committee considered a request from the Bureau of Foreign and Domestic Commerce to nominate a member of the SOCIETY to proceed to South America for the Bureau of Foreign and Domestic Commerce to study South American chemical trade. The Committee unanimously recommended J. Enrique Zanetti.

A letter was presented to the Advisory Committee from the National Research Council, nominating Dr. E. W. Washburn, Dr. Chas. L. Parsons, Dr. H. S. Washington, Dr. F. G. Cottrell, Dr. Julius Stieglitz, and Lt. Col. Edward Bartow as delegates to the proposed organization of an International Chemical Council, or Union, to meet in London, July 15-18, 1919, and nominating Lt. Col. A. B. Lamb and Lt. Col. James F. Norris as alternates, with the suggestion that all of the official delegates who are members of the AMERICAN CHEMICAL SOCIETY be given credentials from the AMERICAN CHEMICAL SOCIETY. It was expected that funds would be available for the payment of expenses of those delegates who should attend the conference from this side.

It was voted that credentials be given and that the above mentioned members be made delegates of the AMERICAN CHEMICAL SOCIETY to consider the organization of an International Chemical Council, or Union, but without authority to commit the AMERICAN CHEMICAL SOCIETY thereto.

The Advisory Committee, on the authority given it by the Council, unanimously recommended Prof. W. A. Noyes as chairman of the board of editors in charge of the scientific series of monographs, and Dr. John Johnston as chairman of the board of editors of the technological series of monographs recommended by the Committee on Publication of Compendia of Chemical Literature, which report was adopted by the Council and the election of editors referred with power to the Advisory Committee.

It was further voted that Doctors Noyes and Johnston should nominate the other four members of the Board of Editors, which nominees, if satisfactory, should be appointed by the president.

It was voted that the series of monographs be known as the "American Chemical Society Monographs—(1) Scientific Series; (2) Technological Series."

It was voted that the Advisory Committee recommend to the Directors that the salary of the chairman of each board of editors be fixed at \$1,000 a year.

It was voted that the Advisory Committee recommend to the Directors that royalties not to exceed \$500 be paid in advance

to each author chosen by the Committee to write a monograph, and that an additional sum of like magnitude be paid to him upon the completion and acceptance of his monograph, the amount so paid to be deducted from any royalties received until such time as the amounts advanced are returned to the SOCIETY or its agent; that thereafter any royalties received should be paid one-third to the AMERICAN CHEMICAL SOCIETY and two-thirds to the author of the monographs.

It was voted that a by-law be put in form to be presented for discussion, and possible adoption, at the next meeting of the Council, permitting "Associate Members" of Divisions, such members to pay not less than two dollars a year to the treasurer of the Division, it being distinctly understood, as in the case of local sections, that such "Associate Members" are to be members of the Division only, and not members of the AMERICAN CHEMICAL SOCIETY.

A communication was received from the chairman of the Pharmaceutical Division, calling the attention of the SOCIETY to the fact that the AMERICAN CHEMICAL SOCIETY should appoint three delegates to the regular decennial meeting of the Pharmacopoeia Convention. The president, with the advice of the Committee, appointed Frank O. Taylor, chairman of the Pharmaceutical Division, F. R. Eldred, and B. L. Murray delegates to the Pharmacopoeia Convention.

An invitation was received from the Bureau of Mines for the AMERICAN CHEMICAL SOCIETY to appoint delegates to attend the ceremonies, exhibits, and demonstrations to be given at Pittsburgh, Pa., September 29-30 and October 1 at the time of the dedication of the new buildings of the Bureau of Mines. The president appointed R. F. Bacon, A. V. Bleining, G. A. Burrell, F. G. Cottrell, J. O. Handy, G. A. Hulet, G. F. Mason, Samuel R. Scholes, and Alexander Silverman.

A letter was received from Mr. Edwin J. Prindle, chairman of the SOCIETY's Committee on Patent and Related Legislation, regarding House of Representatives Bill 5011, 66th Congress, 1st Session, being a bill "To establish a Patent and Trade-Mark Office independent of any other department and to provide for compensation and infringement of patents in the form of general damages, and for other purposes," and House of Representatives Bill 5012, 66th Congress, 1st Session, being a bill "To establish a United States Court of Patent Appeals, and for other purposes," these bills being the outcome of the recommendations in the report of the Committee on Patents of the National Research Council; it was also the report to the AMERICAN CHEMICAL SOCIETY which was presented to the Council at its Buffalo meeting. The bills having been carefully examined, the Advisory Committee, on the authority given it by the Council, voted that the full support of the AMERICAN CHEMICAL SOCIETY be given to these bills, as they believe they are essential to the proper administration of American patents; that Mr. Edwin J. Prindle, chairman of the AMERICAN CHEMICAL SOCIETY's Committee on Patent and Related Legislation be authorized to speak for the SOCIETY in favor of the passage of these bills; and that all members of the AMERICAN CHEMICAL SOCIETY be requested to write to their Congressmen and Senators urging prompt adoption of this important legislation.

The Committee on National Policy of the AMERICAN CHEMICAL SOCIETY, authorized by the Council to speak for the SOCIETY on matters of national policy, recommends heartily to Congress an increase in the force and salaries of the Patent Office, as recommended by the Patent Committee of the National Research Council. They believe such increase in personnel and salaries essential to the proper administration of the Patent Office.

Under the instructions from the Council, as printed on page 91 of the Proceedings for 1919, the Advisory Committee drew up the following resolutions to be presented to the President of

¹ For details see THIS JOURNAL, 3 (1911), 682.

the United States and to Congress, regarding the future work of the Chemical Warfare Service:

WHEREAS, the present war has conclusively shown that chemical warfare is a new, permanent, and essential weapon in modern military operations, and

WHEREAS, the United States must at all times be amply supplied with the best and most complete means for chemical warfare; now, therefore, be it

Resolved, that the AMERICAN CHEMICAL SOCIETY respectfully urge upon the President and the Congress of the United States the paramount necessity of conducting its Chemical Warfare Service in all its branches as a separate unit and that the Chemical Warfare Service be charged with the responsibility of developing and maintaining the chemical equipment of the United States Army at the highest efficiency.

Resolved, that the AMERICAN CHEMICAL SOCIETY, the largest organization of chemists in the world, having 13,500 members, offer its aid whole-heartedly to the Chemical Warfare Service in any way that may lead to the country's chemical preparedness.

The Committee then adjourned.

WASHINGTON, D. C.

CHAS. L. PARSONS, *Secretary*

A copy of the above resolutions regarding the Chemical Warfare Service was transmitted by the Secretary of the AMERICAN CHEMICAL SOCIETY to Secretary of War Baker, who replied as follows:

DEAR MR. PARSONS:

I beg leave thus formally to acknowledge receipt of your letter of June 25, transmitting a copy of the resolutions adopted by the American Chemical Society with regard to the value of chemistry in modern warfare, and tendering the aid of the American Chemical Society to the War Department with a view to placing at the disposal of the country the invaluable services of this great group of scientists.

During the progress of the war this Department was immeasurably aided by the patriotic and self-sacrificing service which men of science gave, and among the great group of scientists who thus served were many members of the American Chemical Society. I take this opportunity, therefore, not only to express my deep appreciation of the services already loyally rendered, but also of this whole-hearted offer of future coöperation.

Cordially yours,

WASHINGTON, D. C.
June 26, 1919

NEWTON D. BAKER

ACCEPTANCE OF HONORARY MEMBERSHIP IN THE AMERICAN CHEMICAL SOCIETY¹

DR. CHARLES L. PARSONS,

Secretary of the American Chemical Society,
Washington, D. C.

DEAR COLLEAGUE:

I thank you very much for your kind letter in which you notify me of my election as honorary member of the American Chemical Society.

I express to you and your illustrious colleagues my indebtedness for such a high proof of your esteem, in proposing me for such a great distinction, and my most vivid recognition of it, and I consent to take part in the quality of honorary member of the American Chemical Society.

Praying that you will accept my most distinguished salutations,

Yours sincerely,

LABORATORY OF GENERAL CHEMISTRY
UNIVERSITY OF BOLOGNA
May 6, 1919

G. CIAMICIAN

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

The 11th Semi-Annual Meeting of the American Institute of Chemical Engineers was held in Boston, Mass., June 18 to 21, 1919. The first session of the meeting was held at the Engineers' Club on Wednesday morning, President Arthur D. Little in the Chair. The attendance was so large that the assembly room of the Club was crowded to the limit. The symposium on electric furnaces, which was presented during the first day's session, proved to be of such great interest and importance that both members and non-members were in attendance in greater number than at any preceding meeting.

At the business session the reports of the Secretary and the Membership Committee showed a continued growth in membership, the total being 333, with a considerable number of applications not yet acted upon. The Treasurer reported a very satisfactory financial condition.

The Committee on Publications reported that the increase in amount of matter presented for publication in the Transactions was so great that it was advisable to publish the annual volume of Transactions in two parts. Under this plan papers presented at a meeting would be assembled and printed immediately. The recommendation of the Committee was adopted by a unanimous vote and later the Council authorized the secretary to proceed with the publication as suggested by the Committee.

The Committee on Chemical Engineering Education reported progress, Dr. Mann's report being the main subject dealt with. By special arrangement with the Carnegie Foundation, members of the Institute were privileged to receive a copy of Dr. Mann's report on request.

The Committee on Meetings reported invitations from Savannah and Atlanta for the winter meeting. Mr. David Wesson, of the Southern Cotton Oil Company, presented an invitation from Savannah and described the delightful climate in this region in the winter. Members present were in favor of Savannah, and later the Council voted to hold the winter meeting at Savannah early in December. A meeting will, therefore, be arranged for Savannah, plans being made for visits to the typical southern industries.

The symposium on electric furnaces was introduced by Mr. C. T. Bragg, of the Michigan Smelting and Refining Company, Detroit, Michigan. Mr. Bragg spoke of "The Future of the Electric Furnace," and prophesied a large extension of its use. Mr. H. W. Gillett, of the Bureau of Mines, read a paper on "Utilization of Electric Brass Furnaces." Mr. T. F. Baily, of the Electric Furnace Company, presented a paper on "Electric Furnaces of the Resistance Type," and showed moving pictures of the electric furnaces in operation. The rocking electric arc furnace was described by Mr. H. M. St. John, of the Detroit Furnace Company. In this type of furnace the rocking motion secures uniform heating and thorough mixing of the metal and alloy, and insures economy of electric energy. The furnace was shown in operation by means of moving pictures and a very clear conception was obtained in this manner of the construction and operation of this type. After some discussion of the papers already presented, the members adjourned to the dining room of the Club where luncheon was served. The Honorable Andrew J. Peters, Mayor of Boston, was present as the guest of the Institute and addressed the members, welcoming them to Boston. The Mayor expressed appreciation of the important service which the chemical engineers rendered to the Government and the country during the critical war period. President A. D. Little responded to the Mayor and stated that within pistol range of the meeting, the laboratory method of teaching science was first introduced at the Massachusetts Institute of Technology and that the same Institute had recently introduced the direct industry contact in its new school of chemical engineering progress.

¹ A translation from the Italian.

After luncheon Mr. W. L. Towle, of the Westinghouse Electric and Manufacturing Company, presented a paper on "Electrical Considerations of the Electric Furnace Installation." Mr. Towle explained how the electric current could be most economically made available and used in electric furnaces. The paper on the "Ajax-Wyatt Induction Furnace," by Mr. G. H. Clamer, of the Ajax Metal Company, was read by Mr. C. T. Bragg, as Mr. Clamer unfortunately could not be in attendance. The paper by Dr. E. F. Northrup, of the Palmer Physical Laboratory, Princeton University, on "Some Practical Results Secured with High-Frequency Induction Furnaces," was also read by Mr. Bragg. The results obtained by Dr. Northrup were very remarkable, especially along the lines of reducing the amount of refractory lining and high efficiency in use of the current.

Mr. C. H. Booth, of the Booth-Hall Company, read a paper on "The Booth-Hall Rotating Furnace." The construction and operation of the furnace was illustrated by lantern slides.

Mr. C. A. Winter, of Schenectady, spoke, during the discussion, of the very considerable increase of efficiency in the utilization of power which might be expected in the near future. Mr. Collins, of the General Electric Company, described the electric furnace which the General Electric Company is developing. This is a muffled arc type of furnace, which can be built in small and large sizes.

Mr. F. J. Ryan, of Philadelphia, and Mr. E. L. Crosby, also took part in the discussion.

The general impression created by the papers presented was that a great deal of work is being done on the development of the electric furnace, and that its possibilities have by no means been exhausted. Its use is being rapidly extended to a very great variety of metals and alloys.

Wednesday evening the museum and laboratories of A. D. Little, Inc., were inspected. The neat and orderly appearance of the entire building was especially noticeable. The chemical museum as well as the experimental paper mill, which was in operation, proved very interesting to every one present. At 9.00 o'clock the smoker and entertainment, which had been provided by Mr. R. S. Weston, was started. Light refreshments, cigars, and cigarettes were distributed. The entertainment consisted of some very amusing moving pictures and slight-of-hand tricks by an expert performer, who did not seem to think that Mr. David Wesson or Dr. Frerichs, or other highly scientific chemical engineers who were present were very close observers of the method of tying knots or transmitting cards through the air into loaves of bread. Everyone was surprised at how well the chemical engineers joined in the community singing under the leadership of Mr. Weston.

On Thursday morning a party of about 130 boarded the steamer "Gernett" at the North Avenue Pier for a tour of inspection of the industrial plants along the Boston water front. The first place visited was the Boston fish pier, where at least a million pounds of fish are handled every day and sold in quantities of not less than a thousand pounds.

The Revere Sugar Refinery was next visited. This proved to be a modern, strictly up-to-date plant. The bags long used for filtering had been replaced by Sweetland filter presses. The sugar was clarified by a small quantity of filter-cel. The absence of manual labor was noticeable. The centrifugals and driers and other apparatus were of the latest and best.

The next landing was at the Naval Recruiting Station, which was under the general charge of Mr. Henry Howard. The recruits with their officers were lined up for dress parade, while the band played for the benefit of the visitors.

The ship-building plant at Squantum was then visited, where destroyers are being built at a very rapid rate. These vessels were seen in all stages, from one whose keel had been laid the preceding Saturday to vessels nearly ready for com-

mission. After leaving the ship-building plant, the steamer proceeded to Marblehead, where dinner was served at the Eastern Yacht Club. Dr. Chester G. Gilbert, of the Bureau of Mines, addressed the members after dinner on the subject of "Energy in the Realm of Reconstruction." Dr. Gilbert called attention to a number of the very serious problems which the nation is facing, one of the most important being that of labor and immigration. Emphasis was put upon the necessity of excluding undesirable immigrants and also of solving the problems arising from a shortage of labor by increasing the efficiency of existing labor.

On Friday morning the laboratories of the Massachusetts Institute of Technology were inspected. This was followed by a business session and reading of papers. Dr. C. S. Palmer read a paper on "Wool Scouring Wastes," showing the method in use for utilizing this fat.

Dr. Edward Gudeman, of Chicago, opened the symposium on registration of chemists. Dr. Gudeman pointed out the difficulties arising from the fact that at present there are no legal means of excluding incompetent chemists from professional practice and suggested registering and licensing as the remedy. Prof. J. R. Withrow spoke of the laws being passed in western states establishing systems of licensing and called attention to the necessity of care that unwise legislation should not be enacted.

Prof. A. W. Smith and Mr. David Wesson took the negative stand on the question and objected to licensing chemists as beneath the dignity of the profession and also not likely to accomplish any good results. During the discussion Dr. A. C. Langmuir raised the question as to whether, on account of the labor unions, it might become necessary for chemists to organize for the purpose of obtaining adequate compensation for their services.

Mr. W. H. Russell read a very comprehensive paper on "The Growth and Development of the Manufacturing Plant of the Providence Gas Company," showing a great many lantern slides of this very modern and efficient gas manufacturing plant. The paper on "The Manufacture of Castor Oil in the United States," by J. S. Shrader, was read by title, as was also the paper on "Flash and Burning Points of Gasoline-Kerosene Mixtures," by James T. Robson and James R. Withrow.

Luncheon was served at Walker Memorial Hall. Mr. E. J. Prindle, secretary of the Patent Committee of the National Research Council, was introduced. Mr. Prindle urged upon the members the program of improvement of the patent office and patent system which has been adopted by the Patent Committee of the National Research Council. The Patent Committee of the Institute, headed by Dr. L. H. Baekeland, had reported the same program at the morning meeting. A resolution was adopted by the Institute endorsing the reforms recommended by the Patent Committee.

The members of the Institute and their guests then proceeded to Harvard University, where the Peabody Museum, the Wolcott Gibbs Laboratory of Research Chemistry, and the Jefferson Laboratory of Physical Research, were inspected. The party was then taken for a sight-seeing trip through Cambridge, Charlestown, and historic Boston, and then proceeded to the Country Club at Brookline, where dinner was served. The after-dinner program was presided over by President Little, who called upon Mr. Henry Howard to speak on the system of recruiting for the United States Merchant Marine which Mr. Howard had organized. He told of how stations were established along the Atlantic and Pacific coasts and in how remarkably short a time sailors and petty officers were provided in sufficient numbers to man the ships of the United States Emergency Fleet Corporation.

Prof. D. C. Jackson, head of the electrical engineering department of the Massachusetts Institute of Technology, was then

called upon to give his impressions of the reconstruction needed in France. Prof. Jackson, as Lieutenant Colonel, had spent some time in the devastated area in France. He gave a very interesting account of the overseas work in connection with the American troops transported to France, and also the tremendous task of reconstruction required to place France in its pre-war condition, so far as its industries are concerned. Everyone was interested to learn that it is entirely feasible to restore Rheims Cathedral.

Col. W. H. Walker was then called upon to give his experience in the gas warfare service of the United States. Col. Walker emphasized the necessity of organizing an army of the United States on such a basis that a permanent military class will not be established in the United States.

On Saturday morning a private car was provided for the trip to Lawrence, Mass., where the Pacific Mills were visited. The entire process of cloth printing was inspected, including the etching of the designs on the brass cylinders used for printing.

On returning to Boston a sight-seeing trip to Lexington and Concord was taken by a party of about forty.

The large number of ladies in attendance were entertained at a luncheon at the Hotel Lenox on Wednesday, followed by a visit to the Forsyth Dental Infirmary and the Boston Museum of Fine Arts, and a theatre party in the evening. During Thursday the ladies accompanied the men on the steamer trip around the harbor and had dinner at the Eastern Yacht Club. On Friday morning the ladies inspected the laboratories of the Massachusetts Institute of Technology and then the candy factory of Page and Shaw. This proved particularly interesting. They then visited the laboratories of A. D. Little, Inc., and spent the afternoon and evening with the men. They also accompanied the men on the trips Saturday morning and afternoon.

It was the general opinion that the Boston meeting was the most delightful and it was certainly the best attended meeting which the Institute has ever held.

POLYTECHNIC INSTITUTE OF BROOKLYN
BROOKLYN, N. Y.

J. C. OLSEN,
Secretary

FIFTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES¹

The forthcoming National Exposition of Chemical Industries at the Coliseum and First Regiment Armory, Chicago, during the week of September 22 to 27, inclusive, holds possibilities of as great benefit to American chemical industry as in the past during the war period when it contributed so directly to the firm establishment of a chemical industry in this country. This Exposition will prove that the chemical industry in this country is advancing with leaps and bounds, that the industries are flourishing, and that the end is not yet in sight. It will show what optimism has done for the country and what a continued spirit of optimism can do.

One feature of the Exposition will be the number of electric furnace exhibits; all the foremost companies will be there. The activity of the war period produced an increased interest in metals, not only in new alloys and in treatment of metal but in the method of manufacture. It is a sign of the times that the earlier interest in electric furnaces which was purely theoretical in its nature now is of industrial importance and plant men all over the country are turning their attention to this means of smelting and melting metals. There will be on exhibition the Rennerfelt furnace handled in America by Hamilton and Hansell, the Bailey furnace by the Electric Furnace Company, the Taylor furnace by the Industrial Electric Furnace Company, the Detroit rocking furnace by the Detroit Electric Furnace Company, and the furnace of Booth Hall and Company.

¹ The managers, Charles F. Roth and Fred W. Payne, are located in their Chicago office at 417 South Dearborn St.

There will be some revelations in the line of metals—acid- and alkali-proof bronzes, prepared for specific purposes, which even quite recently were unheard of; exhibits of bronze of such hardness and strength that instruments made of it are used to cut chilled steel, a performance exceeding even the fabulous bronze of the Egyptian which history tells us was of hardness sufficient to make chisels. The Exposition will prove that the metallurgy and the chemistry of metals have made quite as gigantic strides in the last few years as organic chemistry. Much of the wartime development could not be made known until now and the Exposition will offer the first public opportunity of revealing some of the progress made.

The advancement of electrochemistry, particularly as related to electric steel, brass, bronzes, and the furnaces used, has created a broader interest than in the strictly electrochemical field, and we now find the American Institute of Mining and Metallurgical Engineers joining with the American Electrochemical Society in a meeting during the Exposition to discuss "Electric Steel and Electric Furnaces." In the evening after the meeting motion pictures of electric furnaces in various phases of their operation will be shown at the Exposition.

The United States Bureau of Mines will have on exhibit some thirty metals showing the complete course of extraction from their ores, the various stages through which they pass, and the materials used in their extraction.

Organic chemistry in the fields of dyes, pharmaceuticals, and various organic technical products has made great strides in the last year, and exhibits will demonstrate that the greatest achievements in the war period were not alone in organic products for the taking of life or for temporarily incapacitating men. The technical organic chemical products will probably arouse the greatest interest, having been as they were, nearly all developed for war use, a great many in the way of protection against water or disintegrating or corrosive liquids, gases, and fire. These products, now on a peace basis, are finding their way into the mechanical industries and the arts. These are decided improvements and will take the place largely of many natural products having less desirable properties.

The mineral world and mineral utilization will come in for its share of recognition and will show that in the general advancement of the chemical industries it has taken no small part. Ceramics will be brought strongly to the front through exhibits of products and materials developed for specific purposes during the war period and only now permitted free display for the industries that can use them.

Numerous instruments, devices, and apparatus have been perfected during the intense war period for precise measurement of temperature, weights, volumes, velocities, flow of liquids, gases, solids, electric current, and any and all kinds of commodities that are to be measured. Their number is legion and they occupy no small space in this great Exposition.

Of plant equipment used for distinct chemical reactions, there will be large numbers of exhibits. It will surprise many to view these and consider the various and unexpected applications for, and the industries into which they enter. While designed for some particular purpose in a chemical plant, they have been found of even greater service in far removed and dissimilar industries. There will be many engineering devices and articles of equipment for plants and factories in general, placed in the Exposition by manufacturers upon whom the seeds of chemical knowledge distributed throughout the country in the past four years have not fallen in vain; they have realized that the expression "chemical industries" is more comprehensive than the mere manufacture of chemicals. Notable among these exhibits are those of conveying systems, elevating systems, weighing and measuring devices, tiering and stacking machinery as well as hoists and cranes.

The indifference of manufacturers and large companies to

the health and welfare of workers in plant, factory, and mine is now being offset by a growing and active interest in the welfare and protection of the employee from danger through disease, accident, or any of the hazards attending the particular industries. The workman's body parts are being protected by varied kinds of protective equipment for the chemical, gas, electric, metal smelting, mining and manufacturing industries, his eyes by goggles and shields, his breathing apparatus by masks, hoods, and breathing pieces, his health through his stomach by various devices and methods, and the prevention of accidents by signals and devices. Of these safety appliances there will be exhibits of varied interest. The United States Bureau of Mines will feature their safety work in the plant and the mine, and in connection with this a special program is being arranged under the chairmanship of M. F. Leopold, Safety Engineer of the Bureau of Mines.

The Forest Products Laboratory of the Forest Service will make an exhibit of the work it has been conducting on processes, raw materials, products, by-products, etc. Among the subjects will be investigations on pulp and paper, ethyl alcohol from wood waste and sulfite liquor, the increased production of acetate of lime in hardwood distillation, and work on naval stores.

The Laboratory has plans for showing in an effective and readily comprehended way the work of the Forest Service on the relation of national forest administration of water power, timber, and other natural resources to general industrial development in neighboring regions.

The program of the Exposition will be one of much interest. The meetings of the societies which are being held in conjunction with the Exposition are scheduled for the following dates:

American Institute of Mining and Metallurgical Engineers, September 22 to 27
American Ceramic Society, September 24
American Electrochemical Society, September 24 to 26
Technical Association of the Pulp and Paper Industry, September 24 to 27

Plans being made for these meetings include a joint session of the American Electrochemical Society with the Mining Institute upon the subject of "Electric Steel and Electric Furnaces" on Wednesday of the week. This will be followed by another joint session on "Pyrometry," probably on Friday, when the following phases of the subject will be considered and discussed: Methods of Pyrometry, Industrial Pyrometry, Pyrometry and its Relation to Science. The Electrochemical Society is arranging a meeting on "Catalysis." As an indication of the activity of its members recent reports showed about a hundred papers prepared for the meeting of the Mining Institute.

The American Ceramic Society meetings will be concluded in one day but it promises to be one of unusual and memorable activity.

The Technical Association of the Pulp and Paper Industry

is planning an exhibit showing all the phases and stages in paper making from the tree to finished paper, including the machinery through which pulp passes at each stage.

There is also being arranged a program of speakers and motion pictures by the Exposition managers. The speakers will be of national prominence; men of affairs of the midwest will be there to welcome the visitors from other parts of the country and speakers from the industries known to all our readers will be present.

Many exhibitors are bringing moving picture films, the United States Government is preparing numerous technical subject films through the Bureau of Mines, embracing all of that Bureau's work, and these will have their first showing at the Exposition. The Bureau of Commercial Economics at Washington is again coöperating with the Exposition in equipping it with some films now being made.

The Bray Studios are preparing for the Exposition several films in which they will show by their unusual and interesting drawings, taken in such rapid sequence as to seem in motion, the manner and conduct of chemical action and reactions usually invisible to the eye and only conceived by the mind in abstract form. This in itself will be a feature well worth while, particularly since the showing of these films will be elaborated and discussed by Mr. Jam Handy, Vice President of Bray Studios.

The titles of some of the films are:

"Continuous Motion Conveying, Stacking, Elevating, Loading, and Unloading by Brown Portable Handling Machines." (Courtesy Brown Portable Conveying Machinery Company.)

"Resistance Type Furnaces for Melting Nonferrous Metals" and "Electric Furnaces in the Heat Treatment of Essential War Materials." (Courtesy of Electric Furnace Company.)

"The Detroit Rocking Electric Melting Furnace in Operation." (Courtesy Detroit Electric Furnace Company.)

"Shawinigan Power Development and the Shawinigan Industries." (Courtesy Shawinigan Water & Power Company.)

"The Manufacture of Zinc Oxide." (Courtesy New Jersey Zinc Company.)

"Operation of Koppers By-Product Coke Plant." (Courtesy The Koppers Company.)

"Chemistry in Munitions."

"Chemistry of Photography."

"Invisible Chemistry of the Electric Battery."

"Invisible Phases of Crystallization."

"Chemistry in Agriculture."

"Formation of Coal Made Visible."

"Chemistry of Gas Engines Made Visible."

"The American Chemical Society Meeting, April 1919, at the National Aniline & Chemical Company's Plant, Buffalo." (Courtesy Community Motion Picture Bureau.)

More complete program of the meetings at the Exposition will be given in next month's issue of *THIS JOURNAL*.

A glance at the roster of exhibitors suggests more interesting features than the space at our disposal will permit elaboration upon.

LIST OF EXHIBITORS AT THE FIFTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES

FIRST REGIMENT ARMORY AND COLISEUM, CHICAGO, SEPTEMBER 22 to 27, 1919

Abbé, Paul O.	Anaconda Copper Mining Company	Booth Hall & Company
Abbé Engineering Company	Angel, H. Reeve, & Company, Inc.	Boud Brook Chemical Company
Abbott Alkaloidal Company	Aniline Dyes & Chemicals, Inc.	Boyer Oil Company
Abbott Laboratories	Arkell Safety Bag Company	Boyer Oil Manufacturing Company
Ainsworth, Wm., & Sons	Armstrong Cork Company	Bristol Company, The
Albany Felt Company	Arnold Hoffman & Company, Inc.	Brown Instrument Company
Alberstone Stone Company	Arzinger, W. O., Machinery Company	Brown Portable Conveying Machinery Company
Allen Electrolytic Cell Corporation	Atlas Powder Company	Buffalo Foundry & Machinery Company
American Chemical Society	Austin Company	Butterworth-Judson Corporation
American Chemical Manufacturing Company	Bachmeier & Company, Inc.	Canada: Carbide Company
American Ceramic Society	Bailey Meter Company	Canada: Ontario Bureau of Mines
American Cyanamid Company	Baker, J. T., Chemical Company	Canada: Shawinigan Water & Power Company
American Dyes Institute	Barrett Company, The	Canada: Shawinigan Electric Metals Company
American Electrochemical Society	Bausch & Lomb Optical Company	Canadian Chemical Journal
American Hard Rubber Company	Beach Russ Company	Canadian Electro Products Company
American Iron Scale Company	Becker, Christian, Inc.	Canadian Electrode Company
American La France Fire Engine Company	Bekley Perforating Company	Canadian National Railways
American Limestone Company	Beckman & Linden Engineering Corporation	Carborundum Company, The
American Metal Products Company	Beighlee Electric Company	Carnotite Reduction Company
American Meter Company	Benjamin Electric Manufacturing Company	Carrier Engineering Company
American Transformer Company	Blackmer Rotary Pump Company	Celite Products Company
American Water Softener Company	Blair Campbell & McLean, Incorporated	Celluloid Zapon Company

- Central Scientific Company
Chemical Equipment Company
Challenge Company
Chemical Construction Company
Chemical Engineer
Chemical Foundation, Inc.
Chemical & Metallurgical Engineering
Chemical Catalogue Company, Inc.
Chicago Section, American Chemical Society
Cleveland-Cliffs Iron Company
Contact Process Company
Clinefield Products Corporation
Color Trade Journal
Coors Chemical Porcelain Company
Corning Glass Works
Crane Company
Crane Packing Company
Daigger, A., & Company
Day, J. H., Company, Incorporated
De Laval Separator Company
Denver Fire Clay Company
Devine, J. P., Company
Detroit Electric Furnace Company
Detroit Range Boiler & Steel Barrel Company
Diamond State Fiber Company
Dings Magnetic Separator Company
Dorr Company, The
Dow Chemical Company
Drackett, P. W., & Sons Company
Drying Systems, Inc.
Duriron Castings Company
Dunck Tank Works
Eagle Tank Company
East Iron & Machine Company
Eastman Kodak Company
Economic Machinery Company
Economy Engineering Company
Edgar Brothers Company
Egyptian Lacquer Manufacturing Company
Eimer & Amend
Electric Furnace Company
Electric Bleaching Gas Company
Electrolytic Engineering Corporation
Electron Chemical Company
Elmore, G. H.
Elyria Enameled Products Company
Empire Laboratory Supply Company
Engelhard, Charles
Everlasting Valve Company
Fansteel Products Company, Inc.
Fiber Making Processes, Inc.
Fleisher, W. L., & Company, Inc.
Fletcher Works
Foamite Firefoam Company
Foote Mineral Company
Forest Products Laboratory
Foxboro Company, The, Inc.
Fuller Lehigh Company
Gaertner, W., & Company
Garrigue, Wm., & Company
Garrigues, Chas. F., & Company
General American Tank Tar Corporation
General Bakelite Company
General Ceramics Company
General Chemical Company
General Electric Company
General Fire Extinguisher Company
General Filtration Company, Inc.
Glamorgan Pipe & Foundry Company
Glens Falls Machine Works
Gordon Engineering Company
Groch Centrifugal Flotation Company
Goulds Manufacturing Company
Guernsey Earthenware Company
Grundler Patent Crusher & Pulverizer Company
Hamilton & Hansell, Inc.
Hanovia Chemical & Manufacturing Company
Haynes Stellite Company
Hauser Stander Tank Company
Hardinger Conical Mill Company
Hemingway, Frank, Inc.
Hepworth, S. S., Company
Hercules Engineering Corporation
Hercules Powder Company
Herold China & Pottery Company
Hood, B. Milflin, Brick Company
Hooker Electrochemical Company
Hoskins Manufacturing Company
Huff Electrostatic Separator Company
Hunger Dry Kiln Company
Ideal Stencil Machine Company
Industrial Electric Furnace Company
Industrial Filtration Corporation
Innis Speiden & Company
Irving Iron Works Company
Irving National Bank
Jewell Polar Company
Journal of Commerce & Commercial Bulletin
Journal of Industrial & Engineering Chemistry
Johnson & Carlson
Kenart Synthetic Products Company
Kewaunee Manufacturing Company
Knight, Maurice A.
Knookville Board of Commerce
Koppers Company, The
Koppers Products Company
Lead Lined Iron Pipe Company
Leeds & Northrup Company
Lindsay Light Company
Liquid Carbonic Company
Little, Arthur D., Inc.
Lungwitz, Emil E.
Lungmotor Company
MacBeth Evans Glass Company
Machinery Utilities Company
Magnetic Manufacturing Company
Manufacturers Record
Marden, Orth & Hastings Corporation
Mathieson Alkali Works, Inc.
McGraw-Hill Company, Inc.
Mead & Company
Merck & Company
Merrill Company, The
Metals Disintegrating Company
Mineral Point Zinc Company
Mojonnier Brothers Company
Monsanto Chemical Works
Mine Safety Appliances Company
Miner Edgar Company
Mott, J. L., Iron Works
Nassau Valve & Pump Corporation
Nash Engineering Company
National Aniline & Chemical Company, Inc.
National Filtr Cloth & Weaving Company
Nelson, Alfred W., Company
New Jersey Zinc Company
Newark Wire Cloth Company
Newport Chemical Works, Inc.
Niagara Alkali Company
Niagara Electro Chemical Company
Nitrogen Products Company
Northwestern Chemical Company
Norton Company
Ohio Pottery Company
Oil, Paint & Drug Reporter
Oliver Continuous Filter Company
Ontario Bureau of Mines
Organic Salt & Acid Company
Parks-Cramer Company
Pennsylvania Salt Manufacturing Company
Permutit Company
Peterson Leonard & Company
Pfaudler Company
Philadelphia Drying Machinery Company
Philadelphia Quartz Company
Philadelphia Textile Machinery Company
Pneumercator Company
Pratt Engineering & Machinery Company
Precision Instrument Company
Precision Thermometer & Instrument Company
Product Sales Company
Provost Engineering Corporation
Pyroelectric Instrument Company
Quigley Furnace Specialty Company
Raritan Copper Company
Raymond Brothers Impact Pulverizer Company
Raymond Lead Works
Redmanol Chemical Products Company
Republic Flow Meters Company
Research Corporation
Research Laboratory of Chicago
Revolator Company
Roessler & Hasslacher Chemical Company
Rollin Chemical Company
Rossendale-Reddaway Belting & Hose Company
Ruth Company, The
Sarco Company, The
Sargent, E. H., & Company
Schaar & Company
Schaeffer & Budenberg Manufacturing Company
Schutte & Koerting Company
Schwartz Sectional System
Scientific Equipment Company
Scientific Materials Company
Scott, Ernest, & Company
Semet-Solvay Company
Sharples Specialty Company
Shawinigan Electro Metals Company
Shawinigan Water & Power Company
Sherwin Williams Company
Sly, W. W., Manufacturing Company
Soderling, Walter, Inc.
Solvay Process Company
Sowers Manufacturing Company
Sperry, D. R., Company
Stein, Hall & Company, Inc.
Stoelling, C. H., Company
Stokes, F. H., Machinery Company
Stresen-Reuter & Hancock, Inc.
Sturtevant Mill Company
Star Brass Works
Sullivan Machinery Company
Sunbeam Chemical Company
Swedish Crucible Steel Company
Swenson Evaporator Company
Tagliabue, C. J., Manufacturing Company
Tank Equipment Company
Taylor Instrument Companies
Technical Association Pulp & Paper Industry
Technical Products Company
Texas Gulf Sulfur Company
Thermal Syndicate Company, Ltd.
Thermo Electric Instrument Company
Thomas, Arthur H., Company
Thwing Instrument Company
Tolhurst Machine Works
Tower & Wooden Tank Industrial Council
United Filters Company
United Lead Company
United Lined Tube & Valve Company
U. S. Cast Iron Pipe and Foundry Company
U. S. Industrial Alcohol Company
U. S. Industrial Chemical Company
U. S. Stoneware Company
United States Bureau of Mines
United States Forest Service
U. S. Wind Engine & Pump Company
Union Steam Pump Company
Union Sulfur Company
Union Thermometer Company
Universal Oil Company
Valley Iron Works Company, Appleton, Wis.
Valley Iron Works, Williamsport, Pa.
Van Schaack Brothers Chemical Works
Virginia Smelting Company
Vitreous Enameling Company
Wallace & Tiernan Company, Inc.
Wedge Mechanical Furnace Company
Wendnagel & Company
Werner & Pfleiderer Company
Western Reserve Chemical Company
Westinghouse Electric & Manufacturing Company
Whitall Tatum Company
White, J. G., Engineering Corporation
Whitlock Coil Pipe Company
Wilson-Macaulen Company
Zapon Leather Cloth Company
Zaremba Company
Zavon, Inc.

A MOVEMENT TO DEVELOP RESEARCH IN COLLOID CHEMISTRY

Shortly before the armistice was signed the National Research Council appointed a special committee on the chemistry of colloids, but this committee lapsed with the conclusion of the war. In April 1919, a new committee was appointed to encourage research in colloid chemistry and to foster the training of more colloid chemists. This committee was appointed with the following personnel:

HARRY N. HOLMES, *Chairman*, Oberlin College, Oberlin, Ohio
 JEROME ALEXANDER, 59th St. and 11th Ave., New York City
 W. D. BANCROFT, National Research Council, Washington, D. C.
 G. H. A. CLOWES, Eli Lilly Co., Indianapolis, Ind.
 W. A. PATRICK, Johns Hopkins University, Baltimore, Md.
 J. A. WILSON, 203 Juneau Ave., Milwaukee, Wis.

It is the opinion of this committee that there is great need of more well-trained colloid men. The demand from the industries exceeds the supply. But, more important still, other sciences need the help that colloid chemists can give. Medicine, agriculture, physics, geology, botany, zoology—all are willing debtors to this division of chemistry. Their colloid problems are awaiting solution.

"To the abstract thinker in science," writes Martin Fischer, "colloid chemistry, therefore, represents the larger field. But the practical worker knows, too, that in a better knowledge of the properties of those very materials which the orthodox chemist has too often cast aside in his jellies, pastes, and glues is found the explanation of much that interests him. Is it any wonder, then, that colloid chemistry appeals to the agriculturist, the metallurgist, the dealer in precious stones, the tanner of skins, the manufacturer of wood pulps and paper, the dyer, the histologist, the steel worker, the weaver of textiles, the smelter, the manufacturer of paints?"

We must lay proper foundations for the development of colloid chemistry in America. More courses in this subject should be given. It is true that several universities now offer lectures on colloids but very few give related laboratory instructions—partly because of the lack of a suitable laboratory manual. For that matter the present texts are scarcely adequate. Members of our committee are now at work on a text and a laboratory manual which will make instruction in the subject more effective.

The committee offers a number of lectures planned to stimulate interest in colloid chemistry and urges universities, sections of the AMERICAN CHEMICAL SOCIETY, scientific organizations of various types, and great industrial research groups to include one or more such lectures in their annual program. In all, or nearly all, cases the cost will be limited to traveling expenses. Other lecturers may be secured by arrangements with the chairman of the committee and topics not mentioned in the list may be called for. A number of leaders in the colloid field are not included because of lack of time in making arrangements. Some of these may be secured later through the chairman.

Many of us recall the inspiring lectures, five in a series, given here in 1914 by Wolfgang Ostwald. Some of our lecturers may be persuaded to give a similar series, for proper remuneration, but as a rule the offerings are for separate lectures. Of course, the convenience of the speaker desired must be consulted. Industrial men have difficulty in getting away and there is a limit to the number of times a university man can accept such invitations.

LECTURERS ON COLLOID CHEMISTRY

LT. COL. W. D. BANCROFT, *Chairman*, Division of Chemistry and Chemical Technology, National Research Council, 1023 Sixteenth St., Washington, D. C.

Theory of Photography
 Theory of Dyeing
 Contact Catalysis
 Adsorption

JEROME ALEXANDER, National Gum and Mica Co., 59th St. and Eleventh Ave., New York, N. Y.
 Industrial Application of Colloid Chemistry

HARRY N. HOLMES, Oberlin College, Oberlin, Ohio
 Colloid Chemistry
 Emulsions
 Silicic Acid Gels

G. H. A. CLOWES, *Director* of Biochemical Research, Eli Lilly Co., Indianapolis, Ind.
 Colloid Chemistry
 Colloids in Pharmacy and Biology

JOHN ARTHUR WILSON, *Chief Chemist*, Empire Tannery (A. F. Gallun and Sons), Milwaukee, Wis.
 Imbibition of Gels

WALTER A. PATRICK, Johns Hopkins University, Baltimore
 Adsorption
 Tyotropic Properties of Solutions
 Emulsions

E. B. SPEAR, Massachusetts Institute of Technology, and Consulting Chemist, 69 Massachusetts Ave., Cambridge, Mass.
 Precipitation of Colloids
 The Colloidal Chemistry of Glue; Gum, Starch, and Carbohydrates

W. K. LEWIS, Massachusetts Institute of Technology, Cambridge, Mass.
 The Colloidal Chemistry of Tanning
 The Colloidal Chemistry of Rubber

EUGENE C. BINGHAM, Lafayette College, Easton, Pa.
 Viscous and Plastic Flow from the Colloid Viewpoint (this may be given in a single lecture or a course of five lectures on "Viscous and Plastic Flow" may be secured)

HARRY B. WEISER, Rice Institute, Houston, Texas
 Colloid Chemistry
 The Preparation and Properties of Colloidal Solutions (Illustrated by experiments)
 Adsorption by Precipitates
 Technical Applications of Colloid Chemistry

RICHARD C. TOLMAN, *Associate Director* of Fixed Nitrogen, Research Laboratory, American University, Washington, D. C.
 Smoke Screens

WILLIAM M. GROSVENOR, Consulting Chemist, Chemists' Building, 50 East 41st St., New York, N. Y.
 Flotation

DAVID SPENCE, *Vice President and Superintendent* of Norwalk Tire and Rubber Co., Norwalk, Conn.
 The Colloidal Chemistry of Rubber

There are many trained chemists who contemplate taking up the study of colloids. To save their time we offer a brief bibliography to be followed approximately in the order given. A stranger to the colloid field is in danger of wasting time reading the wrong things first. The chairman alone is responsible for this suggestive bibliography. No two men could agree on such a list of readings, so it is open to criticism.

BRIEF BIBLIOGRAPHY

1—Emil Hatschek: "An Introduction to the Physics and Chemistry of Colloids," 100 pp. P. Blakiston's Son & Co., Philadelphia, 1916. Based on a course of ten lectures. A remarkably clear introduction to colloids.

2—Jerome Alexander: "Colloid Chemistry," 90 pp. D. Van Nostrand Co., New York City, 1919. Deals largely with the practical applications of the science.

3—Plimmer: "Practical Organic and Bio-Chemistry," Longmans, Green & Co., New York City, 1918. Pp. 374-391 give a brief but excellent discussion of colloids. A remarkably well-balanced chapter.

4—Bayliss: "Principles of General Physiology," Longmans, Green & Co., New York City, 1915. In pp. 74-110 is given a clearly written introduction to the "Colloidal State."

5—Wolfgang Ostwald: "Theoretical and Applied Colloid Chemistry," Translated by Martin Fischer. 232 pp. John Wiley & Sons, Inc., New York City, 1917. Revision of a course of five lectures given in the United States a few years ago. A very stimulating book.

6—Philp: "Physical Chemistry," Edwin Arnold, London, 1910. Pp. 177-244 deal very ably with colloids and lay stress on adsorption.

7—Zsigmondy: "The Chemistry of Colloids," Translated by Spear. 288 pp. John Wiley & Sons, Inc., New York City, 1917. Probably the most useful book of its size on the subject yet published. Contains 33 pages on the industrial applications of colloids.

8—Freundlich: "Kapillarchemie," 591 pp. Leipzig, 1909. The greatest classic in the literature of colloids.

9—Wolfgang Ostwald: "Handbook of Colloid Chemistry," Translated by Martin Fischer. 278 pp. P. Blakiston's Son & Co., Philadelphia, 1915. Not as useful as Zsigmondy's book. Gives valuable references to the literature. A translation of Ostwald's "Grundriss der Kolloidchemie."

10—Bechold: "Colloids in Biology and Medicine." Translated by Bullowa from second German edition. 464 pp. D. Van Nostrand Co., New York City, 1919. A splendid book; somewhat specialized as the title indicates, but valuable to any student of colloids. Contains 40 pages on "Methods of Colloidal Research," including much of the author's own work on ultrafiltration.

11—Taylor: "Colloids" 327 pp. Longmans, Green & Co., New York City. Not well arranged. Contains some useful directions for the preparation of colloids. Should be used only as a reference book on isolated points.

12—Burton: "Physical Properties of Colloid Solutions." 197 pp. Longmans, Green & Co., New York City, 1916. Contains a useful bibliography. Rather physical in treatment.

13—The Svedberg: "Herstellung Kolloider Lösungen." 507 pp. Theodor Steinkopf, Dresden, 1909. A classic. Gives full directions for preparing hundreds of colloids. Contains a valuable bibliography.

14—Martin Fischer: "Oedema and Nephritis." 2nd Ed. 695 pp. John Wiley & Sons, Inc., New York City, 1914. Outlines and defends a treatment of disease based on the principles of colloid chemistry.

15—Martin Fischer and Marian Hooker: "Fats and Fatty Degeneration." 146 pp. John Wiley & Sons, Inc., New York City, 1917. Theories of emulsification discussed, especially in relation to body tissues.

16—U. S. Bureau of Soils, Bulletin 52: "Absorption by Soils." 95 pp. 1908. Very useful.

17—U. S. Bureau of Soils, Bulletin 51: "Absorption of Vapors and Gases by Soils." 1908.

18—Ashley: "Technical Control of the Colloidal Matter of Clays." U. S. Bureau of Standards, Technologic Paper No. 23. 115 pp. Written in 1911.

19—W. C. McC. Lewis: "Some Technical Applications of Capillary and Electrocapillary Chemistry," *Mel. & Chem. Eng.*, **16** (1916), 253-259; also *J. Soc. Chem. Ind.*, May 31, 1916. Somewhat like the book by Alexander (No. 2).

20—Whitney and Ober, *J. Am. Chem. Soc.*, **33** (1901), 856-863. Give an excellent bibliography, with brief comment, of colloid work published before 1901. Nearly 150 references.

Kolloid-Zeitschrift and its *Beihfte* have devoted their columns exclusively to colloid research. Very important.

The *Journal of Physical Chemistry* contains a vast amount of invaluable material and no student of colloid chemistry can afford to neglect this journal. Many of the articles contain exceptionally full summaries of the work done in special fields, and are really monographs. The results of colloid research, however, are found in most of the great journals.

Among the many interesting special topics we suggest a few typical ones. A hundred others may be just as important and interesting.

1—EMULSIONS

See Bancroft's series of articles, *J. Phys. Chem.*, 1912, 1913, 1915, 1916.

Martin Fischer's book, "Fats and Fatty Degeneration," described above.

Pickering, *J. Chem. Soc.*, **91** (1907), 2001.

Clowes, *J. Phys. Chem.*, **20** (1916), 407.

Newman, *Ibid.*, **18** (1914), 34.

Briggs and Schmidt, *Ibid.*, **19** (1915), 479.

This list gives a sufficient number of references to earlier literature.

2—SOAPS

Detergent action of, S. A. Shorter, *J. Soc. Dyers Colourists*, **32** (1916), 99. Reference to Spring, Pickering and Hillyer will add to this.

Hydration of, Martin Fischer, *Science*, **48** (1918), 143. (Given under another title.)

3—THEORY OF DYING

Bancroft, *J. Phys. Chem.*, **18** (1914), 1, 118, 385; **19** (1915), 50, 145.

Pelet Jolivet and others, *Compt. rend.*, **145** (1907), 1182.

Kraft, *Ber.*, (1899), 1608.

Freundlich and Losev, *Z. physik. Chem.*, **89** (1907), 284.

Linder and Picton, *Trans. Chem. Soc.*, **87** (1905), 1906.

Alexander, *J. Soc. Chem. Ind.*, **30** (1911), 517.

Books:

The Chemistry of Dyeing, by Wood.

Die Theorie des Farbenprozesses, by Pelet Jolivet.

The Chemistry and Physics of Dyeing, by Dreaper.

4—VISCOSITY OF COLLOIDS, PLASTIC FLOW

Articles by Eugene C. Bingham in the last few years.

5—CAPILLARY ANALYSIS

Gordon, *J. Phys. Chem.*, **18** (1918), 337.

Book by Goppelsroeder summarizing his own original work, "Neue Capillar und Capillaranalytische Untersuchungen," 1908.

Articles by Goppelsroeder in *Kolloid-Zeitschrift*.

6—FLOTATION PROCESS

Articles in the *Journal of Physical Chemistry* and various mining and engineering journals.

Book by Megraw.

Bulletin issued by U. S. Bureau of Mines.

7—HYDROUS FERRIC OXIDE

Bancroft, *J. Phys. Chem.*, **19** (1915), 232.

8—ULTRAFILTRATION

Bechold, *Z. physik. Chem.*, **60** (1907), 257; **64** (1908), 328; and his book above mentioned.

9—ADSORPTION BY SOILS AND KAOLIN

J. E. Harris, *J. Phys. Chem.*, **18** (1914), 355.

10—COLLOID CHEMISTRY AND SOME OF ITS TECHNICAL ASPECTS

J. Soc. Chem. Ind., **33** (1909), 280.

11—KOLLOIDCHEMIE UND PHOTOGRAPHIE

Book by Lüppe-Cramer, Dresden, 1908.

Articles in *Kolloid-Zeitschrift*.

The above list of journal articles was selected almost at random with no attempt at completeness. It is thought that acquaintance with a few such topics will stimulate interest in a larger list.

Besides the investigators named earlier in this paper, there should be mentioned Graham, Duclaux, Hardy, Quincke, Perrin, Linder and Picton, Carey Lea, Lottermoser, Gutbier, Schulze, Spring, Donnan, von Weiman, Oden, Cornu, Whitney and Blake, Paal, Buxton and Teague, Bredig, E. A. Schneider, Spence, and many others who have done useful work.

The colloid committee asks the coöperation of the chemical public in building up a card catalogue listing the following:

1—Names of all workers in the field and the research they are engaged in.

2—Names of men and universities offering courses in colloid chemistry, extent and nature of courses, and number of students.

3—Names of companies employing, or wishing to employ, colloid chemists, number of such chemists, and any details about the work they care to make public.

4—Names of men able and willing to deliver a few lectures as may be convenient, according to the plan outlined above.

With this card catalogue in fairly complete form the committee may easily become a sort of clearing house for colloid chemists and their employers. We will be in a position to place men and to secure men, to offer suggestions, and to help at many points. We earnestly urge all interested to send this information to the chairman as soon as possible.

American chemists are anxious to buy good "made in America" apparatus. Unfortunately an ultramicroscope of the Zsigmondy type is not made in this country. If all possible buyers of such an instrument will notify us we will use the information to hasten the manufacture of a suitable American ultramicroscope. We have already had some correspondence with a prominent instrument maker on this subject. A market must be assured.

One of the great needs is an English translation of Freundlich's "Kapillarchemie." It is invaluable and a translator who can bring it up to date will perform a very great service.

Several men, university and industrial, have written us that the great need of colloid chemistry is "more quantitative work." There is something in the implied criticism, but we must not go to either extreme. Other lines of research also develop the fundamental conceptions of colloid chemistry. We admit that there must be something beyond generalizations and we are confident the quantitative work will be forthcoming.

The National Research Council is not yet ready to allow us to start a system of industrial fellowships, officially, but has no objection to committee members doing so as individuals. It may be that something more definite will develop along this line later.

Suggestions of any sort will be welcomed. The committee claims no monopoly on ideas.

OBERLIN COLLEGE
OBERLIN, OHIO

HARRY N. HOLMES

EXECUTIVE COMMITTEE OF THE DIVISION OF CHEMISTRY AND CHEMICAL TECHNOLOGY, NATIONAL RESEARCH COUNCIL

At the meeting held in Washington, June 3, 1919, there were present Messrs. Alsberg, Bancroft, Lamb, and Washburn.

It was voted that the following delegation be nominated by the Division to represent America at the July meeting of the International Chemical Council to be held in London, and that these nominations be transmitted to the constituent societies of the Division with the suggestion that each society give credentials to those of its own members who are represented on the delegation:

DR. E. W. WASHBURN, Acting Chairman, Division of Chemistry and Chemical Technology, Temporary Chairman of delegation

DR. CHARLES L. PARSONS

LT. COL. A. B. LAMB

DR. F. G. COTTRILL

DR. JULIUS STIEGLITZ

First alternate—DR. E. C. FRANKLIN

Second alternate—DR. H. S. WASHINGTON

LT. COL. EDWARD BARTOW

Alternate—LT. COL. JAMES F. NORRIS

The following extracts from the minutes of the meeting of the Executive Board of the Council, held on June 2, were presented to the Committee for consideration and for decision as to whether the Committee would recommend sending a similar communication to the Rockefeller Foundation on behalf of the Division of Chemistry and Chemical Technology:

In behalf of the Division of Physical Sciences, Mr. Millikan, as retiring chairman, recommended that a communication be sent to the Rockefeller Foundation requesting an annual appropriation of \$20,000 for two or three years' traveling expenses in connection with the plan of stimulating and organizing research in physical subjects through the formation of groups of research men in these subjects.

Moved: That the Executive Board approve the foregoing recommendations of the Division of Physical Sciences and that the chairman of the Council be authorized to address a letter to the Rockefeller Foundation requesting an annual appropriation of \$20,000 for two or three years in support of these plans.
Adopted.

It was voted that in the opinion of this committee the use of such a sum for a similar purpose in connection with chemical research would not be a wise expenditure at the present time for the following reasons:

1—The proposed plan, to be successful, would require the enlistment of the services of the best men in the country in traveling about and consulting with the various research workers. Such a utilization of their time would detract just so much from the progress of their own research work, with no certainty that the hoped-for stimulation and organization of the research workers of the country would exceed in value this loss.

2—The Committee also feels that the first step in attaining the purposes of the proposed project should be a carefully prepared and indexed research census and that the promotion of cooperation between investigators working along similar lines can be best attained by calling a conference at some central point. The program of work for each such conference should be carefully worked out in advance by correspondence with the investigators, supplemented by such personal visits as the chairman of the Division may be able to make.

3—In view of the amount of preparatory work to be done in connection with securing the necessary data, corresponding with the research workers, and arranging the program for such conferences, the Committee does not feel that during the first year it would be practicable to call more than five such conferences, but feels that a sum of money, not to exceed \$7000, could be wisely and fruitfully expended in this way during the first year and would be glad to join the Physics Division in requesting such a sum from the Rockefeller Foundation, to be used in this manner. It feels, however, that any requests for additional amounts should be based upon the knowledge and experience gained during the first year.

The report of the special committee appointed by the Council to consider the plans proposed by the AMERICAN CHEMICAL SOCIETY with reference to the preparation of critical tables of

physical and chemical constants, was brought to the attention of the Executive Committee and it was voted that this report be spread upon the minutes. The report was approved by the Interim Committee of the Council at its meeting on June 3, 1919. It was voted that the Executive Committee approve this report and instruct the delegates to the International Chemical Union to present it at the July meeting of that organization, with the request that the undertaking be assigned to America to be carried out in accordance with the plans outlined in the report.

It was voted that the AMERICAN CHEMICAL SOCIETY be requested to give similar instructions to its delegates.

The Committee voted to transmit the following names to the chairman of the Council for appointment as chairman of the three trustees in charge of the business control of the critical tables:

DR. W. H. NICHOLS

DR. JOHN JOHNSTON, first alternate

MR. HUGH K. MOORE, second alternate

DR. W. K. LEWIS, third alternate

It was voted that Dr. E. W. Washburn and Dr. Arthur I. Day be nominated as members of the Joint Committee on Ceramic Research provided for by the annual meeting of the Division, the other two members of the Committee, Dr. R. B. Sosman and Mr. Homer F. Staley, having been nominated by the Board of Trustees of the American Ceramic Society.

The acting chairman reported that plans for the continuance of the Committee on Explosives Investigations on a permanent basis were proceeding toward satisfactory conclusion.

The following progress report of the Committee on the Thermal Properties of Explosive Materials was received and placed on file:

Your Committee reports that it has formulated Research Problems Nos. 154 and 155, entitled, respectively: "The Specific Heats and Thermal Diffusivities of Explosives," and "The Explosion Temperatures of Explosive Materials;" and that it expects shortly to have these two problems assigned for investigation at some university.

E. W. WASHBURN, Acting Chairman
CHARLES E. MUNROE
WALTER P. WHITE

AMERICAN CHEMICAL SOCIETY DIVISION OF INDUSTRIAL CHEMISTS AND CHEMICAL ENGINEERS

At the Philadelphia meeting, September 2 to 6, 1919, the Division of Industrial Chemists and Chemical Engineers, in addition to their general program, will conduct a symposium in cooperation with the newly formed Dye Section and the Division of Pharmaceutical Chemistry, at which the subject of an annual patent renewal fee system for the United States will be discussed. Mr. E. J. Prindle, chairman of the Committee on Patents for the AMERICAN CHEMICAL SOCIETY, will preside, and, in addition to a number of leading chemists particularly interested in patents who have been asked to prepare talks limited to this single question, it is hoped that a large number will discuss the matter from the floor. We ask the members to again read Dr. Hess's open letter in the July number of THIS JOURNAL, and come prepared to take part in this important discussion.

Dr. A. V. Bleining, the well-known ceramic engineer, who made such important contributions to the art of optical glass pot making during the war, has arranged a symposium on refractories, a subject of vital importance to the industrial chemist and one with which most chemists are entirely too unfamiliar. There will be a number of interesting papers in this symposium and a lively discussion is sought.

Among the general papers will be one upon "Cost Accounting in Laboratories," which should prove of wide interest.

WASHINGTON, D. C.
July 7, 1919

HARRISON E. HOWE, Secretary

CHEMICAL WARFARE SERVICE RESEARCH DIVISION REUNION

Col. G. A. Burrell, late in charge of the Research Division of the Chemical Warfare Service, is contemplating a reunion of the Research Division in Philadelphia during the meeting of the AMERICAN CHEMICAL SOCIETY.

The reunion will take the form of a dinner on Thursday evening September 4, from 6 to 8 P.M. It is hoped that as many of the men as possible of the Research Division will attend the reunion. It will be appreciated if all those who expect to attend will notify Col. Burrell at 62 Cedar Street, New York City, in order that proper arrangements for the dinner may be made.

AMERICAN ELECTROCHEMICAL SOCIETY FALL MEETING

The tentative program for the Chicago Meeting of the American Electrochemical Society, September 23-25, 1919, has been announced by the board of directors. Several sessions will be held jointly with the American Institute of Mining and Metallurgical Engineers, which meets in Chicago, September 22 to 27, 1919.

On Tuesday, September 23, the Society and Institute will go by boat to Gary, Ind., to visit the plant of the United States Steel Corporation. A symposium on electric steel will be held on the boat and continued at the Congress Hotel in the evening.

Wednesday morning the Society will hold a general session and in the afternoon a joint session with the A. I. M. E. in a symposium on nonferrous electrometallurgy. In the evening a special visit will be made to the electric furnace display at the National Exposition of Chemical Industries at the Coliseum.

Thursday will be devoted to a symposium on "Catalysis," to be followed by a smoker in the evening.

On Friday the Institute will probably hold its symposium on "Pyrometry," to which members of the Society are invited.

Headquarters of both the Society and the Institute will be at the Congress Hotel, and according to present plans all sessions will be held there.

The American Electrochemical Society's headquarters at the Exposition of Chemical Industries will be Booth 229, on the balcony of the Coliseum.

ARE YOU INTERESTED IN CHEMICAL SPELLINGS, NAMES, AND PRONUNCIATIONS?

It is the plan of the Committee on Spellings, Nomenclature, and Pronunciation of the AMERICAN CHEMICAL SOCIETY to

attempt to standardize usage in these fields to the extent that this is possible. An effort will be made gradually to build up lists of approved rules covering spellings, nomenclature, and pronunciation and to secure observance of them. As a first step we are endeavoring to compile a list of all chemists who are particularly interested in any or all of these subjects. We will need many opinions from time to time and it is particularly our desire that no one be left off our list who would like to take part in the work of determining best usage. If interested, please tell the chairman, whose address is Ohio State University, Columbus, Ohio.

E. J. CRANE, *Chairman*

DIVISION OF INDUSTRIAL CHEMISTS AND CHEMICAL ENGINEERS, AMERICAN CHEMICAL SOCIETY

The last directory of the Division of Industrial Chemists and Chemical Engineers appeared in 1913. The Executive Committee of the Division has under consideration the question of issuing a new directory but does not wish to decide the matter without hearing from a considerable number of the Division members. Obviously, if it is to be of any value, the directory must be kept up to date and printed frequently, thereby involving both considerable expense and work. The Executive Committee question whether the results to be obtained justify this effort, and the Secretary would like to hear from as many as possible, and asks that those writing him indicate whether they would be prepared to pay their portion of the expense.

1201 SIXTEENTH STREET
WASHINGTON, D. C.

HARRISON E. HOWE, *Secretary*

CALENDAR OF MEETINGS

American Chemical Society—Fifty-eighth (Annual) Meeting, Philadelphia, Pa., September 2 to 6, 1919.

National Exposition of Chemical Industries (Fifth)—Coliseum Chicago, Ill., September 22 to 27, 1919.

SOCIETIES MEETING IN CHICAGO DURING EXPOSITION WEEK

American Institute of Mining and Metallurgical Engineers—September 22 to 27, 1919.

American Ceramic Society—September 24, 1919.

American Electrochemical Society—September 24 to 27, 1919.

Technical Association of Pulp and Paper Industry—September 24 to 27, 1919.

NOTES AND CORRESPONDENCE

SKIN DISEASES FROM CERTAIN LUBRICANTS

By CHARLES BASKERVILLE¹

The British Department of Scientific and Industrial Research has published some results of studies on oil rashes. They appear to be due (a) to plugging small glands at hair roots (especially on workers' arms and legs), and (b) to mechanical injury to the skin by metallic particles suspended in the cutting lubricant.

In the first type mentioned the mixture of oil and dirt blocks up the gland openings, causing inflammation, which may lead to suppuration or even abscesses. If the former, when many hairs are involved, there may be red spots with black centers, or yellow heads in the event abscesses have been produced. These statements are based upon the information as to the report at hand. In the second type mentioned, namely, when

the surface is abraded through mechanical injury by the metallic particles, the familiar conditions for germ and septic infection are favorable.

The Commission recommends liberal washing and dusting of parts with a compound of equal parts of starch and zinc oxide. Conditions favorable to the formation of free fatty acids are to be avoided and the removal of metal particles, with frequent cleaning of the machines, is recommended. Frequent examination of machines is advisable. Workers affected should not operate machines as they are likely to spread infection. The addition of 1 to 2 per cent carboic acid or other antiseptics to the lubricant was tried, but not found to be reliable. The treatment recommended is frequent washing with hot water and soap, and in the event of septic infection there should be an application of antiseptic dressings.

¹ Chairman, Committee on Occupational Diseases, American Chemical Society, who assumes responsibility for the statements contained in this communication in so far as the committee is concerned.

Experience of the writer, supported by numerous reports of accidents, as well as cases of cuts, abrasions, and other injuries caused by metallic bodies of various composition, more or less

contaminated by germs of likely infectious character, proved by bacteriological tests, prompts him to recommend regular washing with a soap with a notable amount of pine oil as a constituent. The surfaces are not only thoroughly cleansed, but the parts are thus rendered thoroughly sterile, bacteriologically. Such compositions must not be applied to the eyes or taken internally.

COLLEGE OF THE CITY OF NEW YORK
NEW YORK CITY, July 8, 1919

WOOL GREASE

AHRENS' "SAMMLUNG CHEMISCHER UND CHEMISCH-TECHNISCHER VORTÄGE"

Editor of the Journal of Industrial and Engineering Chemistry:

When making a careful search for the more important references to wool grease in the scattered literature of that subject, the only real monograph that I was able to find on this interesting and complex substance, was the following:

"Das Wollfett," by Ed. Donath and B. M. Margosches; in Ahrens' "Sammlung chemischer und chemisch-technischer Vorträge," 6 (1901), 39-160.

But few chemists appear to know of the existence of this really valuable monograph and the reason seems to be that, while many chemical libraries have the Sammlung, few of the librarians catalogue the details of each monograph, with the names of the respective authors, but usually list the whole under the heading of Ahrens. Of course, the Sammlung has many other valuable papers which may escape the attention of special searchers; and it is suggested that the matter be brought to the attention of the librarians concerned. The writer has studied the libraries of many of the larger cities and also of some of the large schools of technology, with the result described.

The writer would be glad to get in touch with those fellow-chemists who are interested in the general subject of wool grease.

MELLON INSTITUTE
PITTSBURGH, PA.
July 8, 1919

CHARLES S. PALMER

WAR TRADE BOARD TRANSFER TO DEPARTMENT OF STATE

By Executive Order of the President, the War Trade Board has been merged into the Department of State and all the present personnel of the Board have been transferred to the Department of State.

By direction of the Secretary of State, the War Trade Board organization thus transferred has been established as the War Trade Board Section of the Department of State and has been placed under the direction of Mr. Lawrence Bennett, who has been designated as chief of the Section.

The activities of the Board will continue without interruption or alteration in present practice except as specifically noted below. For all practical purposes, the status of the employees of the Board will be unchanged. The present internal organization will remain intact and all routine administrative matters will continue to be performed by the officials who have heretofore performed such functions. Licenses and refusals will continue to be issued in accordance with the present regulations. Changes in the present regulations and new regulations will be issued by the Chief of the Section in like manner as instructions of the War Trade Board have been issued heretofore.

All routine correspondence will continue to be conducted on the letterheads of the War Trade Board and may be signed by the officials who have heretofore customarily signed such letters. Licenses and refusals will continue to be issued upon the present forms and may be issued and signed by the officials who have heretofore customarily performed such acts. In

signing letters, however, it is no longer proper to use the name "War Trade Board" as a part of the signature. It will be sufficient to use simply the name of the Bureau, as for example, "Bureau of Exports, By _____."

Certified copies of documents included in the records of the War Trade Board and of licenses or refusals thereof and of regulations issued by the War Trade Board may no longer be authenticated by the War Trade Board officials. They may be authenticated only in the name of the Secretary of State under the seal of the Department of State by the Chief Clerk. Forms for this purpose are in the course of preparation.

COLUMBIA UNIVERSITY

GENERAL BAKELITE COMPANY FELLOWSHIP

The General Bakelite Company has provided the funds for an industrial fellowship in the department of chemical engineering of Columbia University. This fellowship differs from the general type of industrial fellowships in that in addition to the amounts paid to the Fellow and for the chemicals and apparatus used by the Fellow, an additional sum is paid to the University to compensate it for the use of the laboratories and other facilities used by the worker. A further difference is that no time or other limitation is put upon the publication of the results of the investigation. Mr. Mortimer Harvey has been appointed to the General Bakelite Company Fellowship for 1919-1920.

FIXED NITROGEN RESEARCH LABORATORY

A "Fixed Nitrogen Research Laboratory" has been organized in the Nitrate Division of the Ordnance Department, with headquarters at the American University, in buildings formerly occupied by the Chemical Warfare Service. Lt. Col. A. B. Lamb, of the Chemical Warfare Service, is director; Dr. R. C. Tolman, formerly of the Chemical Warfare Service, and Prof. W. C. Bray, of the University of California, are associate directors; and Dr. H. A. Curtis, formerly of the Nitrate Division, Ordnance Department, is executive officer. The work carried on during the war on the fixation of nitrogen in the Department of Agriculture laboratories at Arlington, Virginia, the Geophysical Laboratory, and elsewhere, will be concentrated at the American University. In the absence of Col. Lamb in Europe, Dr. Tolman is acting director. At present the staff consists of fifty-five persons.

A HIGHLY UNSATURATED HYDROCARBON IN SHARE LIVER OIL—CORRECTION

In the article of the above title [THIS JOURNAL, 8 (1916), 889], the following corrections should be made:

Page	Column	Line	
895	left	27	"333 per cent" should read "343 per cent."
895	left	28	"327.60 per cent" should read "333.7 per cent."

See also THIS JOURNAL, 9 (1917), 109.

M. TSUJIMOTO

IMPERIAL INDUSTRIAL LABORATORY
YENCHU-SHIMA, TOKYO, JAPAN
May 14, 1919

TREATMENT OF LOW-GRADE NICKEL ORES—CORRECTION

In the article of the above title [THIS JOURNAL, 11 (1919), 644], the following correction should be made:

Page 645, 1st column, ninth line from the bottom, "unsaturated" should read "untreated."

July 7, 1919

CHARLES W. DAVIS

WASHINGTON LETTER

By PAUL WOOTON, Union Trust Building, Washington, D. C.

No better case ever was made before the Committee on Ways and Means of the House of Representatives than that of the dyestuffs industry, during the recent hearings. Apparently the members of the Committee are not regarding the question as a partisan one. The Democrats, as well as the Republicans, seem agreed that the industry may have whatever tariff protection may be necessary to build up a sturdy domestic dyestuffs industry. The much mooted point is the licensing plan. The division in the Committee on this matter, however, is not along party lines. The consensus of opinion among those who have followed the hearing closely and who are in touch with the views of members of Congress is that the bill, when it emerges from Congress, will provide high tariff safeguards supplemented by a licensing system which will be considerably simplified as compared with the plan now before the Committee.

As far as potash, tungsten, and magnesite are concerned, it is apparent that those industries have failed to make a highly convincing case. It is believed that little, if any, legislative aid will be extended the potash industry while the tungsten and magnesite schedules face decided reduction from the rate of duty asked.

An idea of how the Democrats feel toward the dye industry may be obtained from the following expression of opinion by Representative Collier, one of the members of the Ways and Means Committee, who has been most unbending in his attitude toward high protective tariffs:

We must keep pace with the rest of the world in chemistry. We must augment the ranks of our chemists. American brains and American ingenuity applied intensively to the ever present chemical problems will accomplish greater results than those of which the Germans ever were capable. The building up of a great dyestuffs industry will contribute importantly to that end. In addition, the dyestuffs industry is almost in a class alone in its importance as a key industry. Germany probably would not have gone to war had she not been convinced of the superiority of her chemists. Perhaps we may be able to assist more in maintaining peace when a great chemical development in this country has been added to our other claims to prowess.

Owing to the unanimity of feeling with regard to the dyestuffs industry, its friends are anxious that the dyestuffs bill be reported by itself. If it is made a part of an omnibus emergency tariff measure, its passage would be delayed by the extended discussion which is certain to accompany the consideration of any other commodities. If the dye bill is allowed to stand alone, its prompt passage is regarded as a certainty.

What amounted to an investigation of the Alien Property Custodian's office grew out of the dyestuffs hearings. Despite the very strenuous probing, done largely by Representative Moore, of Pennsylvania, nothing to discredit the Chemical Foundation or the Alien Property Custodian was unearthed. In fact, in the opinion of many, the information brought out regarding the Chemical Foundation has reflected very favorably upon it and upon the men who are devoting their time to its work. The large lawyers' fees which came in for so much criticism are not regarded as excessive by disinterested attorneys who call attention to the intricate and technical nature of the work and the large amount of money involved.

The Committee was visibly impressed by the argument of Col. John P. Wood, of Philadelphia, against the licensing system. Until he appeared, most of the objections to the license were based on the possibility of its dishonest administration. Col. Wood, however, based his objections on the impracticability of applying the plan to the industry. He went into detail and showed the great inconveniences and losses which would be caused by the delays incident to the procurement of licenses.

These arguments against the licensing plan lost their importance when, on the following day, the Alien Property Custodian showed unmistakably to the Committee that even while the Committee was sitting agents of the German cartel were circulating petitions against the license plan in textile centers.

In order that the potash producers might have an opportunity to refute some of the admittedly telling arguments made by the farmers, that hearing was reopened for the presentation of additional evidence. An effort was made to prove that domestic potash contains no injurious ingredients. In response to a direct request, the producers also gave the Committee a detailed statement to support their assertion that \$50,000,000 has been invested in the domestic industry. In the statement the names of the individual companies were given, but the amount invested was placed under general heads as follows:

cement mills, \$1,888,447; kelp, \$1,677,650; molasses distilling slop, \$512,487; Nebraska lakes, \$11,270,200; Salt Lake brines, \$800,000; Seale Lake, \$10,400,000; alunite and silicates, \$2,860,000; sugar refineries, \$953,682; wood ashes, \$163,160; miscellaneous, \$1,436,000. In addition to the concerns having the above amounts invested, a long list of other companies was submitted from which the producers' association had not been able to secure reports.

To the charge that the packing interests control the domestic potash industry, the reply was made that 6 per cent of the domestic potash production comes from the alunite plant in Utah, which belongs to the Armour interests. Swift and Company, it was pointed out, had operated a kelp plant on the Pacific coast but the plant has been closed for some time. Thus, it was asserted that 94 per cent of the domestic potash production is entirely independent of the packing industry.

Few records made before the Ways and Means Committee are of greater interest than that made during the hearings on the dye industry. Dr. Grinnell Jones, of the Tariff Commission, in setting forth the general situation in regard to dyes, made among others, the following observations:

The output of dyes during 1918 was \$7,155,600 lbs., which is a gain of almost 25 per cent over the 1917 output, which was almost exactly equal to the imports during the year preceding the outbreak of the European war. In 1917, more than 300 different dyes were made. However, in spite of the great and encouraging progress, the American industry is still unbalanced.

The American industry has been especially successful in producing the classes of dyes known as "azo" dyes, sulfur dyes, and induline dyes, and has had considerable success in making triphenylmethane dyes and indigo. On the other hand, many important dyes are still missing entirely, or only made in small experimental lots.

Conspicuous among the undeveloped branches of the dye industry are a whole series of so-called "vat" dyes for cotton, derived from the raw material anthracene. These dyes are the fastest dyes known, and are absolutely essential for gingham and cotton shirtings of the best quality. Experimental work on these dyes has been active, but actual production has been negligible up to the present time. There is, however, no question that these dyes will be produced within a short time, provided the companies feel that they have sufficient protection to justify them in making the necessary additional investments required. There were 77 firms that reported the manufacture of dyes during 1918.

During this same period there has been a notable development of other products derived from coal tar. The importance of coal-tar products for the manufacture of explosives is so familiar that I do not need to elaborate it here.

American chemists and engineers have not accomplished in 4 years all that the Germans have done in 40. Although encouraging progress has been made in the last four years, the industry, when viewed as a whole, is not yet on a secure economic basis. From a tariff point of view, the industry is still an infant industry.

That the textile industry has learned its lesson and now is willing to support a tariff on dyestuffs is indicated by the statement of Rufus R. Wilson, secretary of the National Association of Cotton Manufacturers. An extract from his remarks is as follows:

The American spinner in the last four years has become convinced that it is absolutely essential not only to our own safety as a nation, but to protect our industry, that we shall have a sufficient protection on dyes in this country. They feel that they never again want to be in a place where they will be at the mercy of some alien power for their dyestuffs needed in the manufactures here in America. There was a very serious time in the early days of the war, when 4,000,000 people might have been put out of work for want of dyestuffs. I have been asked to come here particularly to say to you that the cotton spinners through their formal organizations strongly favor a licensing system. They favor that both on patriotic grounds and also on the ground of enlightened self-interest. They feel that in that way they would be protected both in the quality of domestic dyes and also the stuff that they would get from abroad.

Counsel for the Chemical Foundation made the following statement to the committee:

This hearing is to demonstrate the necessity, at the present time, of a stimulus to the coal-tar chemical industry, and it does not make very much difference what a man's predilections may be in regard to the general economic policies that should obtain in the country. As a matter of fact, it has been pretty thoroughly demonstrated that there is one industry, the coal-tar chemical industry, which is so inseparably interwoven with the industrial independence of a nation, and its program for national defense, that it must at all hazards exist in a country which is to be in reality one

of the great independent nations of the world. Our proposition, as we have embodied it in the measure already before this committee, was essentially one free from the slightest political significance, free from any idea that the President or anybody else should have a determining influence in the matter of administration of the license system, but was one which was to be entirely related to the customs system of the United States in so far as the details of administration were concerned, because I knew, as I think from his long examination of the subject, Mr. Choate knew, that the best equipped body of experts in the United States to take care of the details, was the customs officials of the United States, and therefore there has not yet been presented a particular form of license system. It is desired by the people concerned with dye industry, to attach it, perhaps, in the form of an amendment to the Longworth bill.

During the testimony of Frank B. Cheney, a silk manufacturer of South Manchester, Conn., Chairman Fordney of the committee, made the following observation:

The licensing system, as has been presented here, on the potash and dyestuffs, would furnish no revenue at all and it is not proposed to, but it would take a sum of money out of the Treasury to administer the law. I am afraid of the licensing system not being effective.

The trade knows, that the Democratic Party, which is in power, does not believe in a protective tariff, and no matter what Congress may do, the White House has the power to act as a stumbling block in opposing any protective measure. Is it now, because of that fact, you would want Congress to pass the licensing system?

To this, Mr. Cheney replied:

I have not connected the licensing system with the Democratic Party. First, I would like to say that the licensing system, as I understand it, does not propose to interfere at all with the revenue derived from import duties.

Those duties would be applied to goods which were brought in under a license just as they are now. But, on the other hand, I believe that the licensing system will produce more revenue than we formerly got from our dye imports, through the income taxes, which would come to the Government from the largely expanded dyestuff industry, which will be built up behind this licensing system.

Cheaper processes for the manufacture of a number of dyestuffs and medicinal preparations will result, it is believed, from discoveries made by experts of the United States Department of Agriculture who have been investigating ways of making certain sulfonic acids. With a view to helping the chemical industry of the country, the Department is offering to cooperate with manufacturers in establishing the process on a commercial scale. The expenses of installation are to be borne by the manufacturing concerns cooperating. Experts of the color laboratory of the Bureau of Chemistry will be assigned to the plants and will assume control of the undertaking.

In all such undertakings, the stipulation will be made by the Department that the manufacturing concern is not to divulge anything pertaining to the original process or to any that may be developed later, but that the right to patent any or all of these remains in the Department of Agriculture, these patents, if they are allowed, to be dedicated to the free use of the Government and the public.

In the laboratory experiments the sulfonation of a number of hydrocarbons has been studied, and in some cases the laboratory work has reached such a stage that large-scale experiments are necessary to prove the value of the process. The work on benzene is most advanced. Sulfonated benzene is used in the manufacture of resorcinol and of synthetic phenol. The laboratory work on the sulfonation of other hydrocarbons is nearing completion.

The War Trade Board Section of the Department of State announced July 14 that General Import License PBF No. 37 (W. T. B. R. 726, issued May 8, 1919; amended by W. T. B. R. 739, issued May 16, 1919) has been revised and extended, effective July 14, 1919, so as to permit the free importation from Germany of all commodities except those hereinafter specifically mentioned.

As now amended, General Import License PBF No. 37 authorizes the importation into the United States from all countries of the world, except Hungary and those parts of Russia under the control of the Bolshevik authorities, of all commodities except those hereinafter enumerated, to wit:

1—The following foodstuffs:

(a) Sugar

(b) Wheat and wheat flour, the control over whose importation is now vested in the Wheat Director (see W. T. B. R. 797, issued June 30, 1919)

2—The following commodities, the importation of which continues to be controlled by reason of existing agreements:

Pig tin, and all metal alloys containing tin, including tin drosses, tin oxides, solder drosses, type metals, anti-friction metals, waste metals and other metals containing tin, except tin plate and tin plate scrap.

3—Salvarsan, neosalvarsan, arsphenamine, and all substitutes thereof and equivalents thereof.

4—All commodities whatsoever which have been produced or manufactured in Hungary.

5—The following commodities, the control of whose importation by individual import licenses is desirable:

(a) Dyes and dyestuffs, including dye bases, crudes, and intermediates

(b) Potash

(c) All drugs and chemicals

It should be noted that the foregoing Paragraph 5, as now amended, provides that hereafter individual import licenses will be required for all importations of drugs and chemicals from every source whatsoever.

All applications for licenses to import dyes or dyestuffs, including dye bases, crudes, and intermediates, must be accompanied by supplemental information sheets as set forth in W. T. B. R. 670, issued March 27, 1919. (Bureau of Imports Ruling 489.)

American consuls abroad have been instructed to issue certificates of non-enemy origin before certifying invoices covering shipments of potash, dyes or dyestuffs, or drugs or chemicals intended for importation into the United States.

The prior rulings of the War Trade Board which required the purchase price of certain commodities permitted to be imported from Germany to be deposited with the American Relief Administration (W. T. B. R.'s 764, 772, and 779) have been rescinded, and such purchase price may now be remitted in any manner desired by the importer under the terms of the General Enemy Trade License issued simultaneously with this ruling, W. T. B. R. 802.

The Chemical Foundation, Inc., through its Counsel, Emory, Varney, Blair, and Hoguet, has begun a suit in the United States District Court of New York, against the Anglo-French Drug Company, a New York concern, to stop the importation of arsphenamine and neo-arsphenamine, on the ground that such importation constitutes an infringement of patents held by the Chemical Foundation, Inc.

Judge Hand has issued an order to bring the Anglo-French Drug Company into court. This order reads as follows:

On the bill of complaint herein and the affidavits of Samuel A. Tucker and Lucius E. Varney duly verified on the 2nd day of July 1919, LET THE DEFENDANT SHOW CAUSE at a general motion term of this court to be held in the Post Office Building in the Borough of Manhattan on Thursday, July 17, 1919, at 10.00 A.M. or as soon thereafter as counsel can be heard, why an order should not be entered enjoining the defendant, *pends lite*, from selling "supsalvs" and "ampsalvs" or otherwise infringing the arsphenamine and neoarsphenamine patents here in suit and belonging to the Chemical Foundation, Incorporated.

This suit is the first to be begun by the Chemical Foundation, Inc., to protect its patent rights. The infringing arsphenamine was imported and offered for sale generally in New York by the Anglo-French Drug Company under the name of "ampsalvs" and "supsalvs" and was advertised to be, or to contain, the genuine Ehrlich "606" and "914," otherwise known as salvarsan and neo-salvarsan.

The Chemical Foundation, Inc., is the owner of more than forty-five hundred one German-owned dye, chemical, and drug patents. These patents were sold to the Foundation by the Alien Property Custodian under an Executive Order approved by the President. It is the purpose of the Foundation to protect in every way its rights under these patents. No expense or effort will be spared.

The War Department is offering for sale a surplus of several million pounds of standard grade chloride of lime, containing 35 per cent of available chlorine which is prepared for commercial use in 50 and 700 lb. drums. It was acquired by the War Department for use by the Army as a disinfectant and as a raw material in the manufacture of poisonous gases. The major portion of the present surplus is located at Edgewood, Maryland. Communications designed to inaugurate negotiations for the material should be addressed to the Director of Sales, Munitions Building, Washington, D. C.

The War Trade Board Section of the Department of State announced July 15 that nitrate of soda may now be imported freely under the authority of General Import License PBF-37, thus eliminating the necessity of securing individual import licenses to cover importations of this commodity.

The War Trade Board announced on June 20 that application for licenses to export pharmaceutical products and medical accessories to Germany will be considered, provided the particular commodities to be shipped cannot be procured in Germany. In submitting applications to the War Trade Board, Washington,

D. C., covering these shipments, exporters should present such evidence as they may have that the pharmaceutical products or medical accessories which it is desired to export are not procurable in Germany.

The War Trade Board Section of the Department of State announced July 15 that on or after that date, all shipments of tin ore and tin concentrates may be imported under the authority of General Import License PBF-37, thus eliminating the necessity of securing individual import licenses to cover importations of these commodities.

INDUSTRIAL NOTES

LIST OF APPLICATIONS MADE TO THE FEDERAL TRADE COMMISSION FOR LICENSES UNDER ENEMY-CONTROLLED PATENTS PURSUANT TO THE "TRADING-WITH-THE-ENEMY ACT"

YEAR	PAT. No.	PATENTEE	ASSIGNEE	PATENT	APPLICANT
1918	1,253,252	Kardos and Nawiasky	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Bluish green vat dyes and process of making them	National Aniline Co., Inc., 21 Burling Slip, New York City
1918	1,280,648	Bohn	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	New anthracene dyes and process of making same	National Aniline Co., Inc., 21 Burling Slip, New York City
1908	876,839	Pummerer	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Red dye and process of making same	National Aniline Co., Inc., 21 Burling Slip, New York City
1909	910,839	Munch	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Process of making thioindigo leuco compounds	National Aniline Co., Inc., 21 Burling Slip, New York City
1910	949,592	Munch	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Process of making a thioindigo dye	National Aniline Co., Inc., 21 Burling Slip, New York City
1908	894,004	Homolka and Wilde	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Process of making alpha-oxy-thionaphthenes	National Aniline Co., Inc., 21 Burling Slip, New York City
1909	916,030	Schmidt and Bryk	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Vat dye and process of making same	National Aniline Co., Inc., 21 Burling Slip, New York City
1910	963,813	Schmidt and Bryk	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Red halogenized dye and process of making	National Aniline Co., Inc., 21 Burling Slip, New York City
1913	1,061,781	Schmidt and Thiess	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Greenish blue hexabromindigo	National Aniline Co., Inc., 21 Burling Slip, New York City
1913	1,070,541	Schmidt and Thiess	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Pentabromindigo	National Aniline Co., Inc., 21 Burling Slip, New York City
1904	778,476	Elbel	Kalle & Company, Aktien-gesellschaft, Biebrich, Germany	Beta-naphthol azo dye and process of making same	National Aniline Co., Inc., 21 Burling Slip, New York City
1914	1,103,383	Singer and Milarch	Chemische-Fabrik Griesheim-Elektron, Frankfurt-on-the-Main, Germany	Process of making anthraquinone	National Aniline Co., Inc., 21 Burling Slip, New York City
1914	1,119,546	Singer	Chemische-Fabrik Griesheim-Elektron, Frankfurt-on-the-Main, Germany	Process of making anthraquinone	National Aniline Co., Inc., 21 Burling Slip, New York City
1915	1,150,152	Singer	Chemische-Fabrik Griesheim-Elektron, Frankfurt-on-the-Main, Germany	Process of making alizarin	National Aniline Co., Inc., 21 Burling Slip, New York City
1916	1,199,273	Iljinsky	R. Wedekind & Co.	Process of dyeing with dye-stuffs insoluble in water or water-insoluble leuco compounds of dyestuffs	National Aniline Co., Inc., 21 Burling Slip, New York City
1918	1,285,726	Kalischer	R. Wedekind & Co.	Anthraquinone derivative and process of making same	National Aniline Co., Inc., 21 Burling Slip, New York City
1918	1,285,727	Kalischer	R. Wedekind & Co.	Vat color and process of making same	National Aniline Co., Inc., 21 Burling Slip, New York City
1917	1,216,134	Kardos	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Green vat dyes and process of making them	National Aniline Co., Inc., 21 Burling Slip, New York City
1911	994,437	Ossian Aschan, Helsingfors, Russia, and Wilhelm Kempe, Berlin, Germany	Chemische-Fabrik auf Aktien (vorm. E. Schering), Berlin, Germany	Process of preparing camphor	Dr. Horatio Nelson Frazer, 218 Lincoln Place, Brooklyn, N. Y.
1914	1,116,398	Paul Ehrlich and Alfred Bertheim, Frankfurt-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Dibydrochloride of diaminodioxarsenebenzene	Division of Laboratories and Research of the New York State Department of Health, 278 Yates Street, Albany, N. Y.
1911	986,148	Paul Ehrlich and Alfred Bertheim, Frankfurt-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Derivative of oxyarylarisnic acids and process of making same	Division of Laboratories and Research of the New York State Department of Health, 278 Yates Street, Albany, N. Y.
1913	1,081,592	Paul Ehrlich and Alfred Bertheim, Frankfurt-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Medicinal preparation	Division of Laboratories and Research of the New York State Department of Health, 278 Yates Street, Albany, N. Y.
1913	1,081,897	Paul Ehrlich and Alfred Bertheim, Frankfurt-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Medicinal preparation	Division of Laboratories and Research of the New York State Department of Health, 278 Yates St., Albany, N. Y.
1917	1,234,380	Josef Patek, Karlsruhorst, near Berlin, Germany		Method of manufacturing hydrogen peroxide	Commercial Electrolytic Corporation, 55 Liberty St., New York City
1913	1,063,383	Albert Pletzsch and Gustav Adolph, Munich, Germany		Art of making hydrogen peroxide	Commercial Electrolytic Corporation, 55 Liberty St., New York City
1916	1,196,544	Friedrich Wilhelm Heuser, Gross-Lichterfelde, West, near Berlin, Germany	Accumulatoren Fabrik Aktien-gesellschaft, Berlin, Germany	Method of coating metal with metal	The Rail Joint Company, 61 Broadway, New York City
1917	1,218,423	Julius Edgar Lilienfeld, Leipzig, Germany		Röntgen-ray tube	Green & Bauer, Inc., Hartford, Conn.

LIST OF APPLICATIONS MADE TO THE FEDERAL TRADE COMMISSION FOR LICENSES UNDER ENEMY-CONTROLLED PATENTS PURSUANT TO THE "TRADING-WITH-THE-ENEMY ACT." (Continued)

YEAR	PAT. No.	PATENTEE	ASSIGNEE	PATENT	APPLICANT
1914	1,122,011	Julius Edgar Lilienfeld, Leipzig, Germany		Process and apparatus for producing Röntgen rays	Green & Bauer, Inc., Hartford, Conn.
1914	1,116,398	Paul Ehrlich and Alfred Bertheim, Frankfurt-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Dihydrochloride of diaminodioxarsenebenzene	Massachusetts State Department of Health, Boston, Mass.
1911	986,148	Paul Ehrlich and Alfred Bertheim, Frankfurt - on - the - Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Derivative of oxyarylarisnic acids and process of making same	Massachusetts State Department of Health, Boston, Mass.
1913	1,081,897	Paul Ehrlich and Alfred Bertheim, Frankfurt - on - the - Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Medicinal preparation	Massachusetts State Department of Health, Boston, Mass.
1913	1,081,592	Paul Ehrlich and Alfred Bertheim, Frankfurt - on - the - Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Medicinal preparation	Massachusetts State Department of Health, Boston, Mass.
1912	1,013,181	August Klages and Hermann Vollberg, Salbke, Germany		Process of making chlorosulfonic acid	Atlas Powder Company, Wilmington, Del.
1914	1,116,398	Paul Ehrlich and Alfred Bertheim, Frankfurt - on - the - Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Dihydrochloride of diaminodioxarsenebenzene	George J. Wallau, 6 Cliff St., New York City
1911	986,148	Paul Ehrlich and Alfred Bertheim, Frankfurt - on - the - Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Derivative of oxyarylarisnic acids and process of making same	George J. Wallau, 6 Cliff St., New York City
1913	1,081,592	Paul Ehrlich and Alfred Bertheim, Frankfurt - on - the - Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Medicinal preparation	George J. Wallau, 6 Cliff St., New York City
1913	1,081,897	Paul Ehrlich and Alfred Bertheim, Frankfurt - on - the - Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Medicinal preparation	George J. Wallau, 6 Cliff St., New York City
1914	13,848	Georg Korndorfer and Baptist Reuter, Höchst-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Derivatives of diaminodioxarsenebenzene and process of making same	George J. Wallau, 6 Cliff St., New York City

The Merchants and Manufacturers Exchange of New York plans to make the Grand Central Palace a great clearing house for world commerce. On September 30, the United States Government will turn the exposition building back to the Exchange. For months this great twelve-story building—the largest exposition building in the world—which occupies an entire city block, has been used as an army base hospital. Reconstruction of the entire interior will make it ideal as a permanent show place for all sorts of manufactured products. The industries will be grouped and permanent exhibits will be made on eight spacious floors, each floor having approximately 60,000 sq. ft. of space. The remainder of the building (the four lower floors) will be utilized for the annual exhibitions which have made the building famous, such as the Automobile Show, Electrical Exposition, and the Exposition of Chemical Industries. Permanent exhibits of products of the more important industries will be opened beginning October 15.

Within the last two years a machine has been developed for the production of a regular shaped, bilged keg and barrel of paper and another, somewhat similar, for the manufacture of square, rectangular, or odd-shaped paper boxes. In the barrel-making process, the paper is used as a strip, say 6 in. wide, in a roll of good size. This roll is placed upon a spindle and the 6 in. sheet drawn off and passed through a device for the purpose of coating one side with an adhesive and, at the same time slitting the sheet into two 3 in. strips. The two strips are, at this point, attached to mandrels which are set revolving at considerable speed. After the mandrels have revolved a sufficient number of times they are set to separating as well as revolving. The two ends of the container are thus made first and then, pulling away from one another, the rest of the cylindrical package is made. When the container is of the proper length, the mandrels cease to separate, the knife which has been slitting the 6 in. strip into two 3 in. strips kicks out, and the full 6 in. strip comes down and wraps as many times as desired around the middle of the barrel as a rolling hoop or reinforcing band. It takes about 20 seconds to make a barrel of flour-barrel size by this process. A factory for the commercial production of this barrel is now in operation in Brooklyn, N. Y.

A new dye recently announced by the National Aniline & Chemical Company, Inc., cotton blue B, is an acid blue that will especially interest the silk dyer, the paper manufacturer, and the ink maker. It will also take the place of a blue for laundry purposes, formerly used.

Final statistics of shipments, production, and stocks of cement in the United States have been issued by the Geological Survey and show a marked decrease, due to the war's influence on business, from the output of 1917, and the lowest since 1909. Producers' reports show that about 54 per cent of the capacity of the cement-manufacturing plants of the country was utilized last year.

A new process for the continuous distillation of tar is in successful operation in England, according to Consul Gasset, of Leeds. By a new process, the tar is distilled continuously, each fraction being given off in uniform quality, the pitch being discharged without cessation, both process and product being free from any noxious or disagreeable fumes. The plant works automatically,

and the inventor states that it can be operated by an unskilled man after only one day's training. It can also be used, if desired, for producing prepared tar for dustless-road construction and tar spraying which comply completely with all the British road board's specifications.

The arrangement made on March 14, 1919, between the representatives of the associated governments and the German delegates (known as the "Brussels Agreement") provides that Germany shall be permitted to export a certain portion of her exportable surplus of dyes and dyestuffs as well as other commodities to the associated countries if those countries wish to purchase and import the same. Under the provisions of the Trading with the Enemy Act it is made unlawful to import any commodities from Germany except under the license of the War Trade Board, and the War Trade Board has determined, in view of the policy so declared by Congress, that German dyes shall not be permitted to be imported into the United States, except to the extent that they are needed in this country. To assist in the study of the dye situation and in determining the extent to which the importation of German dyes will be to the interest of this country, the War Trade Board has appointed an advisory committee on dyes. This committee consists of representatives of the dye-producing industry and the industries interested in the utilization of dyes, and is now constituted as follows: Henry B. Thompson, New York City; Frank D. Cheney, South Manchester, Conn.; Franklin W. Hobbs, Boston, Mass.; Morris B. Poucher, Wilmington, Del.; August Merz, Newark, N. J.; W. H. Watkins, Buffalo, N. Y.; C. H. Herty, New York City. As soon as the necessary arrangements have been completed the War Trade Board will issue an announcement with respect to the character and quantity of German dyes which will be licensed for importation into the United States and the conditions under which such importations may be made.

The British oil companies have agreed to join in a scheme for endowing a School of Chemistry at Cambridge University. The Burmah Oil Company has agreed to contribute £50,000, the Anglo-Persian Oil Company £50,000, the Anglo Saxon Petroleum Company £50,000, and Lord Cowdray and the Hon. Clive Pearson between them £50,000, making the total £200,000. In addition a personal contribution of £10,000 has been made. It is understood that not more than one-half of the sum will be devoted to the extension of the present chemical laboratory and that the remainder will be utilized for supplementing the funds at present available for the upkeep of the laboratories and for the payment of the teaching and research staff of the chemical laboratory. While the main object of the donors is that the university may be enabled to render great service to all scientific work, they trust that the connection which will thus be established between the School of Chemistry at Cambridge and the oil industry may lead to the study in Cambridge of the chemical problems connected with mineral oil.

A report issued by the Commonwealth Advisory Council of Science and Industry points out that Australia is largely dependent on outside sources for the raw materials of artificial fertilizers, and that the Council has devoted much attention to the consideration of possible local sources of phosphates and

potash. There are large deposits of alunite, especially in New South Wales and South Australia. A special committee has made complete investigations into the question, and the results of the work have been published in a bulletin. Investigations on the utilization of kelp are in progress in Tasmania. If the whole Australian wool clip were scoured in Australia, and the potash extracted, this would probably suffice for all local needs. The question of obtaining the potash is under consideration by a special committee at Geelong.

Formaldehyde imported into Canada is, in accordance with a recent decision of the Canadian Department of Customs, to be subject to an import duty of 20 per cent *ad valorem* under the British Preferential Tariff and of 25 per cent *ad valorem* under the Intermediate and General Tariff.

The Pratt Engineering & Machinery Co., Atlanta, has been awarded the contract to build on Hutchinson's Island, opposite the city of Savannah, a very large fertilizer manufacturing plant for the Southern Fertilizer & Chemical Company, whose plant was recently destroyed by fire.

The Sunbeam Chemical Company, Cable, Wis., according to Mr. H. C. Hoffman, president, will begin the manufacture of serums for the medical profession on a large scale this year. The company owns about 1,000 acres where the horses selected for the purpose will be kept. It is said that the company's chemists are working on a process for making camphor synthetically.

Encouraged by the success attending the exhibitions of scientific products held last year at King's College, London, and in January last at Manchester, the British Science Guild is organizing another exhibition, to be held this summer at the Central Hall, Westminster, from July 3 until August 5. The exhibits will include the following sections: Agriculture (including foods and food production); chemistry (inorganic products, organic products, plant, laboratory ware and apparatus); engineering; fuels; metallurgy (ferrous products, nonferrous products, furnaces, and plant); and textiles.

The Rodrian Products Co., Inc., has been organized by Richard Rodrian. Processes for manufacturing certain products by chemical, electrochemical, and metallurgical methods, invented by Richard Rodrian form the basis of the industry. The company is capitalized at \$100,000, and is authorized to issue 2,000 shares of \$50 par value.

The Shawinigan Water & Power Company of Shawinigan Falls, Quebec, have opened an office in London, England, to promote the sale abroad of the chemical products of its subsidiary companies. These include the Canada Carbide Company, manufacturers of carbide of calcium, and the Canadian Electro Products Company, producing acetic acid, acetaldehyde, and other chemicals related to acetic acid.

The result of the cessation of German government orders is seen in the reports issued by firms manufacturing dyes or other chemicals. Meister Lucius & Brüning, Hoechst, with a capital of \$22,500,000, are paying 12 per cent as against 20 per cent last year. A loan of \$12,500,000 is being raised for the purpose of buying raw material abroad. The Berlin Aniline Company, capital \$8,250,000, who paid 18 per cent last year, are now paying 12 per cent. The firm of Weiler-ter-Meer, Uerdingen, with a capital of \$2,500,000, is paying 7 per cent as against 10 per cent. Messrs. Leonhardt & Company, a smaller firm controlled by Cassella & Company, are again paying 4 per cent. The Chemische Fabrik Griesheim-Elektron have just issued a balance sheet showing a net profit of \$1,125,000, compared with \$2,210,000 last year. They have declared a dividend of 7 per cent with a bonus of 6 per cent in addition, as against 16 per cent dividend and no bonus last year. The capital of the company is \$6,250,000. The Badische Anilin und Soda Fabrik, Ludwigshafen, state in their detailed report that the works practically came to a standstill because of the sudden cessation of orders for war material last October. The change over to peace production was made as completely and quickly as possible, but before December lack of coal again caused a general stoppage, and since then, the coal shortage and difficulties with labor have prevented the restarting of all but one or two small departments. The Oppau factory for the manufacture of synthetic ammonia is in course of extension, and increased production is hoped for by the beginning of next year. The new synthetic ammonia works in Merseburg are expected to be completed by 1921. The Badische Anilin und Soda Fabrik shows a net profit of \$2,710,000, as against \$7,500,000 last year. With the aid of the amount brought forward a dividend of 12 per cent is being paid. The capital is \$22,500,000. The amount provided for depreciation is \$10,150,000, as against \$5,300,000 last year.

The Farbenfabriken vorm. F. Bayer & Co., Leverkusen, has a net profit of \$3,020,000, as against \$7,520,000 last year, and will pay a dividend of 12 per cent. The capital is \$22,500,000. For each of the last three years the above two companies have paid dividends of 20 per cent. Kalle & Co., Biebrich, is paying 7 per cent, as against 10 per cent last year. The impression received from studying the reports of the companies mentioned above is that a serious view is taken of the general outlook.

The British American Chemical Corporation was recently incorporated with an authorized capital of \$3,000,000 under the laws of New Jersey to take over the property and business of the old company, the British-American Chemical Company, of Ridgfield Park, N. J.

An investment of \$1,200,000 is announced by the Morris Fertilizer Company, of Atlanta, for adding to its Southern facilities. It will provide for a \$750,000 phosphate mining plant at Bartow, Fla., and a \$450,000 fertilizer factory near Wilmington, N. C. The Florida capacity will be 200,000 tons of export rock annually, and the yearly capacity of the North Carolina factory will be 75,000 tons.

Leading West Virginia manufacturers and financiers have organized the West Virginia Metal Products Co., Fairmont, W. Va., to build a \$1,500,000 plant for fusing copper, spelter and other alloys into brass in furnaces heated by gas and providing for electrical heat when required. The officers of the company, which is capitalized at \$2,500,000, are: *President*, J. E. Watson; *Vice President*, M. L. Hutchinson; *Secretary*, George M. Alexander, all of Fairmont.

German competition was cited in a paper recently read by Professor H. E. Armstrong before the British Royal Society of Arts as one of the factors which have adversely affected the indigo industry of India. He said that before the war the area devoted to the indigo plant in India was less than 150,000 acres, whereas when synthetic indigo was first put upon the market by the Germans in 1897 the area occupied was 1,688,042 acres. Up to 1897 the advance in the prosperity of the Indian industry was phenomenal, but from that period onwards a rapid decline set in, until in 1914 the amount produced was only about one-twentieth of the quantity made in 1896, and the total output became almost negligible. When war broke out arrangements were made to increase production, and the total area in 1916-17 under cultivation was three and a half times that of the preceding five years. Experts had found that many soils were deficient in available phosphoric acid, and that the utmost economy must therefore be observed in the use of phosphates. As to the future of the indigo industry in India, he did not regard the outlook as being as unsatisfactory as some might think.

Reports from Helium Plant No. 3 at Petrolia, Texas, designed and built under the direction of the United States Bureau of Mines, show that production of helium began on April 1 and that the quality and quantity have steadily increased. The government officials in charge of this work are confident that very soon helium of the highest purity on large scale production will be forthcoming from this plant. The plant, which employs the Jeffries-Norton process, developed by the Bureau of Mines, has a capacity of 30,000 cu. ft. of helium per day, and costs \$150,000.

The Chemical Foundation, Inc., has issued subscription blanks covering the proposed stock issue of \$500,000, divided into 4,000 shares of preferred and 1,000 shares of common, each of a par value of \$100. The subscription will be distributed on a basis of four of preferred to one of common, and if enough subscriptions are received the allotment to each purchaser will be reduced to a minimum. The common stock has full voting power, and the interest is limited to a 6 per cent dividend. The preferred stock will be subject to redemption at par and accrued dividends on January 21, 1921.

The Twelfth Annual Conference of Weights and Measures Officials, composed of delegates from the States and larger cities of the United States, met at the Bureau of Standards recently, 27 states being represented. The object of these conferences is to bring about uniform laws and regulations regarding the inspection of commercial weights and measures and also to discuss matters of technique and procedure. Among other results of the Conference was the adoption of a resolution favoring the metric system. Officers elected for the following year were: *President*, S. W. Stratton, Director of the Bureau of Standards; *First Vice President*, Chas. G. Johnson, State Superintendent for the State of California; *Second Vice President*, Thure Hanson, Commissioner of Weights and Measures of Massachusetts; *Secretary*, L. A. Fischer, of the Bureau of Standards.

PERSONAL NOTES

Baron Rayleigh (John William Strutt), an honorary member of the AMERICAN CHEMICAL SOCIETY, died in London on June 30, 1919. Baron Rayleigh was born on November 12, 1842. He was educated at Trinity College, Cambridge, where he was Senior Wrangler and First Smith's prizeman in 1865 and Fellow in 1866. He then devoted himself to physical research and in 1879 was called to the professorship of experimental physics at Cambridge. In 1887 he became professor of natural philosophy at the Royal Institution and remained there until he resigned in 1905. Perhaps his most famous single achievement was the discovery of argon in 1894. He was president of the Royal Society, Chancellor of Cambridge University, and scientific advisor to Trinity House. In 1899 he received the Copley Prize of the Royal Society and in 1904, the Nobel Prize in physical science. He received the honorary degrees of LL.D. from Cambridge and D.C.L. from Oxford. He was one of the original members of the Order of Merit, which was instituted at the coronation of Edward VII, and he was an officer of the Legion of Honor.

The death of Emil Fischer, professor of chemistry in the University of Berlin, was reported from Berlin on July 16. Professor Fischer was born in 1852 and was educated at the University of Bonn. He was awarded the Nobel Prize in 1902 in recognition of his work in organic and biological chemistry. In 1913 the Franklin Institute of Philadelphia conferred upon him the Elliott Cresson Gold Medal. He was a member of many scientific bodies and held honorary degrees from many universities.

Mr. C. A. Little, of Elyria, Ohio, who died April 16, 1919, from pneumonia, following influenza, had been employed for the past twelve years as chief chemist of the Harshaw, Fuller, & Goodwin Company. For eight years, prior to this time, and immediately following his graduation from college, at Canton, Mo., he was employed as first assistant to the chief chemist in the laboratory of the National Tube Company, at Lorain, Ohio. As an analyst, Mr. Little was well known and results obtained by him were never questioned. During his work on the analysis of tin, he obtained results which led him to believe that the atomic weight of that element was not correct. Some time later, the weight was changed, conforming with figures obtained by him. Mr. Little was a quiet man of pleasing disposition, a conscientious worker, and a scientist of great ability.

Dr. Harry L. Fisher has resigned from the staff of the department of chemistry at Columbia University to do research work on rubber in the new laboratory of the B. F. Goodrich Company, and will be located at Akron, Ohio, after September 1.

Mr. Philip Adolph Kober has resigned his position as physiological chemist in the New York State Department of Health, Albany, N. Y., and has accepted an offer with E. R. Squibb & Sons, New York City. Mr. Kober will have associated with him in his work for E. R. Squibb & Sons, Mr. C. W. Eberlain who was recently released from service in the U. S. Navy and who, for some years, has been associated with him as his assistant.

Mr. Martin E. Rohn, formerly with the general laboratories of the Bureau of Aircraft Production, located in Pittsburgh and Dayton, is now associated with the Harrison Works of E. I. du Pont de Nemours & Co., Philadelphia, Pa.

Mr. H. H. Hanson, who recently received his honorable discharge from the U. S. Army where he served in the Food Division of the Sanitary Corps, his last assignment having been that of Nutrition Officer, at Camp Lee, Va., has taken a position in the chemical laboratory of the West Virginia Experiment Station, where he will do work in connection with the new feeding stuffs laws of the State which will include chemical and microscopical examinations.

Dr. David Klein, formerly state chemist of Illinois, who has been serving in the Sanitary Corps with the American Expeditionary Forces in France, has been promoted from the rank of Captain to that of Major. He will spend part of the summer in Siberia with the American Relief Administration. Major Klein has just been appointed associate professor of chemical hygiene in the School of Hygiene and Public Health of Johns Hopkins University.

Mr. Charles H. Stone, for a number of years with the National Aniline and Chemical Company, Inc., and one of its component companies, the W. Beckers Aniline and Chemical Works, Inc., became associated recently with the Atlantic Dyestuffs Company, with works located at Burrage, Mass., as vice president and sales manager.

In view of the retirement of Professor F. P. Dunnington, of the school of analytical and industrial chemistry of the University of Virginia, the following resolution has been passed by the visitors: "Resolved, that the rector and visitors of the University of Virginia accept the resignation of Professor Francis Perry Dunnington with very sincere acknowledgment of his long, capable, and faithful service to the University. The rector and visitors assure him of their confidence and good will, and wish for him a long life of continued usefulness in his career."

Dr. H. K. Benson, formerly Captain in the Ordnance Department of the Army and engaged in research work in nitrogen fixation has returned to Seattle, Washington, to act as professor of chemical engineering and administrative head of the department of chemistry in the University of Washington.

Mr. Harry Eastwood, after spending eighteen months in the Ordnance Department as engineer of tests and chief army inspector, and later on Claims Board work, has resigned to take a position as chemist and metallurgist for the American Radiator Company, at Kansas City, Mo.

Dr. Norman A. Shepard, assistant professor of chemistry at Yale University, has resigned from the Yale faculty to enter the employ of the Firestone Tire and Rubber Co., Akron, Ohio, as research chemist.

Dr. Philip L. Blumenthal, who, after being discharged from the U. S. Gas School at Camp Kendrick, N. J., returned to his old post as research chemist at the Kentucky Agricultural Experiment Station has just recently left that station to join his partner, Stephen C. Babcock, at Lackawanna, N. Y., where they are conducting a general consulting and analytical laboratory under the firm name of the Babcock Testing Laboratory.

Mr. Edward G. Mahin, professor of analytical chemistry and physical metallurgy at Purdue University, Lafayette, Ind., is spending the summer months with the Michigan Smelting and Refining Co., Detroit, Mich., acting in an advisory capacity in developing the methods and equipment of the chemical and physical testing departments.

Dr. Benjamin Palmer Caldwell, for many years professor of general and theoretical chemistry in Tulane University, New Orleans, La., and for the past three years professor of chemistry at Oglethorpe University, Atlanta, Ga., has been elected professor of analytical chemistry in the Brooklyn Polytechnic Institute, Brooklyn, N. Y., and will begin his new duties in the fall.

Mr. Thomas P. Kelly, formerly in the Development Division of the Chemical Warfare Service, has been, since January of this year, in the Technical Sales Department of The Glidden Company, at their main plant in Cleveland, Ohio.

Mr. Louis Baumann, who for the past eight years, has been assistant professor and director of chemical research in the department of medicine of the State University of Iowa, has returned to New York City and expects to devote his time to practical and scientific medicine.

Mr. E. R. Allen has resigned his position as associate in biological chemistry, Washington University School of Medicine, St. Louis, Mo., to accept a position in the azo dye department of the Jackson Laboratory of E. I. du Pont de Nemours & Co., Wilmington, Del.

Mr. W. N. Pritchard, Jr., formerly chemist and inspector on cotton products with E. I. du Pont de Nemours & Co., has accepted a position with the Buckeye Cotton Oil Co., Franklin, Ohio.

Mr. W. O. Robinson, formerly Captain in the Chemical Warfare Service stationed at Edgewood Arsenal where he was chief of the Inorganic Laboratory, Laboratory and Inspection Division, under Lt. Col. Evans, has taken up his old work in the Bureau of Soils, under Dr. H. G. Byers.

Mr. H. J. Nimitz has resigned from the position of deputy state chemist on foods at the State Chemist Department, Lafayette, Ind., and has become manager of the Feed Department of the Buckeye Cereal Co., Massillon, Ohio. The Company is contemplating the installation of a small but complete laboratory, so that Mr. Nimitz can do their chemical work also.

Mr. F. L. Locke and Mr. V. Weaver Smith recently resigned as superintendent and assistant superintendent, respectively, of the British-American Chemical Company, Inc., of Ridgefield Park, N. J., to devote all their time to the Harbor Sales & Manufacturing Company, Inc., of New York City. Mr. Locke is president of this company, and Mr. Smith, secretary-treasurer.

Mr. W. E. Perdue recently resigned his position as chemical engineer in the Petroleum Division of the Bureau of Mines to enter the employ of the Union Petroleum Company of Philadelphia. Mr. Perdue had been with the Petroleum Division of the Bureau for two years, and returned to Washington on the 1st of April last, after eight and a half months spent in Great Britain, France, and Italy as one of the American representatives on the Interallied Petroleum Conference, a war-time body, subsidiary in part to the Allied Maritime Transport Council, handling allocations, deliveries, requirements, stocks, and consumption of petroleum products by Great Britain, France, Italy, and the A. E. F. The American members of this Conference represented the Shipping Board, Navy Department, War Department, Oil Division of the Fuel Administration, and the Interior Department.

Dr. H. G. Byers has resigned from the University of Washington, and has accepted a position as chief of the Division of Chemistry in the Bureau of Soils.

Dr. N. A. Lange, formerly instructor in organic chemistry at the University of Michigan, has been appointed assistant professor of organic chemistry at the Case School of Applied Science, Cleveland, Ohio.

Mr. William Tiddy, formerly chief chemist in the blast furnaces and by-product coke plant of the Inland Steel Co., Indiana Harbor, Ind., is now chief chemist of the Rainey-Wood Coke Co., Swedeland, Pa.

Mr. C. R. Kohn, of India, a member of the AMERICAN CHEMICAL SOCIETY, is now in America visiting places of chemical interest here.

Mr. E. O. Denzler, recently with the Bureau of Mines, Ithaca, N. Y., is now connected with Sargent & Company, New Haven, Conn.

The first du Pont Scholarship at the College of the City of New York has been occupied the past year by John E. Brolles, Jr. The du Pont Scholarship for the year 1919-20 has been awarded to Felix Braude, B.S., class of 1919.

Dr. Joseph W. Richards, of Lehigh University, recently sailed for Norway and Sweden and will be absent from this country until September.

Mr. A. A. Bissiri, formerly of the research department of the Hercules Powder Co., San Diego, Cal., is now in the research department of Parke, Davis & Co., Detroit, Mich.

Mr. Arthur S. Kapewich, in view of the suspension of operations of the Union Dye & Chemical Co., Inc., at Kingsport, Tenn., where he was engaged as research chemist, has accepted another position as chief chemist with the Nitro Powder Co., Kingston, N. Y., with which firm he was connected for over three years prior to his southern engagement with the Union Dye & Chemical Co., Inc.

Dr. L. J. Gillespie, of the Bureau of Plant Industry, has been appointed professor of physical chemistry in Syracuse University.

Dr. Leroy S. Palmer, assistant professor of dairy chemistry in the college of agriculture of the University of Missouri, has been appointed associate professor of agricultural biochemistry in the College of Agriculture, University of Minnesota, and dairy chemist in the Minnesota Agricultural Experiment Station.

George E. Holm, Ph.D., Minnesota, 1919, has been appointed assistant professor of agricultural biochemistry and assistant agricultural biochemist in the Minnesota Agricultural Experiment Station.

Dr. Samuel Wesley Stratton recently had the honorary degree of doctor of science conferred upon him at Yale University. Dr. Stratton is a mathematician and physicist. He has held professorships in the Universities of Illinois and Chicago, was a naval officer in the Spanish War, and since 1901 has been director of the Bureau of Standards.

Mr. S. A. Rice, formerly chemist in the U. S. Army, stationed at the Hydrogen Plant, Fort Omaha, is now head of the chemical control work and secretary of the board of directors of the Ryo Beverage Co., Omaha, Neb.

Mr. Fred H. Smith, formerly 2d Lieutenant in the U. S. Air Service, has returned to the Georgia Experiment Station as nutrition chemist.

The University of Pennsylvania at its recent commencement conferred the honorary degree of doctor of science on T. Charles L. Reese, of Wilmington, Del., and Dr. H. S. Miner, of Gloucester, N. J. Dr. Reese also received the same degree at the commencement of Colgate University.

Major Sterling Temple has received his discharge from the Service at Edgewood Arsenal and is now research chemist for the Roessler and Hasslacher Chemical Co., Perth Amboy, N. J.

Mr. H. M. Loomis, for the past three years director of inspection in the sardine industry for the National Cannery Association at Eastport, Maine, is now national director of inspection for the same association with headquarters in Washington, D. C.

Mr. J. Glanding Daily, formerly manager of the Tungsten Products Co., Baltimore, Md., is now associated with Dr. Sidney J. Lebolt in a general industrial consulting business under the firm name of Daily-Lebolt Co., New Brunswick, N. J.

Mr. Robert T. Baldwin has been appointed assistant to the president, Mr. Orlando F. Weber, of the National Aniline & Chemical Co., Inc., New York City.

Mr. Ellis I. Fulmer, formerly assistant in chemistry at the University of Toronto, where he received his Ph.D. degree in June of this year has been elected to an assistant professorship in chemistry at Iowa State College, Ames, Iowa.

Mr. George Barsky has been appointed to the Bridgman Fellowship (\$1500) at Columbia University for the year 1919-20, and will work in the department of chemical engineering with Professor McKee on the utilization of the waste liquor from sulfite pulp mills. Mr. Barsky received the degree of chemical engineer in 1918 from Columbia University.

Dr. Arthur W. Hixson has been appointed associate professor of chemical engineering at Columbia University. He entered on the duties of his new position July first. Professor Hixson was formerly associate professor of industrial chemistry and metallurgy at the University of Iowa, but for the last year he has been in the Ordnance Department at Washington.

Dr. J. J. Morgan, assistant professor of chemistry at Stevens Institute of Technology, Hoboken, N. J., has been appointed assistant professor of chemical engineering at Columbia University, New York City. Professor Morgan will enter on the work of his new position in September.

Mr. Warren S. Williams, formerly head of the Glass Section, Bureau of Standards, Pittsburgh, Pa., where he was in charge of research on and production of optical glass, has accepted a position with the H. C. Fry Glass Company, Rochester, Pa.

Dr. Maurice L. Dolt, professor of organic chemistry at the North Dakota Agricultural College, has resigned to accept a position as research chemist with the American Cotton Oil Company.

Prof. W. C. Bray, of the department of chemistry in the University of California, has been granted a leave of absence to become one of the three directors of research in the new nitrate division laboratory of the Government.

Major A. J. Allmand has been appointed to the chair of chemistry at King's College, University of London. Major Allmand was demonstrator in physical chemistry at the University of Liverpool prior to his engagement in war work.

Dr. Isaac F. Harris, head of the department of biochemistry of E. R. Squibb & Sons, has been transferred from the plant at New Brunswick, N. J., to the New York offices of this company, 80 Beekman Street, New York City.

Mr. Daniel S. Dinsmoor, formerly in the First Gas Regiment of the U. S. Army, is now in the research laboratory of the Merrimac Chemical Co., North Woburn, Mass., with which firm he was connected prior to enlistment in the Army.

Mr. E. W. Guernsey has severed his connection with the research department of Brown Company, Berlin, N. H., and has accepted a position as assistant research chemist in the Fixed Nitrogen Research Laboratory at Washington, D. C.

Mr. Howard Adler and Mr. Arthur W. Davidson, who have been with the Chemical Warfare Service, have resigned from the chemistry department of the College of the City of New York to devote all their time to post-graduate work in Columbia University.

Dr. H. R. Moody, who was special expert with the War Industries Board, and after its dissolution studied new industrial processes established since the inauguration of the war, will resume his professorial duties at the College of the City of New York in September.

Prof. Reston Stevenson, having returned from France and having secured his honorable discharge from the Army as Major in the Sanitary Corps, has returned to the College of the City of New York, and will resume charge of the work in electrochemistry and physical chemistry in September.

Mr. Arthur B. Cummins is on leave of absence from his position as assistant in agricultural chemistry at the Graduate School of Tropical Agriculture and Citrus Experiment Station, University of California, Riverside, Cal., and will devote his time during his leave of absence to study in the department of chemistry, University of Chicago, Chicago, Ill.

GOVERNMENT PUBLICATIONS

By R. S. McBRIDE, Bureau of Standards, Washington

NOTICE—Publications for which price is indicated can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. Other publications can usually be supplied from the Bureau or Department from which they originate. Commerce Reports are received by all large libraries and may be consulted there, or single numbers can be secured by application to the Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington. The regular subscription rate for these Commerce Reports mailed daily is \$2.50 per year, payable in advance, to the Superintendent of Documents.

GEOLOGICAL SURVEY

Zinc in 1916. C. E. SIEBENTHAL. Separate from Mineral Resources of the United States, 1916, Part I. 25 pp. Issued June 9, 1919.

The production of primary spelter from domestic ores in 1916 was 563,451 short tons, valued at \$151,005,000, based on the average selling price, as compared with 458,135 short tons, valued at \$113,617,000, based on the average selling price, in 1915—an increase of 103,316 tons, or about 23 per cent, in quantity, and of \$37,388,000, or about 33 per cent, in value.

SECONDARY ZINC PRODUCED IN THE UNITED STATES IN 1916, IN SHORT TONS	
Secondary spelter, redistilled.....	29,663
Secondary spelter, remelted.....	21,037
Recovered zinc in alloys, excluding old brass remelted.....	2,600
Recovered zinc in remelted brass.....	61,700

Secondary zinc recovered as metal..... 115,000

Secondary zinc recovered in pigment.....	8,749
Secondary zinc recovered in zinc chloride.....	6,319

Total secondary zinc..... 130,000

¹ These figures include only the quantity of zinc chloride used in wood preservation and were furnished by courtesy of the Forest Service, Department of Agriculture.

The rated capacity of the electrolytic zinc plants was about 40,000 tons annually, but that capacity was attained only near the end of the year. The rated capacity on the completion of plants then under construction was expected to be about 85,000 tons. The output of electrolytic spelter in 1916 was 12,916 tons, of which 1,800 tons was refined from prime western spelter, 887 tons from scrap and drosses, and 10,229 tons from ore.

The price of spelter at St. Louis at the beginning of 1916 was 17.2 cents a pound. By the middle of February it had risen to 20.9 cents a pound, the high point of the year; after which it dropped sharply to 16.5 cents by the middle of March, but rose quickly again to 19 1/8 cents at the middle of April. Then began a long, sharp decline which brought the price to 8.8 cents a pound at the middle of July. A recovery to 10.7 cents was followed by a drop to 8.4 cents on August 10, the lowest price of the year. By fits and starts the price rose to 13.2 cents a pound at the end of November, after which it gradually declined, closing the year at 9.75 cents a pound. For the year the average price quoted for immediate delivery at St. Louis was 13.6 cents a pound, compared with 14.2 cents a pound in 1915 and 5.1 cents in 1914.

The price of the "brass special" grade of spelter at Waterbury, Conn., usually averages about 0.4 cent above the St. Louis price. During 1915 and 1916, however, the differential ranged from 2.1 to 5.7 cents and averaged about 3.3 cents in 1915 and about 4.2 cents in 1916. The price of the highest grades of spelter is not quoted, but sales were reported at more than 40 cents a pound when spelter was at the high point in 1915.

The price of sheet zinc generally ranges from 2 to 2.5 cents above the St. Louis price of spelter but during 1916 it was from 4 to 9 cents above the price of spelter.

Zinc dust, mostly imported from Europe before the war,

generally sold from 1 to 2 cents a pound higher than spelter. In March 1915, the price of zinc dust began to go up, by June it had risen to 40 cents, and at the end of the year it was nearly 40 cents. In 1916 the price declined evenly through the year closing at 20 to 33 cents.

Lead in 1916. C. E. SIEBENTHAL. Separate from Mineral Resources of the United States, 1916, Part I. 18 pp. Issued June 10, 1919.

The following tabular statement gives the general items regarding domestic production and consumption of refined lead, from figures compiled by this Survey.

SUMMARY OF STATISTICS OF REFINED LEAD, IN 1916, IN SHORT TONS	
Total production of refined primary lead ¹ in the United States.....	571,134
Production of desilverized lead in the United States.....	405,619
Production of soft lead in the United States (including desilverized soft).....	235,759
Production of antimonial lead in the United States.....	24,038
Production of lead from domestic ores.....	532,228
Production of secondary lead in the United States.....	96,300
Consumption of primary lead in the United States (disregarding stocks).....	461,238

¹ "Primary lead" which is produced directly from ore, is here distinguished from "secondary lead," which is obtained by refining skimmings, drosses, and old metals. Wherever in this report the word "lead" is used without qualification it means primary lead.

The output of refined lead in the United States from domestic ores in 1916 was 532,228 short tons, valued at \$76,207,000, at the average price of refined lead in New York, compared with 507,026 tons, valued at \$47,660,000 in 1915—a gain in quantity of 45,202 tons, or nearly 10 per cent, and a gain in value of \$28,547,000, or nearly 60 per cent.

MANUFACTURED LEAD PIGMENTS MARKETED IN 1916

PIGMENT	Quantity Short Tons	Value	Average Price per Ton
Basic carbonate white lead:			
In oil.....	96,041	\$16,560,137	\$172.43
Dry.....	32,938	4,714,343	143.13
Red lead.....	23,035	3,933,566	170.76
Orange mineral.....	37,739	5,853,343	155.11
Litharge.....	189,753	\$31,061,589	

The price of lead began the year at New York at 5.5 cents a pound, the minimum of the year, and rose to 8 cents early in April, the maximum. A long decline carried the price down to 5.95 cents a pound in the early part of August. It rose to 7 cents about the middle of September, after which it remained stationary until early in December, when it advanced to 7.5 cents, and it closed the year at about that figure. The average New York price for the year was 6.9 cents, compared with 4.7 cents in 1915, 3.9 cents in 1914, and 4.4 cents in 1913. These are the figures used in calculating the value of the lead produced in the United States during those years.

The Oil Fields of Allen County, Kentucky. With Notes on the Oil Geology of Adjoining Counties. E. W. SHAW AND K. F. MATHER. Bulletin 688. 126 pp. Paper, 20 cents.

The Anvik-Andreafski Region, Alaska. (Including the Marshall District.) G. L. HARRINGTON. Bulletin 683. 70 pp. Paper, 30 cents.

Nickel. F. L. HESS. Separate from Mineral Resources of the United States, 1916, Part I. 5 pp. Issued February 25, 1919.

Although the United States is the largest refiner of nickel it is almost a nonproducer of nickel ore. No nickel ore was mined in this country in 1916, but as usual a small output of the metal, amounting to 918 short tons and valued at \$671,192, was saved as a by-product from the electrolytes in the electrolytic copper refineries.

The imports of nickel for consumption in the United States for 1916, as reported by the Bureau of Foreign and Domestic Commerce, Department of Commerce, have been as follows:

FORM	Quantity Lbs.	Value Dollars	Quantity Lbs.	Value Dollars	Quantity Lbs.	Value Dollars
Nickel, alloys, pig, bars, etc.....	106,019	42,678	31,990	13,557	29,917	7,869
Ore and matte (nickel content)...	34,989,745	4,956,448	56,566,594	7,613,999	72,611,492	9,889,122
Nickel oxide.....	3,194	1,468	497	130	7,968	2,349
Nickel sheets or strips.....	.....	6,851	.....	.....	.....	4,896
Nickel, all other manufactures of..	.....	21,373	.....	6,438	.....	20,984
	35,098,958	5,028,818	56,599,381	7,636,144	72,649,377	9,925,220

Prices on nickel to large steel works seem to have ranged, according to the best information available, between 35 and 38 cents a pound for refined nickel and 5 cents higher for electrolytic nickel. The published quotations which seemed to apply to purchasers who bought less and were not on long-time contracts ranged between 40 and 45 cents a pound for the first seven months and 45 and 50 cents for the last five months, with an added 5 cents for electrolytic nickel.

Lime in 1917. G. F. LOUGHLIN. Separate from Mineral Resources of the United States, 1917, Part II. 30 pp. Issued May 13, 1919.

The total quantity of lime sold in 1917 was 3,786,364 short tons, valued at \$23,807,877—a decrease from the sales of 1916 of 287,069 tons, or 7 per cent, in quantity, but an increase of \$5,298,572, or 28.6 per cent, in value. This was the first year in which the lime marketed in the United States equaled or exceeded \$20,000,000 in value.

The marked increase in the total value of lime sold was due to increased price made necessary by increase in cost of labor and of all supplies, including fuel, coopersage, explosives, and feed. It is reported, however, that the increase in cost of production was greater than the increase in price. The average price per ton, which remained within a few cents of \$4 for a number of years until 1916, when it rose to \$4.54, a record figure, advanced to \$6.29 in 1917. This was an increase of nearly 39 per cent over the price in 1916 and 57 per cent over the normal average price of \$4.

LIME SOLD IN THE UNITED STATES IN 1917 BY USES

	Percentage of Total Quantity	Average Price per Ton
Building lime.....	34.4	\$6.63
Chemical works.....	20.4	5.79
Paper mills.....	9.4	5.65
Glassworks.....	1.6	5.22
Sugar factories.....	1.3	8.03
Tanneries.....	1.8	6.14
Agriculture.....	12.9	5.07
Fluxing.....	5.5	5.44
Dealers—uses not specified.....	5.1	6.42
Other uses ¹	7.3	9.09
	100.0	\$6.29

¹Includes lime for sand-lime brick, slag cement, alkali works, sheep dipping, disinfectant, manufacture of soap, cyanide plants, glue factories, purification of water, etc.

Hydrated lime, according to the accompanying table, after making an increase annually for a number of years and in 1916 a very notable increase of 23 per cent in quantity, in 1917 declined about 1 per cent in quantity but made an increase of 28 per cent in value. The quantity marketed amounted to 709,157 tons, valued at \$4,643,004, in comparison with 717,382 tons, valued at \$3,626,998, in 1916. This final figure for quantity is 1.5 per cent below the preliminary estimate of 719,757 tons, published in February 1918. Hydrated lime represented nearly 19 per cent of total lime in 1917, or practically the same percentage as in 1916. The average price per ton increased 29 per cent and was \$6.54 in 1917, which is notable in view of the fact that the average price per ton was under \$4.50 from 1911 to 1915 and exceeded \$5 for the first time in 1916.

The Evaporation and Concentration of Waters Associated with Petroleum and Natural Gas. R. VAN A. MILLS AND R. C. WELLS. Bulletin 693. 104 pp. Paper, 20 cents. The salts deposited in wells during the extraction of gas and oil, those occurring interstitially in the sediments, and those constituting the Louisiana and Texas salt domes all agree closely in composition with hypothetical salts whose loss from solution during concentration has been predicted by us through comparisons of

the analyses of the dilute and concentrated brines under scrutiny.

It is our purpose to describe the mode of concentration of these waters, the changes they have undergone, and some of the relations that the changes bear to the occurrence and production of petroleum and natural gas. Though samples of the waters under investigation were collected only in the Appalachian fields, the conclusions are widely applicable.

As shown in the concluding chapter, many of the principles herein set forth are capable of practical application, and it is intended that this bulletin shall be of economic value to oil and gas operators as well as of scientific interest. We shall feel repaid for our studies if we make apparent the need for further detailed field and laboratory investigations of the chemical and physical interactions between petroleum and natural gas, on the one hand, and the associated waters and reservoir rocks, on the other.

The Kantishna Region, Alaska. S. R. CAPPS. Bulletin 687. 116 pp. Within the Kantishna district there are several claims that are held for their content of the antimony trisulfide, stibnite. Genetically the antimony lodes are directly related to the gold lodes already described, and the veins have the same association of minerals, but in the antimony lodes antimony occurs in large masses, whereas in the gold lodes antimony, although occasionally recognized, is a minor constituent. At least three months and possibly a longer time must, therefore, elapse between the date the ore is mined and the date it reaches the market. When to the cost of mining is added the cost of transportation by sled and small boat to the Tanana and the freight thence to Seattle or San Francisco, no great margin of profit is left for the producer even at the highest war prices. In addition to these high costs the instability of the market and the possibility of a sudden drop in the price of antimony must be considered. At 40 cents a pound the producer might make a fair profit in shipping stibnite ore, but at 25 or 30 cents a pound he might sustain a serious loss. As a result little stibnite ore was mined in 1915, and none was shipped. Some ore was mined and stacked in 1916, but at this time (1917) no antimony from the Kantishna region has reached the market. Tertiary deposits containing lignitic coal occur at intervals throughout the area considered in this report. They are of large extent just east of Nenana River, the Nenana coal field, where deeply cut valleys expose the formation which there contains numerous beds of lignite.

Contributions to Economic Geology—1918. Part I—Metals and Nonmetals except Fuels. F. L. RANSOME, E. F. BURCHARD AND H. S. GALE. Bulletin 690. 147 pp. As the subtitle indicates, the papers included in these volumes are of two classes—(1) short papers giving comparatively detailed descriptions of occurrences that have economic interest but are not of sufficient importance to warrant a more extended description; (2) preliminary reports on economic investigations, the results of which are to be published later in more detailed form. These papers are such only as have a direct economic bearing, all topics of purely scientific interest being excluded.

Mineral Waters in 1917. A. J. ELLIS. Separate from Mineral Resources of the United States, 1917, Part II. 38 pp. Issued April 21, 1919.

Effort has been made in compiling the following table, which gives the quantity and value of mineral water sold within certain ranges of price during 1917, to eliminate freight and marketing charges and the value of returnable containers, and thus to give the net value of the waters at their sources.

RANGE OF PRICE PER GALLON OF MINERAL WATER IN 1917

Price per Gallon Cents	Number of Springs	Quantity Sold Gals.	Value Dollars	Percentage of Number of Springs	Percentage of Total Quantity	Percentage of Total Value
Not more than 2.....	28	3,319,063	\$2,350	4	7	1
More than 2 and not more than 5.....	163	19,354,995	674,219	23	41	14
More than 5 and not more than 10.....	265	14,654,374	1,230,718	38	31	25
More than 10 and not more than 20.....	99	4,052,103	632,423	14	9	13
More than 20 and not more than 30.....	53	924,773	239,648	8	2	5
More than 30 and not more than 50.....	59	3,605,682	1,544,024	9	8	31
More than 50 and not more than 100.....	23	869,240	550,061	3	2	11
More than 100.....	7	4,189	8,267	1	0	0
	6971	46,784,419	4,931,710	100	100	100

¹ Exclusive of 20 springs whose waters are used exclusively in the manufacture of soft drinks.

Antimony in 1917. E. S. BASTIN. Separate from Mineral Resources of the United States, 1917, Part I. 10 pp. Issued May 13, 1919.

In estimating the supplies of antimonial materials available for domestic use in 1917 ores are excluded from consideration in order to avoid confusion and duplication, inasmuch as the recoverable antimony content of both foreign and domestic ores eventually appears in the records of production of metal, alloys, or compounds.

ANTIMONY METAL AVAILABLE IN 1917

	Short Tons
Stocks in bonded ware houses Dec. 31, 1916.....	1,155
Production from domestic ores.....	258
Production from foreign ores.....	2,182
Imports (general).....	17,824
	21,419
Stocks in bonded warehouses Dec. 31, 1917.....	5,201
Exports.....	495
	5,696

Antimony metal available for private stocks or consumption in 1917..... 15,723

ANTIMONY ALLOYS, MAINLY ANTIMONIAL LEAD, AVAILABLE IN 1917

	Gross Weight (Short Tons)	Antimony Content (Short Tons)
Production of by-product antimonial lead ¹	18,646	2,759
Production of antimonial lead from antimony ores and lead ores or scrap lead.....	2,283	348
Recovery from secondary metals and drosses ²	None	4,961
Imports of type metal for consumption.....	None	None

¹ Produced from lead skimmings as by-product of lead smelting.

² Recovered mainly as purified alloys, not as antimony metal. Gross weight not reported.

The domestic production of antimony oxide and other compounds in 1917 has not been reported; the imports for consumption amounted to 10 short tons, gross weight.

Titanium. F. L. HESS. Separate from Mineral Resources of the United States, 1916, Part I, 1 p. Issued February 25, 1919.

Rutile, titanium dioxide (TiO_2), and ilmenite, titanium iron oxide (TiFeO_3), were produced in this country in 1916 only by the American Rutile Co., Roseland, Nelson County, Va. The company sold 110 tons of rutile concentrates carrying 95 per cent of TiO_2 for \$16,500 and 95 tons of ilmenite concentrates carrying 55 per cent of TiO_2 for \$1,900. The ilmenite is obtained as a by-product of the rutile.

A total of 112 short tons of ferrotitanium, valued at \$8,126, was imported for consumption in 1916.

Tungsten. F. L. HESS. Separate from Mineral Resources of the United States, 1916, Part I. 14 pp. Issued February 25, 1919.

The production of tungsten ore in the United States, following a short collapse at the beginning of the great war in 1914, went forward at such a rate that the output for 1915 was greater than in any previous year and was equivalent to 2,332 short tons of concentrate carrying 60 per cent of WO_3 and valued at \$4,100,000. Interest in tungsten was increasing geometrically, and far the larger part of the product was marketed in the second half of the year. At the beginning of 1916 work was in full swing, prices had reached undreamed heights, and the production in the first half of the year was 3,290 tons, valued at \$9,113,000. Prices reached their zenith in March. With the fall in prices work soon stopped on many lean deposits, and the production in the second half of the year steadily declined. The year's output was the largest ever made by any country—5,923 short tons, valued at \$12,074,000.

At the beginning of 1916 prices of tungsten ore were irregular and depended on the buyer's need and probably also on his fear of not being able to get the ore when he might have even greater need for it. Ores carrying 60 per cent of tungsten trioxide brought at that time as much as \$66 a unit, but by the last of March some ferberite sold for \$93.50 a unit at the mill, and even higher prices were quoted in the newspapers, though they could not be confirmed. The prices of the same ore in the New York market would naturally be somewhat higher. Under the stimulus of these high prices production, not only in this country but in the world at large, was at the highest point ever known. At first the sudden demand created by the orders for war steel were far ahead of the instant productive power of the country. The rapid increase in prices, beginning in the fall of 1915, at a time when tungsten mining was at a low ebb, and culminating in an undreamed maximum, caused prospecting and consequent discoveries of new deposits, the increase of development of known deposits, the operation at high tension of old mills, and the hasty building of new mills. As a result, production increased faster than consumption and soon overran the demand that would absorb the output at the extremely high prices prevailing, so that a drop in prices was inevitable. At one time ores carrying $2\frac{1}{2}$ per cent of WO_3 sold for \$20 or more a unit. June closed with the prices around \$20 a unit for ore carrying 60 per cent or more of WO_3 , and by the end of the year lots were sold for \$15 a unit—a price still equal to the highest before known (in 1907). The normal price before had been \$6 to \$7 a unit. These prices were, of course, for concentrates carrying 60 per cent or more of WO_3 and free from injurious quantities of phosphorus, sulfur, tin, copper, and similar impurities. During the height of the demand, however, ores carrying all sorts of impurities and both tungsten and ferrotungsten carrying not only the same impurities but also high carbon were eagerly bought and used.

Tungsten and ferrotungsten sold for \$9 and more a pound for the contained tungsten. By the end of the year they sold for about \$2.50 a pound.

Cobalt. F. L. HESS. Separate from Mineral Resources of the United States, 1916, Part I. 2 pp. Issued February 25, 1919.

No cobalt is known to have been produced in the United States in 1916. That used in this country was imported from Canada, where it is obtained as a by-product from silver ores mined in the cobalt district. Three smelters at Deloro, Thorold, and Welland, Ontario, reduced the metal in 1916.

Cobalt is used in this country principally as a part of stellite, made by the Haynes Stellite Co., Kokomo, Ind. A smaller quantity is used in high-speed tool steels. The price of the metal in 1916 ranged, according to best obtainable reports, between \$1.25 and \$1.50 a pound.

Molybdenum. F. L. HESS. Separate from Mineral Resources of the United States, 1916, Part I. 3 pp. Issued February 25, 1919.

The production of molybdenum in 1916 was the largest yet recorded in the United States and amounted to 103.37 tons of metal in 1,228 tons of ore and concentrates, valued at \$205,000, as against a production in 1915 of 90.88 tons of metal in ore and concentrates value at \$114,866.²

Radium, Uranium, and Vanadium. F. L. HESS. Separate from Mineral Resources of the United States, 1916, Part I. 3 pp. Issued February 25, 1919.

The output of uranium and vanadium ores in 1916 amounted to about 20,300 tons containing 10 grams of radium (Ra), 33.7 tons of uranium (77,600 pounds of U_3O_8), and 460 tons of vanadium. Any value given to the output must be arbitrary and open to question, for the larger part of the uranium ores was produced by companies who themselves used the ores, and the vanadium ore was produced wholly by the Primos Chemical Company, who also reduced the ore. Although there is a market for carnotite ore ($K_2O \cdot 2UO_3 \cdot V_2O_5 + 8H_2O$), which gives a basis for estimating the value of other similar ores, there is none for vanadium ore. The approximate value, as ore, was probably about \$500,000.

The price of radium was from \$90 to \$120 a milligram for the element contained in a salt, such as the chloride or bromide, in a material containing 50 per cent or more of the pure salt.

Prices for carnotite were nominal and a subject of individual bargaining but ran about \$2 a pound for the U_3O_8 in ore carrying 2 per cent of U_3O_8 , with a bonus for richer ore and a penalty for lower grades. Uranium in ferrouranium, carrying 30 to 40 per cent of uranium, was quoted at \$7.50 a pound.

Vanadium in ferrovanadium, carrying 35 to 50 per cent of vanadium, was sold for \$1.80 to \$2.50 a pound.

Quicksilver in 1917. F. L. RANSOME. With a Bibliography. I. P. EVANS. Separate from Mineral Resources of the United States, 1917, Part I. 89 pp. Issued March 18, 1919.

That there was unusual activity in quicksilver mining in the United States in 1917 is shown by the fact that the production rose to 36,159 flasks, a quantity that has not been reached since 1883. The increased output, however, was obtained almost wholly from mines that had been productive in preceding years and not from newly discovered deposits. The high price of quicksilver has not led to as much prospecting, either of new territory or in well-known quicksilver districts, as might have been expected, and at comparatively few places have energetic efforts been made to reopen old mines that were abandoned when prices were from one-third to one-half of those that have prevailed during the past three years.

QUICKSILVER PRODUCED IN THE UNITED STATES IN 1917

STATE	Ore Treated Short Tons	Percentage Tenor	Flasks of 7.5 Lbs.	Value Dollars
California.....	235,786	0.38	23,938	2,521,151
Texas.....	28,242	1.42	10,791	1,136,508
Nevada.....	3,639	1.02	997	105,004
Oregon.....	12,732	0.11 ¹	388	40,864
Arizona.....	79	1.90	40	4,213
Idaho.....	6	3.12	5	526
	280,484	0.48	36,159	3,808,266

¹ Abnormally low, owing to accumulation of unworked stock.

Average price per flask:	
San Francisco.....	\$105.32
New York.....	109.30
London.....	£22 5s. 3d.
Total number of mines producing.....	51
Total increase of production in 1917 over 1916, flasks.....	6,227
Total exports from United States, pounds.....	808,336
Total imports into United States, pounds.....	390,494

Potash in 1917. H. S. GALE AND W. B. HICKS. Separate from Mineral Resources of the United States, 1917, Part II. 85 pp. Issued March 13, 1919.

The potash industry of the United States began in 1914, when American Potash (Inc.), of Long Beach, Cal., made a small production from kelp. Stimulated by high prices, it has grown steadily since that date. The potash-bearing material reported to the United States Geological Survey as produced in the United States in 1917 amounted to 126,961 short tons, having an approximate average content of potash (K_2O) of 25.6 per cent. This was equivalent to a total content of 32,573 short tons of K_2O , valued at \$13,980,577, or \$429 a short ton, at point of shipment. The production in 1916 was 35,739 short tons of potash-bearing material having an average content of about 27 per cent of K_2O , or a total content of potash (K_2O) of 9,720

short tons, valued at \$4,242,730. The production in 1917 was therefore nearly three and a half times the production in 1916, and it represented 13.6 per cent of normal consumption in the country. The experimental production in 1914 was not reported. The production in 1915 amounted to 1,090 short tons of K_2O , valued at \$342,000.

PRODUCTION

POTASH SALTS PRODUCED IN THE UNITED STATES IN 1917

SOURCE	Number of Pro- ducers	Total Production Short Tons	Available Potash (K_2O) Quantity Short Tons	Percent- age of Total	Value at Point of Shipment Dollars
Mineral:					
Natural brines.....	10	79,876	20,652	63	8,261,873
Alunite (refined salts and crude and roast- ed alunite).....	3	7,153	2,402	7	892,763
Dust from cement mills	8	13,582	1,621	5	700,523
Dust from blast fur- naces.....	3	2,133	185	1	68,841
Organic:					
Kelp.....	10	11,306	3,572	11	2,114,815
Molasses residues from distilleries.....	4	8,589	2,846	9	1,130,907
Wood ashes.....	49	1,035	621	2	549,150
Steffens water from sugar refineries.....	5	2,642 ¹	369	1	147,830
Wool washings and miscellaneous indus- trial wastes.....	3	645	305	1	113,875
	95	126,961	32,573	100	13,980,577

¹ Includes 1,333 tons of material produced but not sold in 1917

NATURE AND VALUE OF POTASH PRODUCED IN THE UNITED STATES

NATURE	Percentage of the Total Production	Approximate Percentage of Potash (K_2O)	Approximate Value per Short Ton of Potash (K_2O) at Point of Shipment Dollars
Crude carbonate and sulfate	45	20-26	400
Crude chloride.....	17	10-44	370
Charred residue from kelp and molasses.....	13	30-37	425
Refined sulfate.....	9	38-50	425
Refined chloride.....	7	50	730
Flue dust from cement kilns and iron furnaces.....	3	9	440
Crude carbonate and sul- fate from wood ashes.....	2	60	880
Unclassified.....	4	.....	.....
	100	.....	.....

IMPORTS

In contrast to the large quantity and low cost of German potash used in the United States before the war, there was imported in 1917 only 8,100 short tons of potash (K_2O), valued at \$7,788,406. Approximately 17 per cent of the imports came from Russia, 15 per cent from England, 14 per cent from Japan, 12 per cent from Chile. 11 per cent from Spain, 10 per cent from Italy, 9 per cent from France, 5 per cent from Portugal, 4 per cent from Argentina, and the remaining 3 per cent from various other countries. About 35.5 per cent of the total importation came in the form of argol, cream of tartar, and Rochelle salt, which have heretofore not been included in the potash statistics. Approximately 28 per cent of these commodities came from Italy, 26 per cent from France, 15 per cent from Spain, 12 per cent from Portugal, 10 per cent from Argentina, and the remaining 9 per cent from other countries.

An average of 269,656 short tons of potash (K_2O) was imported annually during the years 1910 to 1913, inclusive, and 207,089 tons were imported in 1914, making an annual average importation for the five years immediately preceding the war, including 1914, of 257,143 tons. During 1915 approximately 48,867 tons of K_2O was imported.

The prices before the war of the higher grade German potash salts delivered under special contracts for large quantities direct from the source of production to Gulf and Atlantic ports were as follows:

PRICES OF GERMAN POTASH SALTS, 1912-1914

	1912-13	1914
Muriate of potash (80 per cent KCl, 50 per cent K_2O).....	\$38.05	\$39.07
Sulfate of potash (90 per cent K_2SO_4 , 48 per cent K_2O).....	46.30	47.57
Manure salts (20 per cent K_2O).....	13.30	13.58
Kainite (12.4 per cent K_2O).....	8.25	8.36

BOOK REVIEWS

Alkali, Etc., Works Regulation Act, 1906. Technical Index to the Alkali Reports with Appendix, 1894 to 1917. 52 pp. His Majesty's Stationery Office, London. Price, 1s. net.

Administration under the English alkali act is concerned primarily with the prevention of the escape of noxious and offensive gases into the atmosphere. Such a strict interpretation of the act is, however, not intended. The index shows that inspection is viewed by the commission from a broader standpoint, as shown by the researches carried out since 1893, being of great educational value to the general public and of economic value in the development and perfecting of technical processes. With these purposes in view, a Technical Index supplementing that of 1893 has been prepared containing references to the various researches since 1893. These references cover all researches on alkali waste, ammonia, ammoniacal liquor, chemical manure works, coal gas purifiers, cyanogen compounds, ferric and ferrous salts, sulfide and polysulfide, oxides of nitrogen, sulfuric acid works, tar works, venetian red works, contact materials, and zinc and tin residue works.

The appendix consists of a compilation of certain of the methods employed in testing the acidity and the various components of chimney and exit gases in such industries as sulfuric acid, chlorine, zinc, and tin, as well as some of the methods used in the analysis of ammoniacal liquors, saturator gases in sulfate of ammonia works, and spent oxides. Many references to the literature are made.

Many of the methods are given in detail, showing systems of calculation, ways of sampling, detailed methods of analysis, and computation factors.

C. S. LUKES

A Handbook of Colloid Chemistry. By DR. WOLFGANG OSTWALD. Second English edition, translated from the third German edition by Dr. Martin H. Fischer, with numerous notes added by Emil Hatschek. 284 pp. B. Blakiston's Son & Co., Philadelphia. Price, \$3.50, net.

As the translators state in their preface, it is a delicate, if not impossible, task to revise and bring up to date a book whose author is alive in another country. They have met the situation by leaving entirely untouched those large portions of the volume which contain the author's individual views, many of which have proven unacceptable, especially his classification of colloids into suspensions and emulsions. The author's attempt to differentiate between physical and chemical heterogeneity (p. 22) is not at all convincing.

There is practically no reference to important work done within the last five or six years, and the book does not, therefore, cover our entire present knowledge of the subject.

The translators have failed to profit by Thomas's suggestion, and retain the typically German expression "*disperse phase*," although on p. 32 they inadvertently lapse into the correct form, "*supermolecularly dispersed phase*." Otherwise the translation is excellent.

JEROME ALEXANDER

The Chemistry of the Coal-Tar Dyes. By IRVING W. FAY. viii + 500 pp. 2nd Ed., Revised and Enlarged. D. Van Nostrand Co., New York City, 1919. Price, \$4.00, net.

This second edition of Dr. Fay's book, with the exception of an added chapter on vat dyes, is practically a reprint of the first edition, which appeared in 1911. In its general descriptive matter the book brings together in quite a systematic form a great deal of information concerning dyestuffs, though it is to be regretted that the author has not benefited by the great

inspiration during the past few years in dyestuff chemistry here in America to incorporate something new and more instructive in his second edition. The book follows the rather hackneyed lines of the old textbooks on dyestuffs.

While we desire to give full credit to the author for the very interesting and instructive material which he has assembled, we cannot help criticising him rather severely for the many crude expressions which detract very much from the literary value of the book. Also there are many bad typographical errors, which are especially noticeable by reason of the fact that they occurred in the first edition as well, and apparently the author has made no attempt to correct the faults in the second edition. In some places the structure of the sentences looks like a bad literal translation from a German or French original, as the following, for example, on page 4: "From the early manufacture of a nature so crude that during suits in Paris in the early days of one manufacturer against another for infringements of patents neither counsel nor experts could either dispute or establish the identity of products made by different oxidizing agents upon the same raw materials, to the present day, when research is often able to reveal the actual structure and how the complex dye molecule is built up, is a long history of processes which have been improved by a most persistent and thorough study, both theoretical and practical, by the celebrated investigators of the scientific world." This sentence appears as an exotic flower in the first chapter, just what it refers to we have been unable to determine, but it certainly is worthy of a long line of German ancestors. Another example is found on page 5: "If coal be heated equally hot, but inside a long cast-iron or earthenware retort shut off from all contact with the oxygen of the air, then a great number of products is formed wholly unlike those resulting from ordinary combustion." Space prevents us from recording more examples of these gems of literary style.

On page 63, the author states that "Picric acid is the final oxidation product of many aromatic substances." He evidently means that it is the final "nitration product."

In Chapter IX the author has changed the title of the first edition, "The Seven Food Colors," to "The Twelve Food Colors," but on the page headings of this chapter he still retains the old title "The Seven Food Colors." In fact the entire book is sadly disfigured by glaring typographical errors, to which, however, the author seems to be quite endeared, as he not only retains in the second edition of the book nearly all of those that occurred in the first edition, but adds a few more new ones. Examples of errors that the author did not take the trouble to correct in the second edition are: on page 6, "synthetic" for "synthetie;" on page 219, "crocin" for "crocein;" on page 349, "anthracine" for "anthracene." Examples of new errors are: on page 247, "Tatzazine" for "Tartrazine;" on page 419, "Lucius und Brünning" for "Lucius and Brünning."

It is to be regretted that in discussing the synthesis of indigo, the author has failed to make mention of the commercial method by which this dyestuff is now made in large quantities in this country. As everyone knows, the method employed for the preparation of this most important of all dyes uses aniline as the starting point; the naphthalene and phthalic acid process is not used in this country at all, and it is doubtful if it was used to any great extent even in Germany just before the war.

Another feature to be regretted is that the author in his present second edition does not take any cognizance of the development of the dyestuff industry in this country. A discussion of this feature would have added greatly to the value of the book.

J. MERRITT MATTHEWS

NEW PUBLICATIONS

By CLARA M. GUPPY, Librarian Mellon Institute of Industrial Research, Pittsburgh

- Agricultural Chemistry:** Elementary Chemistry of Agriculture. S. A. WOODHEAD. 8vo. 195 pp. Price, 3s. 6d. Macmillan & Co., London.
- Aluminum:** The Manufacture of Aluminum, with Full Notes on Aluminum Alloys, Analysis and Examination of Aluminum Works, Materials and the Manufacturing of Carbon Electrodes. J. T. PATTISON. 12mo. 104 pp. Price, \$3.00. Spon and Chamberlain, New York.
- Babbitt:** Analysis of Babbitt. JAMES BRAKES. 12mo. 169 pp. Price, \$2.00. Allen Book and Printing Co., Troy, N. Y.
- Beverages and Their Adulteration.** H. W. WILEY. 8vo. Price, 21s. J. & A. Churchill, London.
- Boiler Chemistry and Feed Water Supplies.** J. H. PAUL. 8vo. 242 pp. Price, \$4.50. Longmans, Green & Co., New York.
- Chemical Calculations.** S. H. SALISBURY AND J. S. LONG. 8vo. 126 pp. Price, \$1.50. W. S. Rhode Co., Kutztown, Pa.
- Chemistry:** Amateur Chemist; an Extremely Simple and Thoroughly Practical Chemistry for the Home, Office, Shop, and Farm. A. F. COLLINS. 12mo. 209 pp. Price, \$1.25. D. Appleton & Co., New York.
- Chemistry:** Intermediate Textbook of Chemistry. ALEXANDER SMITH. 8vo. 520 pp. Price, \$2.25. Century Co., New York.
- Chemistry:** A Manual of Chemistry, Theoretical and Practical, Inorganic and Organic; Adapted to the Requirements of Students of Medicine. A. P. LUFF AND H. C. H. CANDY. 6th Ed. 12mo. 745 pp. Price, \$3.00. Chicago Medical Book Co., Chicago.
- Chemistry:** Organic Chemistry. VICTOR VON RICHTER. Newly translated and revised from the German edition by P. E. Spielmann. Vol. 1, 2nd Ed. revised. 8vo. 719 pp. Price, \$5.00. P. Blakiston's Son & Co., Philadelphia.
- Chemists' Year Book 1918-1919.** Edited by F. W. ATACK assisted by L. WHINYATES. 2 Vols. 18mo. Price, 15s. Sherratt & Hughes, London.
- Chlorination of Water.** J. RACE. 8vo. Price, 7s. Chapman & Hall, London.
- Dry Cleaning:** Practical Dry Cleaner. W. T. BRANNIT AND J. B. GRAY, Editors. 5th Ed. Revised and Enlarged. 12mo. 378 pp. Price, \$3.00. Henry Carey Baird & Co., 116 Nassau St., New York.
- Manganese:** Bibliography of the Occurrence, Geology and Mining of Manganese, with Some Reference on its Metallurgy and Uses. H. L. WHEELER, Compiler. 8vo. 245-261 pp. Gratis. University of Missouri, School of Mines and Metallurgy, Rolla, Mo.
- Mortars, Plasters, Stuccoes, etc.** Prepared, compared, and edited by F. T. HODGSON. 8vo. Price, 8s. 6d. C. Parker, Oxford.
- Physical Chemistry:** The Realities of Modern Science. JOHN MILLS. 8vo. 327 pp. Price, \$2.50. The Macmillan Co., New York.
- Rubber:** Chemistry of India Rubber, including the Outlines of a Theory on Vulcanization. C. O. WEBER. 8vo. 324 pp. Price, 18s. Charles Griffin & Co., London.
- Steel:** Practical Shell Forging and the Plastic Deformation of Steel and its Heat Treatment. C. O. BOWER. 8vo. 279 pp. Price, \$10.50. Longmans, Green & Co., New York.
- Fats:** Process for the Estimation of Butter Fat, Coconut Fat, Palm Kernel Fat, and Their Mixtures. S. H. BLICHFELD. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 11, pp. 1501-1521.
- Fluorine:** Preparation of Fluorine; A Detailed Account of the Various Methods of Preparing Fluorine Concluding with a Detailed Description of the Electrochemical Methods Evolved during the Latter Part of the War by Chemists Working under the Guidance of the Chemical Warfare Service. W. L. ARGO, F. C. MATHERS, B. HUMISTON AND C. O. ANDERSON. *The Chemical Engineer*, Vol. 27 (1919), No. 5, pp. 107-110.
- Forgings:** Methods for Obtaining Better Forgings. W. C. PETERSON. *American Drop Forger*, Vol. 5 (1919), No. 6, pp. 279-280.
- Glass:** Bottle-Glass and Glass-Bottle Manufacture. W. E. S. TURNER. *Journal of the Society of Glass Technology*, Vol. 3 (1919), No. 9, pp. 37-49.
- Glass:** A Costing System for a Glass Bottle Factory. F. SWERTING. *Journal of the Society of Glass Technology*, Vol. 3 (1919), No. 9, pp. 27-34.
- Glass:** Devitrification of Glass. N. L. BOWEN. *Journal of the American Ceramic Society*, Vol. 2 (1919), No. 4, pp. 261-278.
- Glass:** Manufacturing Costs in the Glass Industry. J. D. MILLS. *Journal of the Society of Glass Technology*, Vol. 3 (1919), No. 9, pp. 14-26.
- Graphite Situation:** A Summary of the Whole Graphite Situation as Faced by Canadian Producers. H. S. SPENCER. *Canadian Chemical Journal*, Vol. 3 (1919), No. 7, pp. 213-216.
- Helium:** La Production Industrielle de l'Hélium. F. G. COTTELL. *Chimie et Industrie*, Vol. 2 (1919), No. 5, pp. 525-533.
- Iron:** Le Traitement des Minerais de Fer Pauvres par Concentration Magnétique. M. H. LOUIS. *Chimie et Industrie*, Vol. 2 (1919), No. 5, pp. 511-524.
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MARKET REPORT—JULY, 1919

WHOLESALE PRICES PREVAILING IN THE NEW YORK MARKET ON JULY 15, 1919

INORGANIC CHEMICALS

Acetate of Lime, Basis 80%.....	100 Lbs.	2.00	@	2.05
Alum, ammonia, lump, U. S. P.....	100 Lbs.	4.25	@	4.50
Aluminum Sulfate, (iron free).....	Lb.	3	@	3 1/4
Ammonium Carbonate, domestic.....	Lb.	13	@	13 1/4
Ammonium Chloride, white.....	Lb.	19	@	20
Aqua Ammonia, 26°, drums.....	Lb.	6 1/4	@	7
Arsenic, white.....	Lb.	8 1/2	@	9
Barium Chloride.....	Ton	65.00	@	85.00
Barium Nitrate.....	Lb.	12	@	14
Barytes, prime white.....	Lb.	30.00	@	35.00
Bleaching Powder, 35 per cent, Works.....	100 Lbs.	2.00	@	2.20
Blue Vitriol.....	Lb.	8 1/4	@	8 1/2
Borax, crystals, in bags.....	Lb.	7 1/4	@	10 1/4
Boric Acid, powdered crystals.....	Lb.	13 1/4	@	14
Brimstone, crude, domestic.....	Long Ton	28.00	@	35.00
Bromine, technical, lump.....	Lb.	75	@	
Calcium Chloride, lump, 70 to 75% fused.....	Lb.	18.00	@	22.00
Caustic Soda, 76 per cent.....	100 Lbs.	3.20	@	3.30
Chalk, light precipitated.....	Lb.	4 1/4	@	5
China Clay, imported.....	Ton	20.00	@	30.00
Feldspar.....	Ton	8.00	@	15.00
Fuller's Earth, foreign, powdered.....	Ton	nominal		
Fuller's Earth, domestic.....	Ton	20.00	@	30.00
Glauber's Salt, in bbls.....	100 Lbs.	2.10	@	3.00
Green Vitriol, bulk.....	100 Lbs.	2.00	@	2.25
Hydrochloric Acid, commercial, C. P.....	Lb.	8	@	8 1/4
Iodine, resublimed.....	Lb.	4.25	@	4.30
Lead Acetate, white crystals.....	Lb.	14	@	15
Lead Nitrate, C. P.....	Lb.	85	@	
Litharge, American.....	Lb.	9 1/4	@	10
Lithium Carbonate.....	Lb.	1.50	@	
Magnesium Carbonate, U. S. P.....	Lb.	21	@	22
Magnesite, "Calced".....	Ton	60.00	@	65.00
Nitric Acid, 40°.....	Lb.	6.75	@	7.25
Nitric Acid, 42°.....	Lb.	7.00	@	7.50
Phosphoric Acid, 48/50%.....	Lb.	25	@	28
Phosphorus, yellow.....	Lb.	35	@	40
Plaster of Paris.....	100 Lbs.	2.00	@	2.50
Potassium Bichromate.....	Lb.	23	@	25
Potassium Bromide, granular.....	Lb.	1.25	@	1.30
Potassium Carbonate, calcined, 80 @ 85%.....	Lb.	14	@	16
Potassium Chlorate, crystals, spot.....	Lb.	23	@	25
Potassium Cyanide, bulk, 98-99 per cent.....	Lb.	nominal		
Potassium Hydroxide, 88 @ 92%.....	Lb.	60	@	70
Potassium Iodide, bulk.....	Lb.	3.30	@	3.50
Potassium Nitrate.....	Lb.	27	@	30
Potassium Permanganate, bulk, U. S. P.....	Lb.	55	@	65
Quicksilver, flask.....	75 Lbs.	103.00	@	
Red Lead, American, dry.....	100 Lbs.	10.25	@	10.75
Salt Cake glass makers.....	Ton	17.50	@	22.00
Silver Nitrate.....	Oz.	65	@	67
Soapstone, in bags.....	Ton	10.00	@	12.50
Soda Ash 58%, in bags.....	100 Lbs.	1.93	@	1.95
Sodium Acetate, broken lump.....	Lb.	6	@	7
Sodium Bicarbonate, domestic.....	100 Lbs.	2.45	@	2.50
Sodium Bichromate.....	Lb.	7 1/4	@	8
Sodium Chlorate.....	Lb.	15	@	17
Sodium Cyanide.....	Lb.	29	@	30
Sodium Fluoride, commercial.....	Lb.	14	@	15
Sodium Hyposulfite.....	100 Lbs.	2.60	@	3.60
Sodium Nitrate, 95 per cent, spot.....	100 Lbs.	4.07 1/4	@	
Sodium Silicate, liquid, 40° BÉ.....	Lb.	2	@	2 1/4
Sodium Sulfide, 60%, fused in bbls.....	Lb.	3 1/4	@	3 3/4
Sodium Bisulfite, powdered.....	Lb.	5	@	7
Strontium Nitrate.....	Lb.	25	@	30
Sulfur.....	100 Lbs.	2.25	@	4.60
Sulfuric Acid, chamber 66° BÉ.....	Ton	16.50	@	18.50
Sulfuric Acid, oleum (fuming).....	Ton	24.00	@	
Talc, American, white.....	Ton	15.00	@	
Terra Alta, American, No. 1.....	100 Lbs.	1.17 1/4	@	
Tin Dichloride, 50°.....	Lb.	26	@	28
Tin Oxide.....	Lb.	65	@	70
White Lead, American, dry.....	Lb.	9	@	9 1/4
Zinc Carbonate.....	Lb.	18	@	20
Zinc Chloride, commercial.....	Lb.	14	@	14 1/2

ORGANIC CHEMICALS

Acetanilid, C. P., in bbls.....	Lb.	37	@	38
Acetic Acid, 56 per cent, in bbls.....	100 Lbs.	5.75	@	6.00
Acetic Acid, glacial, 99 1/2%.....	100 Lbs.	12.00	@	12.25
Acetone, drums.....	Lb.	13 1/4	@	16
Alcohol, denatured, 180 proof.....	Gal.	40	@	43

Alcohol, Ethyl, non-beverage, 190 proof.....	Gal.	4.70	@	4.95
Alcohol, wood, 95 per cent, refined.....	Gal.	1.22	@	1.24
Amyl Acetate.....	Gal.	3.75	@	3.85
Aniline Oil, drums extra.....	Lb.	23	@	24
Benzoin Acid, ex-toluol.....	Lb.	1.00	@	1.10
Benzene, pure.....	Gal.	24	@	28
Camphor, refined in bulk, bbls.....	Lb.	1.24 1/4	@	1.25
Carbolic Acid, U. S. P., crystals, drums.....	Lb.	10	@	15
Carbon Bisulfide.....	Lb.	9	@	10
Carbon Tetrachloride, drums, 100 gals.....	Lb.	13 1/4	@	14
Chloroform, U. S. P.....	Lb.	30	@	32
Citric Acid, domestic, crystals.....	Lb.	98	@	1.02
Creosote, beechwood.....	Lb.	2.00	@	2.10
Cresol, U. S. P.....	Lb.	15 1/4	@	17 1/4
Dextrine, corn (carlodos, bags).....	Lb.	7	@	8
Dextrine, imported potato.....	Lb.	nominal		
Ether, U. S. P. 1900.....	Lb.	23	@	24
Formaldehyde, 40 per cent.....	Lb.	20	@	21
Glycerin, dynamite, drums extra.....	Lb.	18	@	19
Oxalic Acid, in casks.....	Lb.	25	@	28
Pyrogallie Acid, resublimed, bulk.....	Lb.	2.60	@	2.75
Salicylic Acid, U. S. P.....	Lb.	40	@	
Starch, corn (carlodos, bags) pearl.....	100 Lbs.	6.07	@	6.25
Starch, potato, Japanese.....	Lb.	9	@	9 1/2
Starch, rice.....	Lb.	24	@	
Starch, sago flour.....	Lb.	7	@	8
Starch, wheat.....	Lb.	10	@	10 1/4
Tannic Acid, commercial.....	Lb.	65	@	80
Tartaric Acid, crystals.....	Lb.	86 1/4	@	87

OILS, WAXES, ETC.

Beeswax, pure, white.....	Lb.	50	@	55
Black Mineral Oil, 29 gravity.....	Gal.	24	@	25
Castor Oil, No. 3.....	Lb.	18	@	
Ceresin, yellow.....	Lb.	16	@	17
Corn Oil, crude.....	100 Lbs.	24 1/4	@	
Cottonseed Oil, crude, f. o. b. mill.....	Lb.	22 bid		
Cottonseed Oil, p. s. y. Oct. option.....	100 Lbs.	27.25	@	28.00
Menhaden Oil, crude (southern).....	Gal.	1.05	@	1.10
Neat's-foot Oil, 20°.....	Gal.	2.05	@	2.10
Paraffin, crude, 118 to 120 m. p.....	Lb.	7	@	8
Paraffin Oil, high viscosity.....	Gal.	40	@	41
Rosin, "B" Grade, 280 lbs.....	Bbl.	16.80	@	17.00
Rosin Oil, first run.....	Lb.	82	@	83
Shellac, T. N.....	Lb.	nominal		
Spermaceti, cake.....	Lb.	31	@	33
Sperm Oil, bleached winter, 38°.....	Gal.	1.95	@	1.97
Spindle Oil, No. 200.....	Gal.	38	@	40
Stearic Acid, double-pressed.....	Lb.	18 1/4	@	19
Tallow, acidless.....	Gal.	1.65	@	
Tar Oil, distilled.....	Gal.	40	@	42
Turpentine, spirits of.....	Gal.	1.12 1/4	@	

METALS

Aluminum, No. 1, ingots.....	Lb.	33	@	
Antimony, ordinary.....	100 Lbs.	8.50	@	
Bismuth, N. Y.....	Lb.	nominal		
Copper, electrolytic.....	Lb.	20 1/4	@	20 1/4
Copper, lake.....	Lb.	17 1/4	@	
Lead, N. Y.....	Lb.	5.45	@	
Nickel, electrolytic.....	Lb.	55	@	56
Platinum, refined, soft.....	Oz.	105.00	@	
Silver.....	Oz.	1.12 1/4	@	
Tin.....	Lb.	72 1/4	@	
Tungsten (W/O).....	Per Unit	7.00	@	
Zinc, N. Y.....	100 Lbs.	9.40	@	9.60

FERTILIZER MATERIALS

Ammonium Sulfate.....	100 Lbs.	4.60	@	
Blood, dried, f. o. b. New York.....	Unit	5.15	@	5.25
Bone, 3 and 50, ground, raw.....	Ton	35	@	37.00
Calcium Cyanamide.....	Unit of Ammonia	5.15	@	10.00
Calcium Nitrate, Norwegian.....	100 Lbs.	—	@	
Castor Meal.....	Unit	—	@	
Fish Scrap, domestic, dried, f. o. b. works.....	Unit	5.15	@	10.00
Phosphate, acid, 16 per cent.....	Ton	15.50	@	16.00
Phosphate Rock, f. o. b. mine.....	Ton	nominal		
Florida land pebble, 68 per cent.....	Ton	5.00	@	6.00
Tennessee, 78-80 per cent.....	Ton	9.50	@	10.00
Potassium "muriate," basis 80 per cent.....	Ton	nominal		
Pyrites, furnace size, imported.....	Unit	18 1/4	@	
Tankage, high-grade, f. o. b. Chicago.....	Unit	5.50	@	

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EDITORIALS

BEWARE THE IDE[A]S OF MARCH!

*"There is work, urgent and vital work, immediately ahead for every member of the AMERICAN CHEMICAL SOCIETY. It is the arousal of this nation * * *."*

These are the words we used in an editorial in the November 1917 issue of THIS JOURNAL urging the importance of toluol recovery for the supply of high explosives for our Army. The words are repeated here, with even greater conviction, if that be possible, for another danger threatens which if it be not overcome bodes ill for the future safety of this country and possibly for the peace of the world. We refer to the abolition of the Chemical Warfare Service, as recommended by Secretary Baker and the Chief of Staff, General Peyton C. March, in the bill (S. 2715) for the reorganization of the Army.

To abolish or not to abolish, that is the whole question. The decision of the matter is in the hands of Congress, representing the people of the United States. Do the people of this country desire that the Chemical Warfare Service be abolished? We do not believe so. Can the members of this SOCIETY arouse the people to the danger involved in this proposal? We do believe so, if they will work, and quickly, through every legitimate channel, the daily and weekly press, the magazines, chambers of commerce, indeed through every organization in America which reflects public sentiment.

In order that chemists may be fully posted as to developments in Washington we are going to tell this story not in our own language but by excerpts from official documents, arranged chronologically. At several points in the testimony editorial comments are bracketed. Here is the story:

On June 16, 1919, the Senate Committee on Military Affairs held hearings on House Bill 5227, "an act making appropriations for the support of the Army for the fiscal year ending June 30, 1920," Senator James W. Wadsworth, Jr., Chairman, presiding. The first statement before the Committee was by Secretary Baker. During the course of his testimony the following colloquy took place:

EXCERPT FROM STATEMENT OF SECRETARY BAKER

(Hearings on H. R. 5227, pp. 27-32, June 16, 1919)

THE CHAIRMAN: Have you any observation to make as to the policy which the War Department would like to adopt with respect to the development of places like Humphreys, or the development of the engineering training school, or the development of any other special technical staff corps work?

SECRETARY BAKER: Yes.

THE CHAIRMAN: I would like to get your ideas, as the head of the department, on that, because I anticipate that some of the bureau chiefs are going to talk to us about that. In fact, they have informed me that they would.

SECRETARY BAKER: Of course, what we are all trying to do is to make permanent the valuable lessons of this war. Perhaps the most impressive lesson we got was the extent to which modern war is a scientific undertaking. Every science that men know, certainly every physical science that men know, was called upon in this war to perform its utmost, and with the utmost speed. The despised science of acoustics, which the professors of physics had regarded as a more or less completed science, reopened its doors, and the whole sound-range system

of fighting with artillery depended upon restudies in a department of acoustics which was largely neglected until this war began. As a consequence, it seems to me that in all of the military establishments we have in the future, the one thing we must have is a scientific research institution. I do not think the War Department ought to have an adequate group of physicists and chemists and astronomers and meteorologists to do all the work of the Army, but it ought to have an institution in which some research work will be going on and in which the work done in private institutions of learning and research laboratories will be correlated, so that the possibilities of usefulness would be available in the event of war.

With that thought in view, I hoped that the Congress would, from time to time, make appropriations to enable us to build at Camp Humphreys a really great engineering school and research laboratory. The place is ideally located for that. I think we own seven or eight thousand acres down there now. It has every facility for the training of Engineer troops in the building of pontoon bridges, the use of forests in construction, and all that sort of thing, and your engineering school at the Washington Barracks was grossly inadequate, but a research laboratory, a research institution down there, would enable the Army of the United States to be, we hope, constantly ahead of any possible adversary in its study of the applications of science to warfare.

THE CHAIRMAN: Is the study and further development of chemical warfare to be handed over to the Engineers?

SECRETARY BAKER: It ought to be, in my judgment, ultimately.

THE CHAIRMAN: What has been the disposition of that service today?

SECRETARY BAKER: It remains practically demobilized, but still kept separate. There is some feeling among the chemical-warfare people that they ought not to become a part of the Engineers, and I think that is due to a too narrow definition of the functions of the Engineers. I would probably be willing to suggest renaming the Engineer Corps and naming it the scientific corps. But my thought would be that the Engineer Corps or the scientific corps of the Army ought to have in peace time a great central establishment, with subdivisions, which would study the chemistry of war, both offensive and defensive, the physics of war, sound ranging, and all that sort of thing, the applications of electricity in war, and that would really be a scientific center, with the very great advantage that men of science in different phases of physical science would be associated and would stimulate one another by their researches, because all of these cross and touch one another. My own belief is that the gas warfare will not be permitted. I think we will not permit gas warfare as we get more civilized.

THE CHAIRMAN: I notice the President in his message urges the imposition of a tariff duty on dyestuffs in order to protect an industry which had a particular value on account of its relation to poisonous gases.

SECRETARY BAKER: Yes; and yet there are two views of chemical warfare. Some people feel that its objective is to knock a man out without killing him, to temporarily disable him. The other view is that it is destructive of the innocent bystander; that it is an indiscriminate and indiscriminating method of slaughter.

SENATOR CHAMBERLAIN: Mr. Secretary, you say it will be prohibited in the future. Were not some of these infamous weapons prohibited by The Hague conference, and did they not use them anyhow?

SECRETARY BAKER: My impression is that the suggestion was made at The Hague, but not enough Governments adhered to it to make it effective.

SENATOR FRELINGHUYSEN: The situation was this at The Hague, that they passed the resolution, or introduced the resolution, prohibiting chemical warfare, and the American delegates opposed it on the ground that there were other means of destruction just as outrageous as chemicals.

SENATOR CHAMBERLAIN: I think that is right. Mr. Secretary, if my information is correct, 33 per cent of the casualties to the American forces were caused by gas—I think there is no doubt about that—and it has been claimed, I think, that Germany moved slowly in the development of gases, and in its manufacture, and if they could have moved as fast as the United States, they would have decimated our Army by the use of gas.

SECRETARY BAKER: I think that is probably so.

SENATOR CHAMBERLAIN: We finally developed a gas that was even more deadly than the German gas, but we did not get to use it, and in the development of that gas there have been produced many things, by-products, that are used on civil lines. Why should the Gas Warfare Bureau be entirely abolished?

SECRETARY BAKER: I do not think it ought to be abolished.

SENATOR CHAMBERLAIN: You practically recommend that.

SECRETARY BAKER: No; I do not recommend that.

SENATOR CHAMBERLAIN: There is no provision made here for it.

SECRETARY BAKER: I think the only safe policy for the United States is to continue its investigations in gas, so that we will always know more about it than anybody else. I think we ought to defend our Army against a gas attack if somebody else uses it, but we ought not to initiate gas. If somebody else initiates it, we ought to be able to do more than they can.

SENATOR CHAMBERLAIN: What has become of the plant at Edgewood?

SECRETARY BAKER: It is still there.

SENATOR CHAMBERLAIN: What is it doing?

SECRETARY BAKER: It is still there as a part of the Chemical Warfare Service, and it is continuing its investigations at the present moment.

SENATOR CHAMBERLAIN: I do not know how the committee feels about it, but I feel at the present time that it would be a very grave mistake either to scrap the Chemical Warfare Bureau or the Aircraft Bureau. But as I read between the lines of this schedule here, you practically do away with both, or, rather, have them absorbed by some other department.

SECRETARY BAKER: I am very much amazed at that statement about the Aircraft Bureau.

* * *

THE CHAIRMAN: Has not any action been taken by the War Department having to do with the partial doing away with the Chemical Warfare Service, and its absorption?

SECRETARY BAKER: Yes. It has been the policy of the War Department to absorb the Chemical Warfare Service into this general scientific bureau which we call "Engineers Corps," now, for a short term, but to continue the investigations and to continue always abreast of the times in defensive appliances against gas, and to be able, on the shortest possible notice, to create an offensive if necessary.

THE CHAIRMAN: This question of the interior organization of the War Department was a moot question all during the war.

SECRETARY BAKER: Of course.

THE CHAIRMAN: And the department acted under the authority conferred on the President by the Overman Act to reorganize and regroup. Now that the war is over, a permanent organization of the War Department is vastly affected by what you can still do under the Overman Act, as that act does not expire until six months after the treaty of peace has been signed, and it is of tremendous interest to the committee to be informed what you are doing now under the Overman Act, because it will have such a tremendous bearing on permanent legislation.

SECRETARY BAKER: We are not doing anything under that act at the present moment, unless the plan of putting the Chemical Warfare Service under the Engineers, or with the Engineers is such an act.

SENATOR FRELINGHUYSEN: You estimated \$47,000,000 for the Chemical Warfare Service. Have you consolidated that appropriation with anything else, or are you abandoning it? The total estimate submitted through the Treasury was \$47,000,000. Originally the 1920 estimate was \$473,000,000.

GEN. LORD: The estimate for the Chemical Warfare Service is carried under the Engineer appropriation.

GEN. MARCH: If you will turn to column 11, which is the revised requirements submitted under this bill, it shows that there is no estimate for it.

THE CHAIRMAN: That, in effect, means the abolition of the Chemical Warfare Service?

SECRETARY BAKER: As a separate service. It combines it as a part of one of the scientific activities of the Engineer Corps.

SENATOR CHAMBERLAIN: If chemical warfare was responsible for 33 1/3 percent of the casualties to the American service, is it not important enough to be considered as a separate institution?

SECRETARY BAKER: Unquestionably, in time of war, the Chemical Warfare Service would be substantially a separate

thing. If we went into another war it would be. But we are getting back to a peace-time basis. [A statement strongly suggestive of certain pre-war utterances. We commend it to that great apostle of preparedness, General Leonard Wood.] If you subdivide the Army into so many small groups that are substantially unrelated to one another and not cooperating and not inspiring one another, they lose their initiative.

SENATOR CHAMBERLAIN: On the other hand, if you put a specialized arm of the service into another arm of the service, you do not get the same results. In other words, the Engineering Department has not paid any attention to that branch of it, and until Gen. Sibert was put at the head of it, you did not get anywhere with Chemical Warfare.

SECRETARY BAKER: I admire Gen. Sibert's services. I think he performed a very conspicuous public service in the control of that machine. But of course it is only fair to say for the gentlemen who were engaged in it before he came there that the most of the experimentation was done before Gen. Sibert came in.

SENATOR CHAMBERLAIN: But he organized it.

SECRETARY BAKER: Yes; and it will not be forgotten that Gen. Sibert himself is an Engineer officer.

SENATOR CHAMBERLAIN: I know that; but it seems to me it ought to be maintained, just as aircraft is to be maintained as a separate bureau.

SENATOR FRELINGHUYSEN: I have here the hearings before the House Committee, and I read from them as follows:

MR. ANTHONY: It is an asset if you can use it, speaking of that service.

GEN. BLAKE: Yes; if we can use it. Now, there is one other item here about which I want to ask Gen. Sibert. The War Department decided to close out the operations of the Chemical Warfare Service as a separate arm of the service, and it has requested the Engineer Department to take up the research and development necessary for keeping up the Chemical Warfare Service. I would ask Gen. Sibert to support the estimate of \$943,911.87, which appears in that total estimated amount for operations of \$30,000,000.

* * *

GEN. SIBERT: The Chemical Warfare Service submitted an estimate for continuing that service in all its branches; that is, not only research, but supply and production and development—under three general sub-heads. The total of that, including the administration of the office in Washington, was the figure given by Gen. Blake—\$943,911.87; \$878,741.87 is the field estimate. It was the plan to concentrate practically all of the operations of the Chemical Warfare Service at Edgewood Arsenal, where we have a plant already built for the manufacture of gases that cost \$34,000,000.

That was cut out, as I understand it?

SECRETARY BAKER: Cut out by the House.

GEN. LORD: It was not definitely cut out, but it suffered the reduction that they made in the estimate.

SECRETARY BAKER: Then the situation is that the department is recommending the appropriation of something over \$900,000, which is Gen. Sibert's estimate of the cost of continuing the research, and the House has modified that by this general cut.

THE CHAIRMAN: The Edgewood plant is idle, is it not?

SECRETARY BAKER: Not quite idle, but substantially idle. There were a number of processes which were pretty nearly completed, and Col. Walker, who was the principal scientist in charge of that, the professor of science at the Massachusetts Institute of Technology, recommended that those experiments be carried through to their conclusion, and that is being done.

THE CHAIRMAN: As this bill has come over here very recently, I have not had a chance to look through it with sufficient care to ascertain whether or not there is any clause included in it having the effect of holding the War Department interior organization in statu quo.

SECRETARY BAKER: We recommended that very strongly.

GEN. MARCH: They put nothing in it at all.

THE CHAIRMAN: You remember that when the Senate committee revised the bill in the last session, and completed it and reported it to the Senate, it contained such a provision.

SECRETARY BAKER: We regret that has not been done. If that be not included, it would mean very serious redistribution of War Department funds.

THE CHAIRMAN: Of course, when we put that provision in we had in mind three or four of your organizations—the Air-

craft Production Service, the Chemical Warfare Service, and so on.

SECRETARY BAKER: Yes; and the construction division was also in your mind.

THE CHAIRMAN: Since then apparently the department has determined to transfer the Chemical Warfare to the Engineers.

SECRETARY BAKER: Yes; that is our view of what ought to be done. It is my view of what ought to be done.

THE CHAIRMAN: It was not in your mind at that time, though?

SECRETARY BAKER: I do not think I had thought of it at that time at all.

* * *

THE CHAIRMAN: Have you any plans in mind affecting the Tank Corps or the Motor Transport Service?

SECRETARY BAKER: I do not know that I have. Gen. March may have considered that. I have not.

THE CHAIRMAN: They were created practically under the Overman Act?

SECRETARY BAKER: Yes.

THE CHAIRMAN: Has the war taught us the necessities for those corps?

SECRETARY BAKER: Yes; you asked me generally about the schools, and I went off on Humphreys as a single instance. I have a very deep conviction that we ought to maintain postgraduate schools for officers of the Army. The Engineer School at Camp Humphreys is only one. We have a very good school for the Coast Artillery at Fort Monroe. It is well equipped and does its work well. Of course, we have schools at Leavenworth for staff work. We have a School of Fire at Fort Sill. But I think the policy of the Government ought to be to build up its postgraduate institutions so that the officers of the Army, those who come from West Point and those who come from civil life alike, can get postgraduate, scientific, intensive, military instruction.

THE CHAIRMAN: Have you anything further?

SECRETARY BAKER: Nothing that occurs to me. I would like to reserve my good will with the committee enough to permit me to come back after I have examined the House bill.

EXCERPT FROM STATEMENT OF GEN. PEYTON C. MARCH, CHIEF OF STAFF, UNITED STATES ARMY

(Hearings on H. R. 5227, pp. 42, 43, June 16, 1919)

SENATOR CHAMBERLAIN: Now, we would like to get your idea about the chemical warfare service.

GEN. MARCH: I think the chemical warfare service is a service that must be kept up in a purely defensive way in time of peace in order to provide against any nation desiring to use gas against us. If you recall, in the so-called league of nations text, which was published the other day by the United States Senate, you have one paragraph which in substance says this: "The use of poisonous gases, or poisonous liquids, being prohibited in war, Germany must not import into her territory any such things." If that means anything, it means that those people have agreed to practically abolish chemical warfare gases.

SENATOR CHAMBERLAIN: Well, they say they are going to abolish war, but they might as well abolish the Army if we are now about to enter that millennium period.

GEN. MARCH: As a matter of fact, the use of chemical gases was not objectionable to us personally, because it makes no difference to a soldier whether he dies as a result of being killed by chemical gas or being struck by a shrapnel bullet, but from the fact that in using that gas you are poisoning the air as well as killing soldiers, and there is great danger to cattle, live stock, and children, from breathing the poisoned air.

SENATOR CHAMBERLAIN: Of course, we do not use any more of those things than is absolutely necessary, but the thing for us to do is to come back at the enemy with their own fire.

GEN. MARCH: What we are doing, Senator Chamberlain, is to retain an enormous amount of the very finest quality charcoal for use in gas masks in order to be protected against any nation which shall use so inhuman an agency as poisonous gas against us. We keep on hand the materials necessary for us to produce poisonous gas, and have a plant to produce it in quantities, so, if we come against nations using it we will go in on the same footing of development. At the present time it is a separate service apart from any other corps and if we did not take it into another corps such as the Engineer Corps, it

would mean the increasing of the Army by large numbers of men that we do not need. [Our guess is that this is the real motif in General March's statement. Fortunately Chairman Wadsworth is quoted as determined to hold the bill in Committee until the return from France of General Pershing and other officers. It will be interesting to learn the views on this point of the men from the battlefield.]

SENATOR CHAMBERLAIN: I am at variance with you on that proposition, but if you do what you propose to do now you can not do it in a separate bureau if it is absorbed by the engineering department or some other department of the Army—it will not be done.

GEN. MARCH: Well, I do not agree with you about that.

SENATOR CHAMBERLAIN: Well, that has been the experience I have seen, from my observation of the last 10 or 12 years.

GEN. MARCH: As a matter of fact, the chemical warfare service in France and in the United States were originated in connection with the Engineer Corps and had engineers in charge of that.

SENATOR CHAMBERLAIN: I repeat again, that I do not object to an engineer being at the head of it—I think an engineer is the proper man—but I think it ought to be a separate institution from the Engineer Corps.

EXCERPT FROM STATEMENT OF COL. V. ABBOT, ACTING CHIEF OF ENGINEERS, UNITED STATES ARMY

(Hearings on H. R. 5227, pp. 262-268, June 18, 1919)

THE CHAIRMAN: You may proceed, Colonel, in your own way and emphasize anything you wish.

COL. ABBOT: The House gave us \$100 on "Engineer Depots" and that is satisfactory without anything further. We now come to the subject of "Engineer schools." We asked the House to insert a paragraph for the construction of permanent buildings for the Engineer school and College of Military Research. That was based on the wording of the bill as reported to the Senate at the last session, except the amount was "\$3,000,000 instead of \$1,000,000."

THE CHAIRMAN: This committee suggested \$1,000,000 in the last session, did it not?

COL. ABBOT: Yes. Now, the need for the starting of some work along this line is very urgent, because Washington Barracks is entirely too small to handle the number of men that we have to instruct at the present time. The last class graduated at West Point only partially finished their course. They have had about two years' instruction. As a result we have to take these young officers and give them at the school at Humphreys practically the entire engineering instruction and the instruction in mechanics and the action of forces which they formerly received at West Point before they will be even as far ahead as the West Point graduates were at the time they were assigned to the Corps of Engineers.

That has made it necessary for us to have a school—an undergraduate school, as we call it—at which there are some 62 officers receiving instruction in what used to be West Point curriculum, and in addition to that we have during the war been unable to give the postgraduate instruction to our officers and a very large increase in the corps has taken place; so that there is more than half of the present corps who have actually been in service who have not had the postgraduate course in engineering, and in order to perform our purposes properly we have got to take that large number of officers, some three hundred and odd, and put them through this school in a reasonable time.

[Is the gas research work of our Army to be carried out by such "put them through" postgraduate engineers from among West Point graduates?]

Now, Washington Barracks is altogether too small to accommodate either the instruction or the quartering of a school of that size, so we have had to take advantage of the cantonment buildings down at Camp Humphreys, where the men can not be comfortably accommodated and where we have no sufficient section rooms, or model rooms, or anything of that kind, and it is absolutely essential that we have some place in which to properly house the plant required to give engineering instruction to these men. The fire risk down there is very great. The buildings are all of wooden construction and quite close together. There are so many of them unoccupied at the present time and the number of troops available to guard them is still very small,

so a fire starting in one place with a proper wind would sweep over the entire reservation.

The plans for the new buildings have been very carefully considered and, at the present time, we believe that \$3,000,000 is what the Government ought to invest in starting that system of instruction on a reasonable basis.

Of that \$3,000,000 the Secretary of War wanted about \$800,000 to be applied to buildings for a college of military research, where they could conduct all kinds of experiments in the development of the military appliances for the Army, and the balance of it, \$2,200,000, is for the recitation rooms and the apartment house accommodations of students. When those buildings are finished we can function reasonably well, but, of course, more will be necessary eventually, but that is what we regard as absolutely necessary to start the work.

THE CHAIRMAN: You have in mind the development of a large institution at Humphreys?

COL. ABBOT: Eventually. If the Army is to continue of any size, the requirements will demand schools to prepare engineers to do the important engineering work of war. Now, not knowing the strength of the Army, we can not tell you how big our school will have to be. We have these different classes of men who are in the corps and who must be instructed, and we are preparing the plans with a small staff to do the work at the present time, and try to be reasonably ready to expand if the Army expands; otherwise to stay where it is in case it does not expand. But that is something we have nothing to do with.

THE CHAIRMAN: No. You have land at Humphreys?

COL. ABBOT: Yes; we have land at Humphreys.

THE CHAIRMAN: How big is that reservation?

COL. ABBOT: Approximately 6,000 acres.

THE CHAIRMAN: Is the water supply adequate?

COL. ABBOT: Yes; it is sufficient for the 34,000 men that were there at the time the armistice was signed, and had the dam been constructed which was under consideration it would have been adequate to supply the 60,000 men which would have ultimately been at the camp had the war continued any length of time. The water supply is there, the filtration plant is there, and that is in a permanent building—those are the only permanent buildings we have there—masonry buildings. It is operating well and satisfactorily.

THE CHAIRMAN: Then, of that \$3,000,000, \$800,000 would be for research institutions.

COL. ABBOT: Possibly. We would rather have it taken care of in this way, because the Secretary may prefer to change the plans a little. We have two different schemes of what we will do with the \$3,000,000. In one case the Secretary would have \$800,000 and we would get our school of research, and in the other case it would give him about \$500,000, and that is within those limits.

THE CHAIRMAN: Now, would \$3,000,000 finish the school itself?

COL. ABBOT: No; not complete with all its recitation rooms and laboratories and matters of that kind, but it will give us an accommodation for the students and the instructors, and recitation rooms, and a sufficient amount of model-room space, a lecture room, and we can get along. Substantially, our plan was to build the buildings in such a way with temporary partitions that we could use them for one purpose now, and, without great expense, restore them to what they would be used for in the finished plan. We will have to use some of the buildings that eventually will be recitation rooms for living rooms for awhile. Those plans are all perfected and worked out in great detail.

THE CHAIRMAN: Of course, as you know, Colonel, the committee and the Congress are very anxious to keep the appropriations down and we are equally anxious not to cripple the Army or to put insurmountable obstacles in the way of further progress, and we recognize the importance of the Engineering Corps. However, it occurs to me that an appropriation for an institution of research might well be postponed. That is not a driving emergency.

COL. ABBOT: I know it is something that the Secretary of War is very anxious for, but we have not had much detail as to just what was to be done about that.

THE CHAIRMAN: It may be a desirable thing to do when Uncle Sam has plenty of money.

COL. ABBOT: We need research. Of course, at the present time we are carrying on research, but the research work is being done in the little temporary wooden structures here and there wherever we can get them. We are learning things, but it

would make it very much easier and more convenient to have a research laboratory in which to conduct our investigations.

THE CHAIRMAN: What would you do with \$1,000,000, if Congress should not see fit to give you \$3,000,000?

COL. ABBOT: I do not think we have any summary for less than the \$3,000,000; but for the \$3,000,000—would you like to have me give you this?

THE CHAIRMAN: Let us see what you plan to do.

COL. ABBOT: These figures are on the \$3,000,000 proposition. For clearing ground, for excavation, and drainage, \$237,841.73; building construction, excluding excavation, utilities, \$1,572,132.95; interior plumbing for water, sewers, light, and gas, \$71,875; water supply, \$30,205—that is for extending the present one—the pipings to the site of the new base post, which is beyond the present cantonment buildings; sewer and sewage disposal, \$47,288; electric power plant—that is temporarily—for street and house lightings, \$196,731.

THE CHAIRMAN: How is that place lighted now?

COL. ABBOT: Well, at the cantonment they have electric lights, I think, probably generated by 35-kilowatt sets—temporary sets. This estimate would put in a much more cheaply operated and practical lighting system. Boiler plants for power and heating, \$164,342. That would avoid the carrying of coal all over creation, breaking up streets, and would deliver the heat at the different houses—a central plant which costs less to operate. Heating and ventilation, \$152,000; and that is the best system, for by the danger of fire and everything of that kind is greatly decreased because there is not a lot of stoves and things of that kind distributed about. The cooking would be done by gas and the lighting by electricity. That is the cheapest practical way of running that place that is in line with recent ideas.

THE CHAIRMAN: Does that total up \$3,000,000?

COL. ABBOT: That totals \$3,000,000—the items I gave you; but that includes the military school and the college of military research—they are all in there. That is the building that we propose to do with the \$3,000,000.

THE CHAIRMAN: Will the college for military research items be taken out of that?

COL. ABBOT: Yes. You could say that \$2,200,000 would cover practically the engineering school end of it with a little arranging of these items, which are in common with the two. The construction would be a little more expensively done at two different times.

SENATOR BECKHAM: In the absence of a permanent building you are now using the cantonment buildings?

COL. ABBOT: Practically; yes.

SENATOR BECKHAM: They are frame buildings?

COL. ABBOT: Yes, frame buildings, and very close together. The trouble is this: In fighting a war men are willing to take all kinds of hardships and live under conditions that they would not stand in time of peace when they are sent down there to study and fit themselves to become officers. During the war men were down there in tents in the mud and everything else, and there was no complaint; the men behaved admirably; but you can not put boys down to study and learn under conditions such as exist down there and expect them to be happy as they would if they were getting ready to go to France; and that is why we want to provide them with suitable instruction rooms and suitable living quarters so that they may look upon life as something worth living.

THE CHAIRMAN: How many students would be accommodated under this plan of \$3,000,000 expenditure?

COL. ABBOT: We can get along with the present classes, which are about 110 men that are down there now. They will be pretty badly crowded, but we can handle it. Later on, we would need more funds, but with that amount of money we can do that; and if we want more funds after that time to extend and better conditions we can ask for an additional appropriation.

THE CHAIRMAN: What do you expect to do with the \$1,000,000 that the committee in the last session was willing to give?

COL. ABBOT: We had not at that time sufficiently detailed plans to really have developed it very thoroughly. We looked it over and saw that we could get some recitation halls and quarters for a certain number of men. The rest of them would have to go to the cantonment buildings. That would leave part of the men properly accommodated and part of them not, but we could get them down and we could instruct them.

THE CHAIRMAN: Is there anything else you want to say on that, Colonel?

COL. ABBOT: Nothing, except we are very anxious to get our school started there, because we can not function at Washington Barracks, and Washington Barracks is now needed absolutely for this staff college which is starting down there this fall, so there is no room there.

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THE CHAIRMAN: How many troops are there there now at Camp Humphreys?

COL. ABBOT: There was a little over 1,200 enlisted men and 300 officers on the report I got this morning. We are authorized to keep 2,150, but we could not do it, the enlistments have not come in fast enough—the permanent enlistments—and the other men were entitled to discharge under the regulations.

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THE CHAIRMAN: Now, in these plans you are making for this permanent school there are you including facilities for instruction in chemical warfare?

COL. ABBOT: No, sir; not explicitly. Whether that is to be under the Engineers or not is a question which has not yet been decided. We temporarily had orders to receive and care for the records, and we put in a request for a little more definite statement as to what our responsibilities were in the matter, because we would have to increase our storage space, before we took in these enormously valuable records, and the final decision on that has not been reached by the War Department authorities.

THE CHAIRMAN: The secretary intimated very plainly to the committee day before yesterday that he was very much in favor of the Chemical Warfare Service coming under the jurisdiction of the Chief of Engineers.

COL. ABBOT: Well, we started that in this last war, and then it was converted into a service by itself. The Thirtieth Engineers was the first gas regiment they had, and made a first-rate record.

THE CHAIRMAN: But no plans, then, so far, have been made for taking on that work at Humphreys?

COL. ABBOT: Unless it would be covered in this Research College that the Secretary of War speaks of. It is exactly for that class of work. It is a large place, where skilled experts will conduct laboratory experiments of all kinds. That was his idea, as far as we could gather it from the secretary. Now that would provide for the experimentations and so, on with gas, if made part of this plan; but the present plans for buildings and school would not accommodate what would be necessary in connection with the gas warfare service within this \$2,200,000. Certainly it would have to come beyond that. That will supply enough for really getting our school on a functioning basis with present-sized classes and the number of instructors that we have.

THE CHAIRMAN: Observation work on gas?

COL. ABBOT: Observation work on gas, but if we take that up we will have to ask for special funds for it.

THE CHAIRMAN: Very well, Colonel; I notice on that item of the Engineers' School the House gives you \$50,000.

COL. ABBOT: Yes, sir; that is satisfactory, and no place being mentioned we presume it means Humphreys. The previous bill said "Washington Barracks." We asked that that be eliminated, so that we would not be unable to apply it wherever we had our school located. We need a school somewhere.

THE CHAIRMAN: And that \$50,000 appropriation is satisfactory to you?

COL. ABBOT: Yes, sir.

EXCERPT FROM STATEMENT OF MAJ. GEN. WILLIAM L. SIBERT, CHEMICAL WARFARE SERVICE

(Hearings on H. R. 5227, pp. 274-284, June 18, 1919)

THE CHAIRMAN: The item in which you are interested was originally estimated by the Chief of Engineers at \$350,000.

GEN. SIBERT: Does that include the Chemical Warfare Service?

THE CHAIRMAN: Yes.

GEN. SIBERT: That is simply because, Mr. Senators, that at the time we submitted the estimate we did not know that we had all the money we needed. We do not need any money.

SENATOR THOMAS: Well, what do you think of that?

SENATOR NEW: You are the most welcome witness that we have had yet.

GEN. SIBERT: In fact, we have somewhere between \$17,000,000 and \$27,000,000 we would like to turn back.

SENATOR THOMAS: I move a vote of thanks, not only from this committee, but from the Congress to be tendered to the department of which this distinguished gentleman—

SENATOR NEW (interposing). This eccentric gentleman.

SENATOR THOMAS (continuing). Is the chief.

GEN. SIBERT: Senator Thomas, that comes from the peculiar wording of the act.

SENATOR THOMAS: The fact that such a thing has come about is an event in the history of this committee.

SENATOR CHAMBERLAIN: Well, General, that does not mean that you want to dispose of the Chemical Warfare Bureau?

GEN. SIBERT: No, sir; I think it ought to be left as a separate service.

THE CHAIRMAN: Well, now, just what is that situation, General? I know the committee will be very glad to have the benefit of your observations on this general question.

GEN. SIBERT: The Chemical Warfare Service was created by an Executive order under the authority of the Overman Act. Before that time the chemical warfare work had been done in several departments of the Army. The Ordnance Department was doing a part of it, the Medical Department a part of it, the Engineer Department a part of it, the Signal Corps a part of it, the Interior Department, a department outside of the Army, was doing the research work. As one would expect, the results obtained were not very satisfactory, because there were so many independent heads trying to operate in the accomplishment of one purpose. Necessity directed that all these agencies be brought together and one service created. That is the Chemical Warfare Service. It was considered, and is, a specialty. Its work is such that no officer of any other bureau of the War Department could attend to it, and do river and harbor work, or work with troops, alternately. That is, an officer could not do more than one of these things. It is to a great extent a specialty.

Chemical warfare itself has been responsible for about 30 per cent of the casualties of the American troops, and it has more possibilities in it than any branch of the service. It is a branch in which specialists should be at work all the time. It is entirely probable that some new substance might be developed that the protecting devices that we now have would not turn. Our soldiers would then be in absolutely the same category as the English troops were at Ypres when the Germans sent over the first gas cloud. Those are my reasons, practically.

SENATOR CHAMBERLAIN: You say, General, that gas is responsible for 30 per cent of the casualties to American troops?

GEN. SIBERT: Yes, sir.

SENATOR CHAMBERLAIN: Have you any idea to what extent it was effective as employed by the allied forces? They did employ it to some extent.

GEN. SIBERT: I think it was pretty nearly the same. It should be said that of these casualties only 3 or 4 per cent died, and of those that lived nearly all of them are getting entirely well. I saw a report from a medical officer that involved observations on 2,000 cases of men that had been gassed. These observations were made four or five months after the attack, and the conclusions were that none of the men showed any tendency toward tuberculosis in consequence of the gas, and that none of them that had old tubercular lesions showed any tendency to have those lesions repeated. In other words, it seems that the men all get well.

SENATOR CHAMBERLAIN: And it is effective in putting an armory out of commission, and yet not a cruel method?

GEN. SIBERT: Not a cruel method. I look on it as the most humane element of war.

SENATOR CHAMBERLAIN: Now, the Chief of Staff, in discussing this matter when he was before the committee, expressed the view, as I remember, that chemical warfare would be discontinued by international agreement because of its severity and its inhumanity. What you have just said tends to indicate that it is no more severe than any other kind of warfare—no more inhuman.

GEN. SIBERT: You can not apply the word "humane" to killing people, and that is what war is.

SENATOR CHAMBERLAIN: I say no more inhuman than any other form of attack which is designed to put men out of commission?

GEN. SIBERT: If any instrument of war imposes unnecessary hardships or injuries, without notice, upon the noncombatant

population, then I say bar it; but so long as its sole function is to kill and maim soldiers, I can not see the difference between it and high-explosive shells.

* * *

SENATOR CHAMBERLAIN: General, for a great many years you were connected here and elsewhere, particularly at the Panama Canal, with the Engineer Corps, were you not?

GEN. SIBERT: Yes, sir.

SENATOR CHAMBERLAIN: So that, having been connected with that corps, and also having played the most important part, I think, in organizing the Chemical Warfare Bureau in America, you feel that the Corps of Engineers could not take care of this as well as it could be taken care of in a separate bureau?

GEN. SIBERT: That is my thought. I do not think that an Engineer officer could be detailed, say, for a tour of duty of three or four years in the chemical warfare, and for a tour of duty on rivers and harbors, and a tour on fortifications, and with troops and be sufficiently qualified when he got to chemical warfare to handle the proposition.

SENATOR CHAMBERLAIN: Was very much progress made in chemical warfare or in the development of gases until this Executive order which consolidated all of these departments which were working at chemicals?

GEN. SIBERT: The work that was being done under the several agencies was being well done, but it had no coordination.

SENATOR CHAMBERLAIN: Yes.

GEN. SIBERT: The research was conducted by the Interior Department, and the head of that establishment never knew the military value of a particular thing he was working on. He never knew when the development of it was sufficiently advanced to justify manufacturing it; and the tendency of the situation was for each one of these separate agencies to develop itself into a complete bureau or a complete entity. The whole service did not advance as it should because of lack of coordination.

SENATOR CHAMBERLAIN: When did you first take hold of it and consolidate these bureaus?

GEN. SIBERT: I came here in May 1918, and the order was not issued until later, but I had verbal orders to take charge of it, and I did take charge of it.

SENATOR CHAMBERLAIN: Can you state how much gas had been shipped over at the time you took charge?

GEN. SIBERT: None.

SENATOR CHAMBERLAIN: And how soon after you took charge did you commence to ship it over?

GEN. SIBERT: It was not long afterward; but they could have shipped some gas over before I took charge.

SENATOR CHAMBERLAIN: But it did not go?

GEN. SIBERT: No, sir; it did not go.

SENATOR CHAMBERLAIN: In the experiments you have made with it at Edgewood and other places, what by-product comes from the manufacture of these gases that can be utilized in industry?

GEN. SIBERT: I would rather put it at the other way.

SENATOR CHAMBERLAIN: Yes; very well.

GEN. SIBERT: The same by-products used in the dye industry are also necessary in the manufacture of several of our gases. I suppose you do not want the names of the different gases.

SENATOR CHAMBERLAIN: I do not care about that.

GEN. SIBERT: There are five of our important gases, one of the constituent elements of which is a by-product or a crude used in the dyestuff industry.

SENATOR CHAMBERLAIN: That is imported?

GEN. SIBERT: Some were imported before the war, but we are making them now. We are making these crudes and intermediates in this country.

SENATOR CHAMBERLAIN: Utilizing them for dyestuffs?

GEN. SIBERT: In distilling coal certain substances are produced. From some of these substances either dyes, high explosives, or toxic gases can be made by introducing other and variable elements, *i. e.*, the processes of making dyestuffs, explosives, and toxic gases are the same to a certain point.

SENATOR CHAMBERLAIN: That is chemical development from that point?

GEN. SIBERT: From that point.

SENATOR CHAMBERLAIN: Mr. Chairman, will you let me ask the general one or two questions on this?

THE CHAIRMAN: Yes; certainly. It is very interesting.

SENATOR CHAMBERLAIN: I am very much interested. General, in the development of the uses in the arts and sciences and in civil life you would be permanently benefiting, producing an article of commercial value, and at the same time keep up the standard of gas development, would you not?

GEN. SIBERT: The dye industry fulfills a necessary field in civil life—that is, it provides the dyes for the textile manufacturer—and at the same time, it uses the same raw materials as are used in the manufacture of high explosives, such as TNT, and practically in making all explosives, except propellants. Propellants come from nitrates.

SENATOR CHAMBERLAIN: Now, may I ask you, can you tell where the suggestion comes from that this chemical bureau be placed under the Corps of Engineers—under the Chief of Engineers?

GEN. SIBERT: I know nothing about that except the orders that are issued.

SENATOR CHAMBERLAIN: Have you conferred with the Chief of Staff or the Secretary of War about it?

GEN. SIBERT: They never have asked me for a report, but I have been asked what I thought about it.

SENATOR CHAMBERLAIN: They have conferred with you about the developments you have made in this Chemical Bureau?

GEN. SIBERT: Nearly all of my relations in the development in the Chemical Warfare Service were with the Assistant Secretary of War, Mr. Crowell.

SENATOR CHAMBERLAIN: Does he agree with you—if you are permitted to say—that it ought to be maintained as a separate bureau?

GEN. SIBERT: He told me that he thought it ought to.

SENATOR CHAMBERLAIN: Has there been an order to abandon it?

GEN. SIBERT: Yes, sir.

SENATOR CHAMBERLAIN: Will you give us that, put it into the record, giving the date of it? Col. Fries has a copy of it, which he hands you.

GEN. SIBERT: I received this letter, written May 19, from the Adjutant General of the Army [reading]:

WAR DEPARTMENT,
THE ADJUTANT GENERAL'S OFFICE,
Washington, May 19, 1919

From: The Adjutant General of the Army.

To: Director of Chemical Warfare Service.

Subject: Transfer of confidential and permanent records of the office of the Director of Chemical Warfare.

1. The future activities of the Army in so far as chemical warfare is concerned have been assigned to the Corps of Engineers. You will confer with the Chief of Engineers and take the necessary steps to transfer to the office of the Chief of Engineers the confidential and permanent records of your office, which shall be considered by the Chief of Engineers and the Director of Chemical Warfare Service as being of permanent value and necessary for future research and experimentation.

2. The Chief of Engineers has been advised to take the necessary steps to provide for the receipt of those records.

By order of the Secretary of War

J. C. ASHBURN, Adjutant General.

SENATOR CHAMBERLAIN: Have you turned them over?

GEN. SIBERT: No, sir; not yet.

SENATOR CHAMBERLAIN: Of course, this consolidation of these agencies had to be through an Executive order?

GEN. SIBERT: Yes.

SENATOR CHAMBERLAIN: Has any Executive order come to you, or have you been advised of any Executive order, which authorizes the transfer?

GEN. SIBERT: No, sir.

SENATOR CHAMBERLAIN: You know nothing about it except that order of the Secretary?

GEN. SIBERT: No, sir; that is all.

SENATOR CHAMBERLAIN: Or of The Adjutant General?

GEN. SIBERT: No, sir.

SENATOR CHAMBERLAIN: Who represented you in France?

GEN. SIBERT: Col. Fries.

SENATOR CHAMBERLAIN: Do you know whether he has talked with any of the officials, either Mr. Baker or the Chief of Staff, about the situation in France?

GEN. SIBERT: He is here, Mr. Senator, and I would rather that he would answer those questions for himself.

SENATOR CHAMBERLAIN: He had entire charge of the Chemical Warfare Bureau there?

GEN. SIBERT: He had entire charge of the Chemical Warfare Service with the troops in France.

SENATOR CHAMBERLAIN: You think it ought to be maintained?

GEN. SIBERT: That is my judgment.

SENATOR CHAMBERLAIN: Mr. Chairman, may I have read into the record what the President had to say on the 20th of May with reference to these poisonous gases? I will give it to the Clerk.

THE CHAIRMAN: Yes.

SENATOR CHAMBERLAIN: You remember that it was in his message?

THE CHAIRMAN: It will be well to read it aloud.

SENATOR CHAMBERLAIN: He said this in his message:

Our complete dependence upon German supplies before the war made the interruption of trade a cause of exceptional economic disturbance. The close relation between the manufacture of dyestuffs on the one hand, and of explosives and poisonous gases on the other, however, has given the industry an exceptional significance and value. Although the United States will gladly and unhesitatingly join in the program of international disarmament, it will nevertheless be a policy of obvious prudence to make certain of the successful maintenance of many strong and well-equipped chemical plants. The German chemical industry, with which we will be brought into competition, was and may well be again a thoroughly knit monopoly capable of exercising competition of a peculiarly insidious and dangerous kind.

That is in line with what you say, that up to a certain point the development of dyestuffs and the development of gases goes hand in hand.

GEN. SIBERT: Yes; and of high explosives.

SENATOR CHAMBERLAIN: And at a certain point they diverge, and it becomes either an explosive or something that is of use in civil life?

GEN. SIBERT: If a nation can be prevented from making dyestuffs, you cripple it more than in any other way I know.

SENATOR CHAMBERLAIN: It is probable that Germany developed her gases through experimentation on the dyestuffs?

GEN. SIBERT: Judging from the evidence of the Alien Property Custodian, Germany tried and succeeded in preventing the development of chemical industry in this country. By preventing this Nation from making dyestuffs, the Nation was kept weak in a military way.

SENATOR CHAMBERLAIN: To show that the President made that suggestion with the knowledge of what was in the peace treaty, I call your attention to, and ask to have inserted in the record, article 171 of the draft of the treaty of peace with Germany. I will read that also. [Reading:]

ARTICLE 171

The use of asphyxiating, poisonous, or other gases and all analogous liquids, materials, or devices being prohibited, their manufacture and importation are strictly forbidden in Germany.

The same applies to materials specially intended for the manufacture, storage, and use of the said products or devices.

The manufacture and the importation into Germany of armored cars, tanks, and all similar constructions suitable for use in war are also prohibited.

So that the President, with the knowledge of that provision, still recommended the production of these gases.

GEN. SIBERT: Mr. Senator, is not article No. 171 one article in a long list headed "Military Restrictions Placed upon Germany"? Does not the heading of that include a long list of things of that character? That is one indication that these are simply restrictions placed upon Germany.

SENATOR CHAMBERLAIN: Yes.

GEN. SIBERT: And that includes airplanes, tanks, etc., in fact, all the implements of war.

SENATOR CHAMBERLAIN: Yes; and yet we are going ahead developing those things. That is, we hope we will.

GEN. SIBERT: Yes.

SENATOR CHAMBERLAIN: That is all I want to ask the general.

THE CHAIRMAN: General, I do not quite understand your present status. You evidently regard the letter which you have just read to us as the equivalent of an order.

GEN. SIBERT: It is an order to me.

THE CHAIRMAN: Transferring the chemical warfare service to the Engineer Corps, and yet the only specific direction in that letter is as to the transfer of the records of the office.

GEN. SIBERT: It transfers all the records, and makes the assertion that in the future all the chemical warfare service of the Army will be performed by the Chief of Engineers.

THE CHAIRMAN: But you have not received any order to turn over your personnel and disband?

GEN. SIBERT: We have had orders to demobilize as fast as we could. We are demobilizing as fast as we can and settle our business. We are 85 per cent demobilized now.

THE CHAIRMAN: Do I understand that you would have been less demobilized if you had not received that letter?

GEN. SIBERT: Had we had a policy, we would have been less demobilized. It was my intention to concentrate practically all of the activities of the chemical warfare service at Edgewood Arsenal, where we have made an expenditure of \$34,000,000 on gas manufacturing plants. We have there laboratories and all the facilities necessary to continue our work; and had we had a definite program we would have provided for the care of that plant for carrying on research and development. Under the present instructions we have demobilized as fast as we could and settle our outstanding contracts, and make our reports.

THE CHAIRMAN: Have you let nearly all of your chemists go?

GEN. SIBERT: Nearly all of them are gone. It was not my intention to keep many chemists permanently; that is, to commission them. We were confronted with the problem of keeping in touch with the chemical world, and at the same time maintaining secrecy, which is essential, because the surprise effect of any new substance is eight-tenths of its value. So that any research work that is being done must be kept secret. If we have a regular force it is certain to get in a groove and not do well, and I concluded that we should not carry on our research through the universities and institutions, because that would publish it to the world; so that I thought if we had one distinguished chemist that we could commission at the head of our research work, we would employ, say for one or two years at a time—one year, probably—men from universities who are specially qualified to carry on the particular line of work in which we are interested, keeping them for a year in an atmosphere of secrecy, and impressing them with the necessity of secrecy. We felt that we could in that way keep in touch with the outside world, and still keep our work secret.

Now, of course, that is only a part of our work. We have the manufacture of all of the gas masks and dug-out blankets, and there is an immense amount of stuff that we manufacture, horse masks, protective clothing, and in addition to that we have troops that are offensive troops in gas warfare. We have a gas regiment. These troops are utilized in making the clouds of gas that we send over on the enemy. They are utilized in operating certain crude mortars in throwing gas over into the enemy's lines; they are utilized in handling the light mobile mortar, going over the top with the infantry; and when a machine gun nest is developed, these gas troops, after you get within 800 or 900 yards of them, will cover the place with gas so that the infantry can go ahead. That is, we are not only a research institution, but we have offensive, defensive, and research, and training. We have the training of all of the Army in the use of defensive appliances—and Col. Fries, what was the proposed organization of the Chemical Warfare Service approved for the Army in the field when the war stopped?

COL. FRIES: It included about 1,200 officers and about 18,000 men; that is, for the field in France.

GEN. SIBERT: Well, in France, yes. It had about 40,000 men altogether.

COL. FRIES: Yes, for France and the United States we had 4,000 officers and 35,000 men. In other words, it developed into being quite a large establishment.

SENATOR CHAMBERLAIN: How many engineer troops were there over there, General?

GEN. SIBERT: I can not tell you, sir.

SENATOR CHAMBERLAIN: It might be well to absorb the engineer corps into the chemical warfare corps.

GEN. SIBERT: It would make the duties too various.

COL. ABBOTT: We raised 312,000 engineers, and 275,000 of them got over.

SENATOR CHAMBERLAIN: I just wanted to know. I am not minimizing the work of the engineers, at all. They did splendid work.

GEN. SIBERT: I can not go back on the engineers.

SENATOR CHAMBERLAIN: Yes; but I had in mind that it would be a sad mistake to have this chemical branch of the service swallowed up in any other bureau of the service; the same as I felt about the aircraft; that is all.

THE CHAIRMAN: Then, so far as you know, by the time you get your contracts settled up, and your personnel demobilized down to the point to which you have been advised it should be demobilized—

GEN. SIBERT: We will go out of existence.

THE CHAIRMAN (continuing): You will turn everything over to the Engineer Corps?

GEN. SIBERT: Just as soon as I get the contracts settled, under that order I am going to turn over everything to the Engineer Corps.

THE CHAIRMAN: Do you remember an item that was put in at the last session by this committee—not an item but a provision—which had the effect of holding in status quo the interior organization of the War Department as of that state?

GEN. SIBERT: Yes; I remember that.

THE CHAIRMAN: If such an item were put in this bill, what would be the effect upon the chemical warfare service?

GEN. SIBERT: We would commence to organize on the line that was contemplated when we made the estimate submitted unless we got orders to the contrary.

THE CHAIRMAN: There would still be a chemical warfare service?

GEN. SIBERT: Yes, sir. We have a considerable force in France yet. I say we are 85 per cent demobilized.

COL. FRIES: I think that 85 per cent applies only to this country.

GEN. SIBERT: It may be more than that on the other side; but there is a considerable part of the chemical warfare service with the troops in the field in France now—a proper proportion; a sufficient nucleus to organize.

EXCERPT FROM STATEMENT OF LIEUT. COL. AMOS FRIES

(Hearings on H. R. 5227, pp. 287–291, June 18, 1919)

SENATOR CHAMBERLAIN: Col. Fries, what is your rank and present tour of duty?

COL. FRIES: I have my regular rank of lieutenant colonel of Engineers now, and I am on duty with the chemical warfare service, in charge of the offense division, which includes the manufacture of all poisonous gases, smokes and similar materials, and the filling of gas shells, the operations not only at Edgewood Arsenal, but at the various gas plants connected therewith.

SENATOR CHAMBERLAIN: You have that duty now?

COL. FRIES: At the present time.

SENATOR CHAMBERLAIN: You were in France in charge of chemical warfare?

COL. FRIES: Yes, sir; I was in charge of the Chemical Warfare Service in France for nearly 16 months, having been abroad very nearly 17 months. In fact, I was in charge from its inception throughout the war, and until 3 weeks afterwards, when I came back on temporary orders, to represent the field side of the chemical warfare in the United States. I submitted a memorandum to the commander-in-chief in which I stated my belief that chemical warfare was of sufficient importance to be continued after the war, and that I felt that some one thoroughly familiar with the field side should be here to represent that side.

SENATOR CHAMBERLAIN: That was Gen. Pershing that you submitted that to?

COL. FRIES: Yes, sir.

SENATOR CHAMBERLAIN: Did he detail you for duty here? Did he send you over?

COL. FRIES: Yes, sir. The memorandum was taken to him personally by the Chief of Staff and the order was then issued accordingly.

SENATOR CHAMBERLAIN: That is the Chief of Staff in France?

COL. FRIES: Yes, sir. Gen. McAndrews.

SENATOR CHAMBERLAIN: When did you come home?

COL. FRIES: I left France on the 5th of December. I sailed from Liverpool on the 8th and arrived in the United States on the 18th.

SENATOR CHAMBERLAIN: Were you to take that up with the Secretary of War or the Chief of Staff here?

COL. FRIES: In the ordinary course of events, I would take it up with the Director of Chemical Warfare Service and the Chief of Staff.

SENATOR CHAMBERLAIN: Did you take it up with both?

COL. FRIES: Yes, sir. I got 30 days' leave, and when I arrived back on the 20th of January I was informed that orders had been issued to completely demobilize the Chemical Warfare Service.

SENATOR CHAMBERLAIN: Where did you get that information?

COL. FRIES: From Gen. Sibert. I then asked to see the Chief of Staff, Gen. March, and I arranged for a meeting to see him through his secretary. When I arrived there to keep the appointment, and after the secretary had consulted the Chief of Staff, I was told that if I had come there to plead for a chemical warfare service it was absolutely no use, as that was a closed matter.

I then asked for 15 minutes to explain what chemical warfare had done in France, and that also was refused.

SENATOR THOMAS: When was this?

COL. FRIES: That was about the 25th of January.

SENATOR CHAMBERLAIN: This was the Chief of Staff that refused you, through his secretary?

COL. FRIES: Yes.

SENATOR CHAMBERLAIN: Did you ever talk to him at all?

COL. FRIES: I saw the Chief of Staff for probably three or four minutes on the day I arrived in Washington. I called there to pay my respects, and talked with him in very general terms for three or four minutes, and he took me in and introduced me to the Secretary of War, and I talked there about the same length of time; but nothing was brought up about the future of chemical warfare, or what it had done, except the usual greetings, and I think a compliment on the work that had been done in France.

SENATOR CHAMBERLAIN: When you got over there—it would be interesting to the committee, I think to listen for a few moments to what the chemical warfare bureau did over there. In what condition did you find it when you got there, and what condition did it develop up towards the armistice?

COL. FRIES: When I arrived I was made director of roads for five days. Then they informed me that I would be made chief of the gas service, which I was a few days later. That was on August 19. There was no gas service then, and very little information except the little gathered from the British and French, principally by two doctors, on the defense side. They, however, gave me very broad orders, so that the service was organized to include research, experiment, development, manufacture of gases and filling of shells, and handling gas troops—fighting gas troops—and all defensive measures, which included the training of the entire Army, together with a separate and complete supply system from the base ports to the fighting line. It took me a long time to organize it, and there being no trained officers, no masks, no gases, the difficulties were very great.

As an engineering officer I looked to the engineers to furnish personnel. That proved impossible for them, they not having enough, so that I was forced to get personnel from the Army everywhere, and not succeeding in getting enough there I sent my own officers to the United States to get personnel. We wanted about 20 per cent chemists, and the rest of them good live men, so that we had men from all over the United States. The officer that I sent over got two or three baseball players, and got quite a little notoriety out of that; but, beginning with nothing in that way, the six companies of engineers, known as the Thirtieth Engineers, which became the first gas regiment, proved so effective that the authorization was increased from 6 companies to 54 companies for this spring's campaign, and we were bending every effort to raise those and get them over when the armistice was signed.

We established the most complete laboratory in France for emergency work. We had to test the masks to see if the gas was wearing them out; we had to inspect the shells that came over from the enemy to see if he was changing his gas, and we had to meet many other emergency problems. We had to store, issue, and fit all gas masks and to train the entire Army in the use of them, and that we did.

We had also, as we began to get gas, to train the Army in the use of the gas itself, which proved to be quite a problem, apart from the defense. That, I think, was done successfully. In fact, Gen. Pershing made some very complimentary remarks in regard to it.

We would have had, for this spring, between 1,500 and 2,000 officers and about 18,000 men in the field as gas troops, who had nothing to do with the use of gas by the artillery.

SENATOR CHAMBERLAIN: Were the gases manufactured in America used by you or by the Allies—by our associates?

COL. FRIES: Up to the time of the armistice we had used no American gases in American shells.

SENATOR CHAMBERLAIN: Why?

COL. FRIES: Well, we did not get the shells soon enough; and then they did not get the bursting charges soon enough. There had been shipped from the United States to France prior to the armistice about 400,000 of the 75-millimeter shells filled with gas, but they got there too late to be fired in any of the battles.

SENATOR THOMAS: How many did you say?

COL. FRIES: About 400,000.

SENATOR THOMAS: What was done with them?

COL. FRIES: Some of them were shipped back and some are over there. Some of the shells filled with mustard gas were shipped back and sunk in the ocean. That was the cheapest way to dispose of them.

SENATOR CHAMBERLAIN: With reference to the progress and development of the German gases, Gen. Sibert has testified that 30 per cent of our casualties came from the German gas alone. Was there not danger at one time of its practically decimating our Army, or incapacitating the Army to fight?

COL. FRIES: In that connection we were pretty badly worried in the spring of 1918 because the Germans began, late in 1917, to use a gas that went through our masks, and we started hard work on the development of a means of stopping it. We developed such a method, but never used it, because while he had the gas he did not get enough of it over to prove very serious; he had not worked out an efficient method; I would say, however, that later we worked that problem out, and are now in the position of having less than 2,000 masks that will keep out that gas, although we had started making them when orders for demobilization were issued.

SENATOR CHAMBERLAIN: Do you think that the gas service ought to be kept separate, or do you think it advisable that it be absorbed by the Engineer Corps?

COL. FRIES: I think it absolutely should be kept separate. We would have the same difficulties over again that we had before, if it were tried to be combined, unless the service in which it was placed built it up practically as a separate service under its own leadership. We took, in the start, an advanced position in having a very closely coordinated chemical warfare service. The French and British paid us the compliment of adopting the same thing by the close of the war.

SENATOR CHAMBERLAIN: That you had adopted?

COL. FRIES: Yes, sir. In the beginning they had their chemical warfare services scattered, and found it necessary to bring them all under one coordinated head. You can not separate the research from the poisonous gases and production and the filling of shells and handling of it in the field. If you get a gas developed yourself that goes through your own masks, unless you think you can end the war by one use of it, you have got to delay the use of that gas until you have developed a mask that will keep it out.

SENATOR CHAMBERLAIN: You say the French and the British adopted your plan?

COL. FRIES: Yes.

SENATOR CHAMBERLAIN: Are they maintaining the chemical service as a separate service?

COL. FRIES: They are maintaining the services as complete services. The French service is under the third bureau, I think, with an artillery major general, or some other general, at the head of it. You see, they have different manufacturing organizations there, and I think their third bureau, with artillery unit, does their manufacturing, which puts a little different phase on where it is placed.

SENATOR CHAMBERLAIN: May I ask you a personal question? Were you not decorated over there?

COL. FRIES: Yes, sir; I have been given two foreign decorations.

SENATOR CHAMBERLAIN: What decorations did you receive from the foreign governments?

COL. FRIES: The French decoration is commander of the Legion of Honor. The British is Companion of St. Michael and St. George.

SENATOR CHAMBERLAIN: For a long time you were connected with the Engineer Corps of the Army in this country?

COL. FRIES: Yes; for 20-years before I went to France.

SENATOR CHAMBERLAIN: And with your knowledge of the two services, you think the chemical warfare service ought to be maintained as a separate institution?

COL. FRIES: It is too big and powerful a thing to make secondary. Anything that accounts for 30 per cent of our casualties becomes one of the most powerful arms of the service. I do not think there is anything else that you could get so many casualties from, except possibly the Infantry, with the rifle, bayonet, rifle grenade, and hand grenade.

SENATOR CHAMBERLAIN: All of them combined?

COL. FRIES: Yes; and the German was using gas only to a small extent, compared to the extent to which we were beginning to get ready to use it. In fact, he began to be afraid, apparently, of the gas program of the Allies, because he asked through the International Red Cross to have them all quit gas warfare, early in 1918.

SENATOR THOMAS: Who was this?

COL. FRIES: The German; and he only asked that in regard to one other thing, and that was the bombing of cities behind the fighting line; so that apparently he was very much afraid of gas, even at that stage of the game.

SENATOR CHAMBERLAIN: If they had developed it as rapidly as the Americans did after they commenced to develop it, it would have put us out of the game, would it not, before we got over, pretty nearly?

COL. FRIES: I am afraid it would. We were very fortunate in the great battle of the Argonne and in the battle at St. Mihiel, in that the German was entirely out of reserve stocks of gases. He accumulated his mustard gas through the winter of 1918, apparently for use in the campaign against Cambrai and against the French at the Marne, and at Compiègne. In those early campaigns in 1918 he apparently used up all his reserve stock, so that when we went into the Argonne fight—and at St. Mihiel, also—where he had one of the best chances to use his mustard gas, he did not use it for days and days, and then only to a fairly limited extent. It was one of the things that had me worried, because I was at the front, at Corps Headquarters and Army Headquarters, watching that, and there was no report of gas for several days.

SENATOR CHAMBERLAIN: Did we have any?

COL. FRIES: We had what we could get from the French. They furnished it in the same proportion that they could get it for themselves. The supply of mustard gas was very limited as the Allies did not begin to use it on the Germans until 11 months after the Germans first used it.

SENATOR CHAMBERLAIN: Your services over there seem to have been recognized by the French and British Governments. Did ours make any recognition of them?

COL. FRIES: Well, Gen. Pershing issued quite a complimentary order. I have not any decorations, if that is what you mean.

SENATOR CHAMBERLAIN: Your reward was practically a demotion from brigadier general to lieutenant colonel, was it?

COL. FRIES: Well, that was a part of the demobilization.

SENATOR CHAMBERLAIN: Anything else of interest that you wanted to tell bearing upon this question.

COL. FRIES: I might make this observation, that if we are going to have to police Mexico or the Philippines again, or Haiti or San Domingo, or any other place where people are not equipped with gas masks, there is no substance or no half dozen substances that can rout them so easily as gas. You can kill them if you want to with the poisonous gas or simply blind them temporarily with the tear gas, and then handle them almost any way you see fit. There is absolutely no escape from the gas. It is heavier than air, and yet it floats with the air and mingles slowly. It rolls into every dugout and depression and lingers in woods. There is no heading it off. If we had had it, for instance, at Mt. Dajo a few years ago when we had to rout the Moros out there, we could have routed them with tear gas with no loss to them or ourselves.

SENATOR THOMAS: What form of gas would you suggest for the Mexicans? [Laughter.]

COL. FRIES: Well, if I felt real cruel I would use mustard gas.

SENATOR CHAMBERLAIN: The beauty about the tear gas is that it puts a man out of business so far as fighting is concerned, but does not kill him?

COL. FRIES: Yes. As a matter of fact the police authorities of the United States have begun to take that up in regard to routing desperadoes who get into houses. All that is bound to be considered sooner or later.

SENATOR THOMAS: Would that work both ways? Would not the bandit or brigands use it also?

COL. FRIES: That is what I mean. It is a problem that somebody has to pay attention to.

THE CHAIRMAN: Are there any other questions that the members would like to ask the general?

Much obliged to you.

COL. FRIES: Thank you.

In the light of the testimony given by all of these officials, and in spite of the statements of Secretary Baker and the Chief of Staff, General March, the Appropriation bill as passed by Congress and approved by the President of the United States contained this paragraph:

That the several organizations of the Army, to wit: The Chemical Warfare Service, the Air Service, the Construction Division, the Tank Corps, and the Motor Transport Corps, with their powers and duties as defined in orders and regulations in force and effect on November 11, 1918, shall be continued to and until June 30, 1920.

THE ARMY REORGANIZATION BILL

Scarcely had the new fiscal year begun when Secretary Baker, on August 4, 1919, transmitted to Congress a bill for the reorganization of the Army, accompanied by a letter of transmittal addressed to Hon. James W. Wadsworth, Jr., Chairman, Committee on Military Affairs, United States Senate (*Congressional Record*, Monday, August 4, 1919, p. 3841). In this letter Secretary Baker writes in part:

"The bill as inclosed provides a peace-time establishment of 510,000 men and in effect makes permanent the organization which has developed in the War Department, except that it abolishes the Chemical Warfare Service and the Inspector General's Department. The work appropriate to be done by the Chemical Warfare Service in peace time ought, in my judgment, to be carried on in the Engineer Department, and should consist of such research and preparation as would enable our Army always to defend itself against the aggressive use of chemical weapons and to overmatch any adversary in offensive operations should they begin against us. This work is essentially scientific and forms an integral part of the coordinated engineering activities which ought, in the future, to center around the Engineer Department, and make it supply not merely the technical civil engineering needed upon public works and fortifications familiar to the Army but all of the engineering—chemical, physical, and mechanical—whereby the achievements of pure science are carried into the realm of practical application in an intensive way should war demand their use."

Hearings were begun on this bill on August 7 and 8, 1919, the sole witness on these two days being the Chief of Staff, General March.

EXCERPT FROM STATEMENT OF GEN. PEYTON C. MARCH, CHIEF OF STAFF, UNITED STATES ARMY

(Hearings on S. 2715, pp. 90, 93-96, August 8, 1919)

SENATOR CHAMBERLAIN: * * * * * Take the Chemical Service. This bill may fix its personnel; when it is fixed, the President will have power, under that section of the bill, to take the personnel as it is fixed and recreate organizations of units as he may see fit. Under that could you not transfer the Chemical Service to the Corps of Engineers?

GEN. MARCH: Not under this bill. However, that is a bad example. Let us take the Tank Corps, because we do not provide for any Chemical Service at all. According to our idea, that is a part of the Engineer Service; it is an investigating service, a service of defense and not of offense.

SENATOR CHAMBERLAIN: In working out the appropriation bill, this committee, and I might say the House committee, indicated a desire to retain the Chemical Warfare Bureau. You leave it out in this bill. Why is that?

GEN. MARCH: That brings up a question not only of national policy but international policy, Senator Chamberlain. The War Department believes that the Chemical Warfare Service ought to be abolished in warfare.

SENATOR CHAMBERLAIN: Altogether?

GENERAL MARCH: Yes; altogether.

SENATOR CHAMBERLAIN: As a world policy?

GEN. MARCH: Yes.

SENATOR CHAMBERLAIN: But will it be?

GEN. MARCH: We believe in removing that practice from modern warfare, making it as humane as possible. We do not believe in poisoning wells and in poisoning the air—

SENATOR CHAMBERLAIN: I am in thorough accord with that view.

SENATOR THOMAS: But will the other fellow believe in it?

SENATOR CHAMBERLAIN: The other fellow came pretty near putting us out of commission for a little while by the use of chemical gas, while those who believe in humanitarian efforts did not indulge in it.

GEN. MARCH: If the humanitarian theory is correct, we ought to adopt methods of warfare and enforce such methods as will protect innocent noncombatants. If a person or a child goes out and drinks from a poisoned spring and is killed, that is not war; if a child goes out and a gas was liberated by an army comes along and kills the child and then it goes on and kills people—noncombatants—in the rear of the army, that is not a part of warfare—

SENATOR THOMAS: That is horrible, General, but suppose, in order to protect that child, and these noncombatants from that sort of warfare, it becomes necessary for us to fight the devil with fire. Then what?

GEN. MARCH: Then we have got to do it.

SENATOR THOMAS: Then should we not be prepared to do so?

GEN. MARCH: Absolutely. The theory of the War Department is this: That instead of having a corps called the Chemical Warfare Service, which must necessarily, in time of peace, be a student organization of college professors and scientists, that is placed under the Engineer Corps. You can not go out, for instance, and indulge in artillery practice at one of the camps, firing shells loaded with poisoned gas, which will be blown over the citizens of the surrounding country. [Yet this was done constantly during the war by the Proving Division, C. W. S., at Lakehurst, N. J.] You can not do that; nor can you turn loose from a lot of cylinders poisoned gas which would be carried wherever the wind lists. That can not be done. So it comes down to a study of the best method of protection against another person who uses that gas against you, does it not?

SENATOR CHAMBERLAIN: Well, yes.

GEN. MARCH: In other words, we must keep up the development of masks which will protect against any kind of gas, and we must study the creation of a gas which would have an overwhelming effect upon the enemy who attacked with gas. We can not form a corps and have them go out and practice that thing against anybody. Why organize a formal corps in the Army of large strength containing men only to be utilized in time of war.

SENATOR CHAMBERLAIN: I am in thorough accord with your views in respect to making war as humane as possible.

GEN. MARCH: As far as the soldiers are concerned, it does not make any difference how a soldier is killed. I think I would just as soon be killed by gas as by a bullet. When I was in France I saw 195 small children brought in from about 10 miles from the rear of the trenches who were suffering from gas in their lungs, innocent little children who had nothing to do with this game at all. [What about the women and children killed and wounded in the church in Paris on Good Friday, 1918, by the long range gun of the enemy? Why not restrict artillery to purely defensive warfare?]

SENATOR CHAMBERLAIN: I quite agree with you that it was very cruel to the civilian population; but at the same time it caused over 30 per cent of our casualties, did it not?

GEN. MARCH: Absolutely so.

SENATOR CHAMBERLAIN: If I have read the record of the war correctly, if Germany had been as quick at production as America became later on, she would have practically disrupted our Army before we could have invented the masks to protect the soldiers.

GEN. MARCH: We are going ahead to-day with the mask business. We have special brands of charcoal, which we have in storage to make a large number of masks. We are going on with experiments, and we intend to have the Engineers, which is a technical corps of the Army, study the subject extensively, instead of having a regular corps.

SENATOR CHAMBERLAIN: But it is the only branch of the service where there is any by-product which can be used in civil life.

GEN. MARCH: That is the point exactly. What we want to do is to encourage the creation of big chemical plants which will produce aniline dyes and those things in the chemical line, which can be readily transferred to factories for the production of gas or explosives. That is what Germany did. They took over their large dye factories and transformed them at once into chemical warfare.

SENATOR CHAMBERLAIN: With all due deference to your expert opinion, it seems to me that that can be done; the very thing you suggest ought to be done, and that it can be done better in a separate corps than it can be by having that corps absorbed by the Engineer Department.

GEN. MARCH: As a matter of fact, what we did was to put that in the hands of the Engineers, who are the technical men of the Army; under Gen. Fries abroad and Gen. Sibert at home.

SENATOR CHAMBERLAIN: It is true you did put it in the hands of Engineers, who were the natural men, but you gave them some power by creating a separate bureau—

GEN. MARCH: What we did, what we will do in any war, is this: The men who will carry on the work of experimentation and the work of production in this line are chemists, college professors, men who are commissioned temporarily for that sort of work and do not give up their whole lives to it—

SENATOR CHAMBERLAIN: Why not transfer all of the scientific bureaus to the Engineer Department?

GEN. MARCH: Which ones?

SENATOR CHAMBERLAIN: Any of them. Take any other branch of the service; take the Tank Corps, and why not transfer it to the Engineer Department?

GEN. MARCH: That is a different thing. The tanks themselves can be produced, and they are fought by men who are fighting men, and that is a different matter.

SENATOR CHAMBERLAIN: Your argument applies just as well to these other bureaus as it applies to the Chemical Warfare Bureau.

GEN. MARCH: I do not think it does.

SENATOR CHAMBERLAIN: I do not see any difference. You might as well abandon any of these other separate bureaus as to abandon it.

GEN. MARCH: The tanks can be put out on a big plain and can shoot at targets without hurting anyone; but in the case of chemical warfare, when poisonous gas is shot out into the atmosphere no one knows what is going to happen. Out at the American University, in some experiments with gas, some of the gas got loose and began to float out over the buildings, and the people around there ran out terrified, for miles.

SENATOR SUTHERLAND: Mr. Scott, a former member of the committee, was affected by it.

GEN. MARCH: Yes; it can not be done. We want to handle it practically and keep it at the disposal of the Army without having these difficulties.

SENATOR CHAMBERLAIN: It seems to me the development of it could be better done in a separate bureau. I will never vote to abolish it, so far as I can stop it, and I will prevent its absorption by any other department of the service if I can. [Good for that Senator who has always, and under conditions that must have sometimes, tried his soul, stood for the highest possible efficiency of our Army!] I just wanted to get your views on it, General.

GEN. MARCH: There they are, sir. That is my best thought on that subject. If the provision in the so-called league of nations, which prohibits the use of poison gas is carried out, all of that will disappear.

SENATOR CHAMBERLAIN: If the provisions of the league of nations were carried out, we would not need any Army.

GEN. MARCH: I do not see that.

SENATOR CHAMBERLAIN: We are going to have peace; the millennium is going to be here. I have not any idea it will all be carried out.

SENATOR SUTHERLAND: We have already had some agreements about humane warfare, but none of them were carried out.

GEN. MARCH: That is true, but this provision specifically says that, the use of poison gas having been prohibited, Germany is forbidden to import into her territory any of the elements which make for poison gas or liquid gas, which is forbidden, the thought being that Germany was the only nation in the world that would start any such thing.

SENATOR CHAMBERLAIN: Well, I think there are others, if they had had the chance.

This completes the story so far as it is available from the public records. There will be further chapters as the hearings proceed. In the making of those chapters whatever influence the chemists of America have should be used to the uttermost; not for the purpose of magnifying or glorifying the chemist or his work, but of insuring to this country one of the greatest safeguards of its future peace.

We do not question for a moment what the judgment of chemists will be concerning this remarkable proposal by the Secretary of War and the Chief of Staff. It means a return to the days of unpreparedness which characterized the period prior to our entering the war. By the terms of the peace treaty, Germany's hands are tied in regard to preparation for war under conditions prevailing at the outbreak of the world war; they are absolutely free for the development of the essentials of chemical warfare. This new development of warfare was born in the hearts of the German people and in their chemical plants. Neither has been changed by the war, except it be that the German heart is more capable than ever of lending itself to the most promising means of slaughter, and, as is well known, that the chemical plants are greater than ever.

Shall we deliberately, no matter on what specious grounds of argument, tie our own hands? It would invite a death blow in a war which General March justly estimates in the following words quoted from the Hearings on S. 2715, August 8, 1919, page 76:

"* * * And a war now, if anybody would have the strength to tackle the United States, would mean that we would have ultimately to mobilize the whole nation."

No more need be said. It is time for war. Bestir yourselves, chemists of America! The country glories in the services you have already rendered in peace and in war. Opportunity for further service now presents itself. The personnel of the Committees on Military Affairs is as follows:

SENATE

James W. Wadsworth, Jr., of New York	George E. Chamberlain, of Oregon
Francis E. Warren, of Wyoming	Gilbert M. Hitchcock, of Nebraska
Howard Sutherland, of West Virginia	Duncan U. Fletcher, of Florida
Harry S. New, of Indiana	Henry L. Myers, of Montana
Joseph S. Frelinghuysen, of New Jersey	Charles S. Thomas, of Colorado
Hiram W. Johnson, of California	Morris Sheppard, of Texas
Philander C. Knox, of Pennsylvania	J. C. W. Beckham, of Kentucky
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Charles C. Kearns, of Ohio	Hubert F. Fisher, of Tennessee
Alvan T. Fuller, of Massachusetts	

Whether we will it or not, gas will determine peace or decide victory in future war. The Nation must be fully prepared!

This proposal of the Secretary of War and the Chief of Staff is a straight-out combination of a pipe dream and military retrogression.

CONTRIBUTIONS FROM THE CHEMICAL WARFARE SERVICE, U. S. A.

THE MANUFACTURE OF WAR GASES IN GERMANY

By JAMES F. NORRIS, Late Lieutenant Colonel, Chemical Warfare Service
U. S. A.

Received July 25, 1919

When it was announced that the British and French military authorities had invited the American army to send representatives to investigate the chemical factories in the occupied zones along the Rhine, the chemists selected for this duty approached the work with unusual interest and enthusiasm. We had all heard of the famous plants and were familiar with their output. We expected to find not only works of great magnitude but to see examples of novel processes in chemical engineering and factory methods. The famous Bayer plant was at Leverkusen, near Cologne, and the huge works of the Badische Anilin und Soda Fabrik at Ludwigshafen. In addition, the factories of Kalle and Company, Meister, Lucius and Brünig, and a number of smaller companies were situated in the occupied territory.

While we saw much of great interest, most of us, I believe, were somewhat disappointed. Novelty was largely lacking. With the exception of the plant for the manufacture of ammonia by the Haber process and for the oxidation of ammonia to nitric acid, there was nothing strikingly new. Here and there we found some device of interest, such as an improved mechanism in a filter press, but, in general, no great advance in factory practice was noticeable. The plant for the Haber process, however, was considered by everyone to be a triumph of engineering ingenuity and skill. The \$25,000,000 spent on it made it possible for Germany to go to war. The investigation of this plant was under the direction of the Ordnance Department, and it is hoped that one of the representatives of the department who prepared a report on the plant will furnish an account of it for publication in *THIS JOURNAL*.

We were also disappointed and somewhat surprised at the lack of novelty in the methods used to prepare war gases. They were, in general, those described in the literature. It is a striking fact that the Germans did not invent a new gas for use in war. They selected with skill the most efficient substances for this purpose from the compounds known, but, as the result of the large amount of experimentation which must have been put on the problem, no new substance was used by them. It should be a matter of pride to American chemists to know that research carried out in the laboratory in Washington yielded two new compounds which were to be used by the American army. They had properties of great value from the standpoint of gas warfare, and served new tactical ends. Mustard gas, which was perhaps the most important gas of the war, was manufactured by the Germans by the tedious and expensive process described in the literature. New and simpler methods were discovered by American and British chemists, and these made it possible for the Allies to use great quantities of the gas. Dr. Duisberg, director of the Bayer Company, told the writer that a dud containing mustard gas fired by the Allies had been examined by their chemists. As the result of finding a substance in the shell contents, which was a by-product in the manufacture of the gas by the new method, the secret of the latter was discovered. A large plant was about completed by the Germans for the manufacture of mustard gas by this method when the armistice was signed. They quickly learned from us, and were about to discard their own cumbersome method.

We did find, however, in the German plants much to admire. The organization of the great works was marvelous. This was seen not only in the way the personnel was handled, but in the

lay-out of the plants as well. Efficiency was the secret of success. In the manufacture of war gases, for example, one chemist was in charge of the preparation of a particular gas and he gave his whole time to it. He was assisted by a foreman and the number of workmen required to do the work. Each man had a particular thing to do—and he learned his job well.

As had been anticipated, the value of research was greatly appreciated. Every plant had a laboratory for this purpose which was a source of pride. We were shown through the research laboratory of the Haber plant by Dr. Gaus, who was in charge of the works. He told us the building and its equipment cost \$2,500,000, and appeared prouder of it than of the great plant itself. Every facility for research in chemistry and physics was provided, and much money had been spent to make the building attractive in appearance. Tiled walls, hardwood finish, and expensive furniture gave the effect of display which the Germans seek in the offices and administrative rooms of their chemical plants.

As soon as the armistice was signed the chemical warfare services of the Allies took up with their respective governments the question of investigating the chemical factories in the occupied territory. After careful consideration it was decided to limit the investigations to the study of the manufacture of war products only. As a consequence, the Germans were ordered to furnish complete details as to the production of war gases, anti-gas material, explosives, and propellants. All the large factories were operated under the control of representatives of the British or French armies. There were no important chemical works in the territory occupied by the American army. Compliance with the order was made necessary by the fact that it was possible for the army authorities to close any factory at will.

The American army was invited by the British and French to send representatives to take part in the investigation of the factories in the zones occupied by them. The Chemical Warfare Service selected two officers to study the production of gases and anti-gas material—Lt. Col. James F. Norris and Major T. W. Sill. The Ordnance Department undertook to investigate explosives and propellants, and detailed for the purpose Lt. Col. C. M. Steese, Capt. R. D. McGrath, Capt. James W. Martin, Jr., and 1st Lt. H. T. Himmelein. Major Frederick Keyes, C. W. S., served with the ordnance officers in their investigation of the Haber plant.

The American party left Paris by automobile on January 30 and went to Cologne by way of Amiens, Cambrai, and Liège. They passed through some of the country that had seen the Hun at his worst, and were prepared in spirit to extract from him as much information as possible. Cologne was made the headquarters for the British and Belgian zones.

The British had taken over one of the best hotels near the cathedral and entertained the French, Belgians, Italians, and Americans who had been invited to take part in the investigations to be made. As it was contrary to orders issued by the occupying army to purchase food in shops or restaurants, the commission was supplied with food from the army mess. This was cooked by servants of the hotel and served in good form. Wine was plentiful, which could be bought, although the price was not what we had been used to. For ten days the twenty-five or more chemists lived together under the pleasantest conditions, and lasting friendships were made. Brig. Gen. Harold Hartley, formerly of Oxford University, whose work in chemistry is so well known, was in charge of the investigations.

He and his aides did everything to make our stay in Cologne profitable and pleasant.

We were all interested to see how a great German city had come through the war. We had heard of the hunger that had weakened the resistance of the German people, and we walked the streets in every quarter to observe. It was plain that food had been scarce. The fat, wabbly men with wrinkled necks were not there. Faces were drawn and cheeks sunken, and a smile was rare. The children, however, appeared well fed and showed their old-time jousousness. We looked for the newly devised shoes lacking leather, of which we had heard, but saw none in use, although they were displayed in the shop windows. A search was made for the articles of clothing made from substitutes as a result of the lack of textile fabrics. A very acceptable fabric was made from wood pulp by converting it into paper from which a fine thread was manufactured. This was woven, dyed, and made into many useful articles. A shirt of this material could be bought for two marks. It was a little harsh and not much preferable to sackcloth, but one could not help feeling it was good enough. To replace rubber in suspenders, garters, etc., fine steel springs covered with a cloth made from paper were used. These were excellent for the purpose and with many other things, born as the result of the war, may find application when normal times return.

The shops of the city were doing a rushing business. Most of the purchasers were British soldiers, however, who were taking advantage of the depreciated value of the mark to buy very cheaply. Prices did not rise with the fall in the mark. Optical goods and photographic cameras were in great demand. Food, wearing apparel, and any articles made of leather were high in price, but other things were, in general, not much more expensive than in pre-war days.

The theaters and cafés were well patronized. We had the usual good music with our beer, which, however, recalled the olden days by being so unlike what we had known before. The people were very sober and quiet. Even in the cabarets there was no spirit of frivolity.

The attitude of the people toward America was very conciliatory. They were of the opinion that the coming in of America ended the war—not the battles we fought, but the potentiality of a rich nation with an almost unlimited supply of men. But they looked to America to help them out. A large photograph of the White House at Washington was displayed prominently in a shop window, with the legend "Where the fate of Germany will be decided." Many of the Germans had friends or relatives in America, and they felt that we as a people did not feel toward them as the British and French did. They hoped the "unpleasantness" would soon be over, and normal relations established again. Some of the chemists expressed this view. They hope to regain their trade and former industrial influence here. We may anticipate very soon the extension of the right hand of fellowship. They have goods to sell and they will be very agreeable.

The great advance that has recently been made in the United States in the manufacture of dyes has aroused the concern of the Germans. Several directors of chemical plants inquired about this and wanted to know if it was all true—if so much money had been invested as was reported. They were afraid of the competition of America, but did not appear to be concerned about what was being done in other countries. They knew that America had the money and men to organize great concerns that could stand against their own wonderful organizations. They were, indeed, quite worried over the future, as far as America was concerned.

Throughout the occupied zones there was perfect order. The managers of several factories agreed that the occupation of the territory was the best thing that could have happened. On the other side of the Rhine labor refused to work and de-

manded unheard-of pay—everything was topsy-turvy. In fact before the allied armies arrived revolutionary notions were growing rapidly along the Rhine. One director of a well-known chemical plant is said to have escaped by night with his life by way of the river, when his employees were especially menacing. When the British army came, he returned and is now at his old post.

All the chemical plants which manufacture war material in the zone occupied by the British were visited from Cologne. The members of the commission were divided into several groups, and the representatives of the American Chemical Warfare Service were assigned to the one delegated to study the production of war gases. The account which is given later will be limited to a consideration of gases and anti-gas material. While we had an opportunity to get a general view of most of the factories, it would be best to leave to others who prepared reports on the manufacture of inorganic compounds, explosives, and propellants, a description of these war materials.

The only place near Cologne where war gases had been made was Leverkusen at the color works of the Bayer Company. The plant is about 10 k. north of Cologne and is built along the Rhine, so that the river furnishes a convenient means of transportation. It was established a long time ago, but has been enlarged greatly in recent years. In normal times, we were told, there are employed about 1500 chemists, engineers, and office assistants, and 7500 workmen. This force was increased during the war, but when we visited the plant it had been reduced to a total of about 7000.

The British authorities controlled the supply of raw materials for the factory imported into the zone of occupation, and the export from the zone of manufactured products. As these were limited in amount the activities of the plant were much curtailed, in fact, but a small proportion of the normal output was being produced. Dyes and pharmaceutical and photographic chemicals were being made in addition to the usual inorganic compounds, but a large part of the personnel of the works was engaged in making repairs and improvements. The plant appeared to be in perfect condition, ready to work at maximum efficiency as soon as normal conditions are restored.

The arrangement of the many buildings is excellent. The storehouses for raw materials are situated along the river front. Next come the buildings for heavy inorganic chemicals, then the plants for nitration, sulfonation, and chlorination, and after these the buildings in which dyes and pharmaceutical and photographic chemicals are made. The last group of buildings consists of mixing houses for dyes, packing houses, the photographic paper plant, storehouses for finished products, and machine and carpenter shops. The experimental dyehouse, laboratories, printing and bookbinding buildings are grouped in the neighborhood of the central administrative building. The elaborate construction and decoration of the latter suggests a modern bank building, and creates an impression of prosperity and wealth. Around the walls of the directors' room was a beautifully painted and artistic frieze which pictured the various plants of the Bayer Company and their activities. Dr. Duisberg, the director, pointed out proudly to the Americans the view of the company's plant on the Hudson River. We were not surprised to see it, although anti-war advertisements had assured us at home that Bayer aspirin had been made on the Hudson for years by an American company. During the war an anteroom had been decorated in a similar way with pictures illustrating the activity of the plant in the preparation of war-gas materials. One saw how gas was made, shells were filled, and gas masks assembled. The work was done by an artist and has a permanent value. The fact that the thing was conceived and executed during the stress of war throws an interesting side light on German character.

The works contains a beautiful and perfectly equipped club-

house for employees. In fact, everything is done to keep the men in a contented state of mind. Frequent lectures are given by professors from the universities, and regular instruction in chemistry, including laboratory work, is provided for all who desire to learn. Provision has been made to give review courses to the chemists who return after five years of absence during the war. They were to be freshened up and all advances made during their absence brought to their attention—another example of efficiency.

The first visit to the Bayer plant was spent in a general inspection. The director furnished a plan of the works, and explained what processes were carried out in the several buildings. The more interesting ones only were visited by the whole commission, but a committee inspected later each building to verify the statements given, keeping a lookout for evidences of the production of war materials which might not have been disclosed.

In the general inspection of the plant we were shown the process for making rubber which had been put on a manufacturing scale during the war. We were given only a general outline of the process. Acetone was first reduced by aluminum and sodium hydroxide to pinacone, which was then distilled under pressure; as the result of the loss of two molecules of water a methyl butadiene was formed. The compound was placed in galvanized iron drums, which were sealed and then heated at about 60° for 4 to 6 months. At the end of this time the polymerized product was obtained as a tough, white, clear, transparent mass. The methyl rubber so formed had all the properties of the best caoutchouc. It was used in the making of automobile tires and other rubber goods. While the process was said to be expensive, hopes of its use after the war were expressed. A decrease in the price of acetone and better yields would probably make the process of commercial value.

The systematic examination of the processes about which information was sought was carried out by several groups. The writer was, as has been stated, a member of the group which looked into war gases, and anti-gas material. In getting the information a simple procedure was followed. A list of the products manufactured was furnished by the director of the plant. The chemist who had charge of the production of a particular gas was called before the committee and asked to describe fully the method and apparatus used, and to furnish figures in regard to output and raw materials. All members of the committee were given an opportunity to ask questions. Stenographers took down all statements made. A visit to the plant was next made where the operations had been carried out. The process was gone over again, the apparatus described in detail, and sketches made of the essential features.

A natural question is, "How did the Germans respond to this inquisition?" We had been curious ourselves on this point, and did not feel sure that we would be able to do more than inspect the apparatus. But they met the problem in the right way and gave the information freely. We reassured them at the start by saying that we were after facts in regard to war products only, and would not attempt to pry into secrets of commercial value in times of peace. We had to inspect every building, of course, to see if all statements in regard to their use were correct, but no questions in regard to details need be answered if by doing so commercial secrets would be disclosed. This reassurance established a more or less cordial relation between us. Of course we had no adequate way of checking up figures of production—the books in most cases had been removed before the occupation by the Allies—but these were of secondary interest. We saw in nearly every case the apparatus used, and, guided by its capacity and a knowledge of the process, we could figure what its normal output could be. With this check the production figures given seemed to be reasonable ones. I am of the opinion that the description of the processes fur-

nished, and the details given, were in the main correct. I had seen made in the laboratory nearly every gas about which we got information and was familiar with the details of the procedures. If a chemist tried to lead us astray by false information—and this happened but seldom—a statement that the information was evidently incorrect at a particular point, with adequate reasons for the view, put him on the right track again. For example, a chemist was describing the manufacture of ethylene and gave a false account of the preparation of the catalyst. As this had been studied in great detail in our laboratories at home, we were in a position to set things right. When an inspection of the plant was made later the chemist confessed his error, and did all he could to rectify it by going into great detail as to his experiments and results.

The products used in gas warfare manufactured at the plant of the Bayer Company at Leverkusen were as follows: Dichlorethylsulfide (mustard gas), diphenylarsenic acid for the production of diphenylchlorarsine, diphosgene (superpalite), phosgene, chlorpicrin, xylol bromide, bromacetone, and charcoal for gas masks. The more important details in regard to the manufacture of these substances are given later in this paper.

The American party left Cologne on February 11, and went to the headquarters of our Army of Occupation at Coblenz. We had found by previous inspection of the territory that no war gases had been manufactured in this zone. There were but a few chemical plants and these made inorganic materials only.

We next went to Mainz, and were the guests of the French, who had laid out a program for our visit to the territory occupied by their army. General l'Heure, who was in charge of the party, divided the chemists into groups, and the method of inspection was similar to that used in the British zone.

At Mainz and Ludwigshafen we were billeted in German houses and thus had an opportunity to come in close contact with some of the people. Everything was done for our personal comfort by the Germans. In one home I was entertained by two elderly ladies who, on my arrival, made sure my bed was just to my liking. When I returned at night I found a warming pan had been put into it—the night was a bit frosty. The next morning I was mildly scolded because I had not set my boots in the hall to be polished, and a promise was extracted that I would do better in the future. At another house when I presented my billeting order the whole family—father, mother, two daughters, a son, and the maid—followed me to my room to look me over—an American army officer. Each one tried to do something for me. I was told how to work the electric heater in my room to get hot water whenever I wanted it, and the master of the household said his wine cellar was at my disposal.

In Mainz we were entertained at meals at the French Officers' Club and at Ludwigshafen our hosts had reserved for the use of the party a table in a large restaurant. There our food was what we had been accustomed to in the past in travel in Germany. There were no restrictions in the French zone in regard to the purchase of food, and, after our formal entertainment was over, we had a chance to see what it was possible for the casual visitor to buy in a restaurant. We were surprised to find that the variety of the food furnished and the prices charged varied but little from pre-war days. There were no regulations here against fraternization, and as a consequence we were able to learn the attitude of the people toward the war and its results. The views expressed served to corroborate those expressed in Cologne. The provisions for our entertainment and the inspection tour were carefully worked out by the French officers in charge of the party, and we were glad to express our hearty thanks for what had been done for us.

The principal works visited in the French area were Kalle and Company at Biebrich, Meister, Lucius and Brünig at Höchst-am-Main, and the Badische Anilin und Soda Fabrik

TABLE I.—SHOWING PRODUCTION OF WAR GASES MADE IN THE GERMAN TERRITORY OCCUPIED BY THE BRITISH AND FRENCH ARMIES¹

Abbreviations used are B for the Bayer Company, Leverkusen; M. L. and B. for Meister, Lucius and Brünig, Höchst-am-Main; K. for Kalle and Company, Bielefeld; B. A. S. F. for Badische Anilin und Soda Fabrik, Ludwigshafen.

GAS	Made by	Production Started	Production Ended	Average Tons per Month	Total Production in Tons
Dichloroethyl sulfide (H. S.)	B.	July 1917	Nov. 1918	300	(4800)
Perchloromethyl formate (diphosgene)	B.	June 1915	Oct. 1918	300	(12000)
Perchloromethyl formate (diphosgene)	M. L. & B.	Sept. 1916	Nov. 1918	139 (Max. 266)	3616
Diphenylchlorarsine	M. L. & B.	May 1917	Nov. 1918	150 (Max. 300)	3000
Diphenylcyanarsine	M. L. & B.				
Ethylchlorarsine	M. L. & B.	Aug. 1917	Oct. 1918	78 (Max. 150)	1092
Phosgene	B. A. S. F.	Before war		288 (Max. 621)	10682
Phosgene	B.	Before war	Made now for dyes	30	
Phenyliminophosgene	M. L. & B.	Mar. 1918	Jan. 1918	68 (Max. 124)	721
Dichloromethyl ether	M. L. & B.	Sept. 1917	May 1918	26 (Max. 51)	233
Dibromomethyl ether	M. L. & B.	Apr. 1917	Dec. 1917	7 (Max. 29)	69
Chlorpicrin	B.	Summer 1916	Nov. 1918	200	(6000)
Chlorpicrin	M. L. & B.	Aug. 1916	Nov. 1918	45 (Max. 101)	1127
Bromacetone	B.	Spring 1916	3 small batches made		
Bromacetone methyl ethyl ketone	M. L. & B.	Apr. 1915	Sept. 1918	19 (Max. 45)	1069
Nylol bromide	B.	Apr. 1915	Manufactured at intervals	50 to 60	(500)

TABLE II.—INTERMEDIATE PRODUCTS USED IN THE PRODUCTION OF WAR GASES

SUBSTANCE	Made by	Production Started	Production Ended	Average Tons per Month	Total Production in Tons
Dihydroxyethylsulfide (for H. S.)	B. A. S. F.	Early 1916	Nov. 1918	319 (Max. 552)	7026
Phenylarsenic acid (for diphenylchlorarsine)	K.	July 1917		100 (Max. 178)	1600
Phenylarsenic acid (for diphenylchlorarsine)	B. A. S. F.	Aug. 1917		150-200	
Diphenylarsenic acid (for diphenylchlorarsine)	B.	Aug. 1917		15 (Max. 60)	
Phenyl mustard oil (for phenyliminophosgene)	K.	Early 1917	Nov. 1918	60 (Max. 90)	840
Ethylarsenous oxide (for ethylchlorarsine)	B. A. S. F.	Apr. 1917	Nov. 1918	30	810
Charcoal	B.	Summer 1916			

¹ The table is not complete on account of the fact that the information necessary was not available in all cases.

at Ludwigshafen. The latter plant was the largest we saw. It employed about 15,000 workmen, 3500 of whom were assigned to the nitrogen fixation plant at Oppau, which was connected with the main plant by a private electric railroad. About one-half of the 250 chemists employed devoted themselves to research and the rest to factory control. All the chemicals required for the production of the products manufactured were made in the plant. The production started with the basic raw materials of chemical industry.

The conclusions reached by all members of the party which had the unusual opportunity of inspecting the great German chemical plants were in the main, I think, the same. We learned no secrets of great commercial value. Here and there we observed a new device or a novel way of carrying out some operation. If more time had been available we would have learned more. By the program arranged for us we were allowed but half a day at the plant of Kalle and Company, about three-quarters of a day at Höchst, and less than two days at the works of the Badische Anilin und Soda Fabrik at Ludwigshafen and Oppau. The British and French are studying the factories under the best conditions, for they have placed in the plants in their respective territories chemists who have the opportunity to watch all operations day by day. It should be recalled that we had military orders to inspect processes for the preparation of war materials only and we all endeavored to carry out the spirit of our orders.

We did go, however, what we went for. The information as to the manufacture of gases covered the subject adequately. It lacks real military value, however, as it is probable that the only gases used by the Germans which will be employed in the next war are phosgene and mustard gas, and the American methods for making these gases are far superior to those of the Germans.

We learned a novel way of activating charcoal for gas masks, but it was probably not the one that yielded the efficient material used by the Germans toward the end of the war. The methods for making charcoal were developed in Austria, and most of it was prepared in that country.

We came to the conclusion that the great success of the German chemical industry was due to organization and the emphasis put on research. Many of their business methods were far from ethical. Secret combinations and agreements between the large concerns eliminated competition and made it possible to mislead the purchaser.

The condition of the factories at present is such that they can put vast quantities of their products on the market at once. We must be prepared to meet every kind of effort on the part of the Germans, honest and otherwise, to regain their hold on the American chemical trade. We have no reason to believe that the means used to get control of the market after the war will be based on higher moral standards than those used during the war. The most impressive scene of destruction that I visited in France was the sight of what was the great chemical plant at Chaunty. This, the oldest chemical works in France, where Gay-Lussac did his famous work on the manufacture of sulfuric acid, where Courtois discovered iodine, and where plate glass was first made, had grown with the times, and was among the largest factories in France. Around it was a thriving town of about 13,000 inhabitants, with some excellent modern public buildings: When the Germans in their first retreat were forced to leave the place, they dismantled the factory and carried away everything that was portable. The fortunes of war brought them back, and before they left a second time a regiment of soldiers was put to work to destroy systematically the factory and the entire town. For a month they kept at work, and when they withdrew but a few bricks were left standing. Every boiler had been blown up with dynamite, and every tank too heavy to be carted away rendered useless. About half an acre was covered with chemical stoneware of all kinds; each piece had been broken with a sledge hammer. Nothing was so small or too large to escape destruction. And to make sure of a good job everything that would burn had been set on fire. Professor Moureu, with whom the wreck was examined, was speechless—there were no words, he declared, in the French language to describe what was before us, or to analyze the spirit in the soul of the man who ordered such an act. Destruction which results from active fighting—from mines and shell-fire—are a part of war, but such a sight as we saw—a whole city destroyed by systematic barbarism—was almost beyond comprehension. The men who inspired the utter demolition of the industries of Belgium and northern France are the same men with whom we are soon to do business.

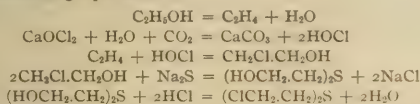
A technical account of the more important facts in regard to the manufacture of the war gases by the Germans follows. These facts will be of interest to the organic chemist and to the chemical engineer as examples of the ways in which exceedingly noxious substances can be handled on the large scale with the minimum amount of danger. The table of production which is

given covers only the places visited. Gases were manufactured elsewhere, but no information in regard to them could be obtained. Statements that were given to us everywhere showed that the government withheld as much information as possible from the men actually in charge of manufacture. At no plant was there knowledge of the source of the material used or the place to which it was sent. The production of war materials was directed from Berlin. When a product was ready for shipment directions were sent to the factory to send it to a specified station some distance away. From this point it was shipped to its proper destination. This was the case with intermediate products as well as finished gases. In some cases products had to pass through two or more plants before the final gas was obtained. For example, the Badische Company made the chlorhydrin which the Bayer Company converted into mustard gas, and neither firm evidently knew the other was concerned in the process. This policy may have been dictated by a desire for secrecy, or by the fact that the war ministry at Berlin assigned to each plant the manufacture of the compounds it was best prepared to handle.

The inspection was finished, the detailed report was written, and as a result of it all the conviction was definite that we had nothing to fear from German chemical industry. Given protection from unfair methods we could successfully compete with it. We all felt that as the result of the war German supremacy had disappeared. The myth of the superman had been buried.

β,β -DICHLOROETHYLSULFIDE (MUSTARD GAS)

This compound was prepared by the method originally described by Victor Meyer and later studied more fully in Emil Fischer's laboratory. The steps involved are represented by the following equations:



The process was carried through the preparation of the thio-glycol by the Badische Company, and this was converted into mustard gas at the Bayer Company plant.

yield of ethylene was stated to be about 90 per cent of the theoretical.

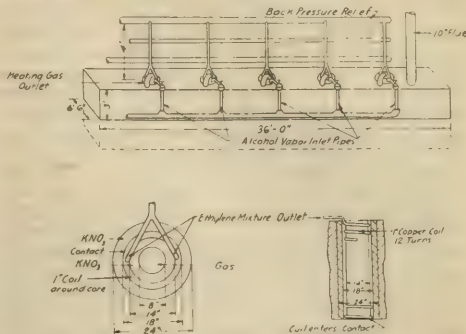


FIG 2—ETHYLENE PRODUCTION AT BADISCHE ANILIN UND SODA FABRIK. 1 UNIT

PREPARATION OF ETHYLENE CHLORHYDRIN—The reaction was carried out in a cylindrical tank resting on its side. The tank was furnished with a stirrer and was insulated by means of cork in order to prevent the transfer of heat from the atmosphere to the inside. For details see Figs. 3 and 4. Enough chloride of lime was introduced into the tank to furnish 500 kg. of available chlorine, together with 5 cu. m. of water. At first, about 20 cu. m. of carbon dioxide were led into the mixture, next ethylene, and later carbon dioxide and ethylene simultaneously. The rate of absorption of ethylene was noted and when it slackened, more carbon dioxide was added. Fuller details as to the addition of the two gases were not given as it was stated that it was a matter of judgment on the part of the workman who was carrying out the operation. The reaction should be carried out at as low a temperature as possible, but it was found impossible to work below 5° with the apparatus employed in this factory. The temperature during the reaction varied between 5° and 10°. In order to maintain this temperature, the solution was constantly pumped from the apparatus through a coil which was cooled by brine. Details of construction will be seen in the diagram. When ethylene was no longer absorbed and there was an excess of carbon dioxide present, the solution was tested for hypochlorous acid. The time required for the introduction of ethylene was between 2 and 3 hrs.

The contents of the apparatus were passed through a filter press by means of which the calcium carbonate was removed. The solution thus obtained contained from 10 to 12 per cent of ethylene chlorhydrin. It was next distilled with steam and a distillate collected which contained between 18 and 20 per cent of chlorhydrin. The yield of chlorhydrin was from 60 to 80 per cent of that calculated from the ethylene used.

PREPARATION OF DIHYDROXYETHYLSULFIDE—To prepare the hydroxysulfide, the theoretical quantity of sodium sulfide, either in the form of the anhydrous salt or as crystals, was added to the 18 to 20 per cent solution of chlorhydrin. The reaction which takes place is as follows:



After the addition of the sulfide, the mixture was heated to about 90° to 100°. It was then pumped to an evaporator, and heated until all the water was driven off. The glycol was next filtered from the salt which separated, and distilled in a vacuum. The yield of glycol was about 90 per cent of the theoretical, calculated from the chlorhydrin.

PREPARATION OF DICHLOROETHYLSULFIDE—The thiodiglycol was taken from the rail to two large storage tanks and thence drawn by vacuum direct to the reaction vessel. Each reaction

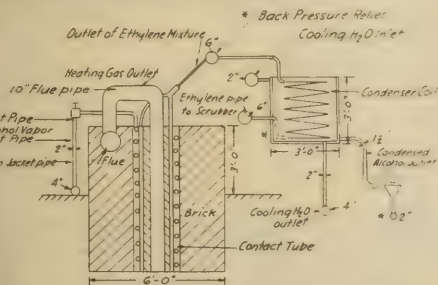


FIG 1—PREPARATION OF ETHYLENE AT BADISCHE ANILIN UND SODA FABRIK. 60 UNITS

PREPARATION OF ETHYLENE—The gas was prepared by passing alcohol vapor over aluminum oxide at a temperature of 380° to 400°. The details of the construction of one of the furnaces are given in Figs. 1 and 2. The furnaces were very small and sixty units were required to furnish the amount of gas required. The tubes containing the catalyst were made of copper and were heated in a bath of molten potassium nitrate. It was stated that the catalyst was made according to the directions of Ipatieff, and that its life was from 10 to 20 days. The gas produced was washed in the usual form of scrubber. The

vessel was placed in a separate cubicle ventilated both from above and below and fitted with glass windows for inspection (see Figs. 5, 6 and 7). The vessels themselves were made of $1\frac{1}{4}$ in. cast iron and lined with 10 mm. lead. They were 2.5 m. high and 2.8 m. in diameter. These tanks were jacketed so that they could be heated by water and steam, and the reaction was carried out at 50° . The hydrochloric acid coming from the main pipe was passed through sulfuric acid so that the rate could be observed, and passed in by means of 12 glass tubes of about 2 cm. diameter. The rate of flow was maintained at as high a rate as possible to procure absorption. The vapors from the reaction were led from the vessel through a pipe into a collecting room, and then through a scrubber containing charcoal and water, through a separator, and then, finally, into the chimney. These exhaust gases were drawn off by means of a fan which was also connected with the lower part of the chamber in which the reaction vessels were set, so that all the gases had to pass through the scrubber before going to the chimney. When the reaction was completed, the oil was removed by means of a vacuum, induced by a water pump, into a cast-iron washing vessel.

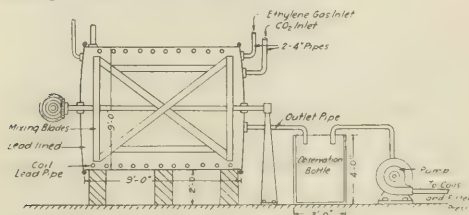


FIG 3—CHLORHYDRIN REACTION KETTLE AT BADISCHE ANILIN UND SODA FABRIK. 16 UNITS

The hydrochloric acid layer was removed to a stoneware receiver also by vacuum. A glass enabled the operator to avoid drawing oil over with the acid. The pan was fitted with thermometer to the interior as well as to the jacket. For testing the material during reaction, provision was made for drawing some up by vacuum to a hydrometer contained in a glass funnel. The final test at this point read 126° Tw. Another portion could be drawn up to a test glass and hydrochloric acid passed through it in full view. A float contained in a glass outer tube served to show the level of the liquid in the vessel. The pans in which the operation is carried on, as well as those employed for washing and distilling the product, were of a standard pattern employed in many other operations in the works.

The washer consisted of a cast-iron vessel, lead lined, and was 2.5 m. in diameter, 2 m. deep, and fitted with a dome cover and stirring gear. Lead pipes served for the introduction of sodium carbonate solution and water. Similar pipes were fitted for drawing these off by means of a vacuum. A manhole on the cover, with a flat top, was fitted with light and sight glasses to which were fitted a small steam coil for keeping them clear. The washed oil is drawn off to a distillation still, which is a cast-iron vessel homogeneously lead coated, 1.5 m. in diameter and 2 m. deep, fitted with a lead heating coil and connected through a spiral lead condenser and receiver to a vacuum pump. The water is distilled from the oil at a pressure of from 62 to 70 mm. absolute pressure. When dried, the oil is sent by vacuum to a mixing vessel, similar in most respects to the washing vessel, in which it is mixed with an appointed quantity of solvent, which in this factory was usually chlorobenzene but occasionally carbon tetrachloride. The relative quantities varied with the time of year, and instructions were sent from Berlin on this point. Thence the mixture was passed to a storage tank and into tank wagons.

Gloves were used at first but were found unnecessary; more casualties resulted with than without their use. Operators were instructed to wash their fingers frequently and to make use of bleaching powder in doing so. They had very few casualties among their workmen—one case of pneumonia and no case of conjunctivitis or heart trouble.

PERCHLORMETHYLFORMATE (DIPIOSGENE OR SUPERPALITE)

This compound was prepared at the Bayer Company plant and at Höchst. The method used at the former was as follows: The process employed consisted, in the first case, of the manufacture of methyl formate by heating 95 per cent formic acid and pure methyl alcohol together without any condensing agent in an iron still homogeneously lead coated and protected by a layer of porcelain tiles. The diameter of the pan was $2\frac{1}{2}$ m. and the capacity 12,050 l. Heat was applied by means of a copper coil. There was a fractionating column with a jacket made of copper and filled with porcelain packing. The ester was distilled and the pure ester placed in the chlorine reaction vessels. There were 33 of these vessels which were from 2 to 3 m. in diameter and 1.5 m. deep. (Fig. 8 is a sketch of a similar kettle used at Höchst.) They were made of cast iron homogeneously lead coated and lined with tiles, it being exceedingly important to prevent the least trace of iron from getting into the vessel. Chlorine was introduced by a number of glass tubes. Some of the vessels appeared to have six and some eight tubes. The chlorine merely bubbled from the end of them. The reaction was accelerated by means of high candle power lights. Osram filaments were found best and the greatest amount of light produced the most rapid reaction. Eight 4000-candle power lamps was the maximum light used on any vessel. Mercury vapor and carbon filament lamps were less effective. The quantity of methyl formate introduced in a charge varied from 1500 to 2000 l. and the time taken to complete the reaction was 8 to 14 days.

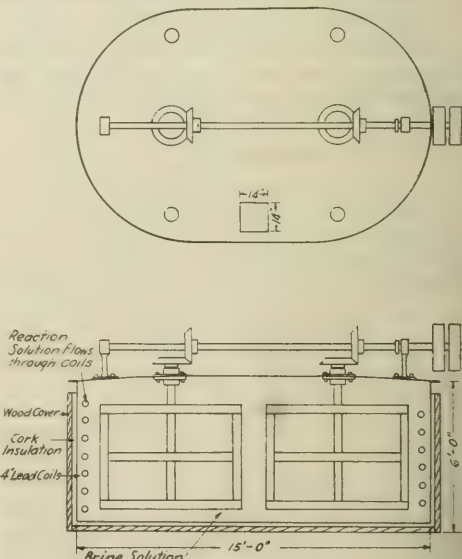


FIG 4—CHLORHYDRIN COOLING TANKS AT BADISCHE ANILIN UND SODA FABRIK. 16 UNITS

The temperature of the reaction had to be controlled, at first by means of a water jacket and later by greater additions of chlorine which was bubbled through wash bottles containing

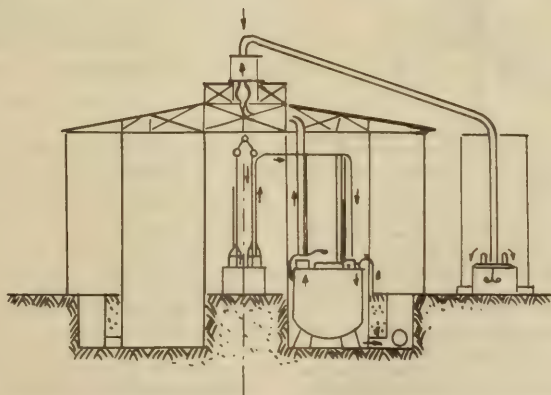
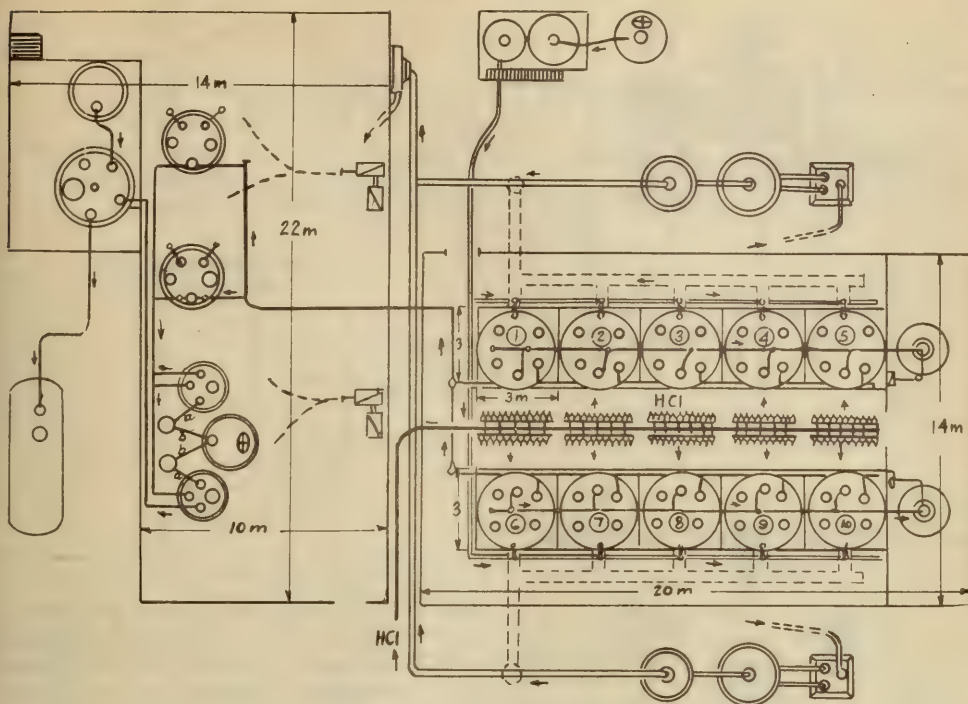


FIG. 5—H. S. MANUFACTURE AT LEVERKUSEN. LAYOUT FOR CHLORINATION OF THIODIGLYCOL

sulfuric acid. The temperature gradually rose finally up to 140° to 160° , as the percentage of chlorine product increased. Sunlight was found to accelerate the reaction, which was able to take place both in the liquid and gaseous phases. When the reaction was completed, the low-boiling fraction was recovered by distillation and the remaining diphosgene was transferred to the containers in which it was sent away.

The still was porcelain lined and fitted with a copper coil internally for heating (see Fig. 9). The diphosgene was tested

finally for its action on iron by measuring the volume of gas given off from a known volume of liquid in contact with iron after standing for 12 hrs. The methyl formate plant was part of the existing installation for the manufacture of other substances, but the plant for the chlorination and distillation was specially installed for the purpose.

In the early days they had several small explosions which were not serious. They had a large number of cases of poisoning among the workmen which also were not serious. All the

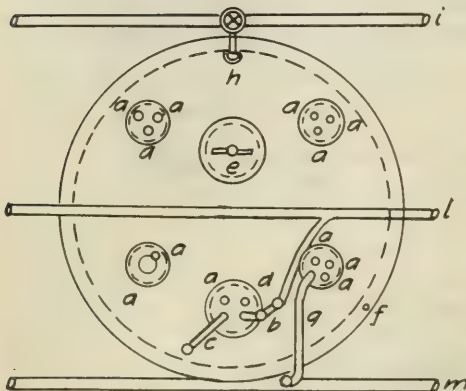
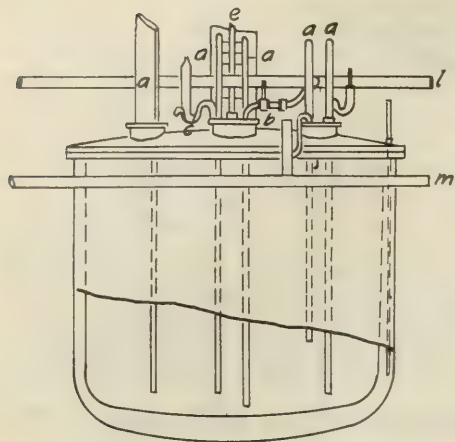


FIG. 6—H S MANUFACTURE AT LEVERKUSEN DETAIL OF CHLORINATION KETTLE

workers were supplied with gas masks and put them on in case of emergency only. The workers suffered from chest and heart affections. Two or three died during the time though our informant would not admit that this was necessarily the cause of death. They sometimes had as many as one-third of the workers absent owing to sickness. The workers were not changed as they wished to retain those who could stand it. Only men were employed in the plant. The diphosgene was usually issued admixed with chlorpicrin. It was also admixed with phosgene.

At Höchst superpalite was prepared by chlorinating methylchloroformate prepared from phosgene and methyl alcohol. The final step was carried out in a way much like that used at the Bayer Company, and does not warrant description. An account of the first step in the process follows: The preparation of the methylchloroformate was carried out in an iron tank homogeneously lined with lead, and had a capacity of 2800 l. It was furnished with a lead stirrer and a lead coil, through which brine for cooling was passed. Phosgene, furnished by the Badische Anilin und Soda Fabrik in tank-wagons, was used. The methyl alcohol was a commercial dry material. In preparing the compound, phosgene and methyl alcohol were allowed

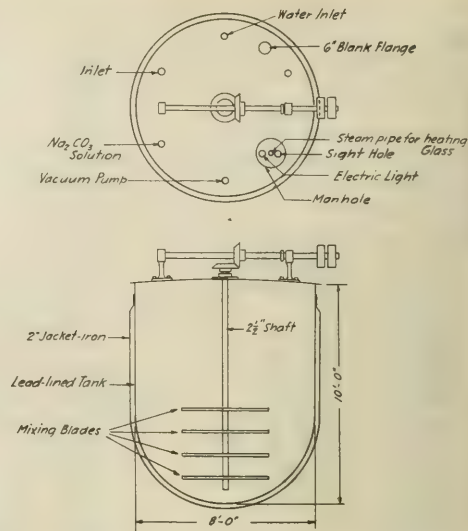
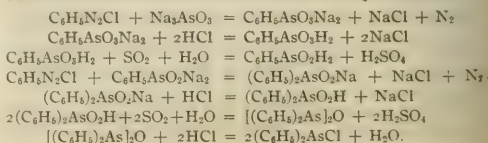


FIG. 7—WASHING KETTLE FOR H. S. MANUFACTURE AT LEVERKUSEN. 2 UNITS

to flow into the apparatus which contained a small amount of methylchloroformate. During the reaction, the temperature was kept below 0° . Between 5 and 10 per cent excess of phosgene over that required by the theory was used and enough of the materials so that at the end about 2000 kg. of the chloroformate were formed. The hydrochloric acid formed in the reaction was absorbed in towers. The kettle was so constructed that if explosions occurred no serious damage resulted. The product of the reaction was withdrawn from the apparatus and distilled, as long as anything came over, in a lead-lined distillation apparatus furnished with a lead coil. The yield of the methylchloroformate was between 80 and 90 per cent of the theoretical.

DIPHENYLCHLORARSINE

This substance (blue cross) was a favorite gas of the Germans, and was made in large quantities. It produced sneezing and a disagreeable, temporary sickness, but it was not considered by the Allies to be very efficient. The method used by the Germans was different from the one worked out by the Allies, and on account of the fact that the German method could be carried out without specially designed apparatus and required as raw materials substances readily obtainable, it was probably preferable. It is doubtful, however, whether the Allies would have made this gas, for as the result of its use no fatalities were reported. The German process consisted in preparing phenylarsenic acid by condensing benzene diazonium chloride with sodium arsenite. The acid was next reduced by sulfur dioxide to phenylarsenous acid, which was, in turn, condensed with the diazonium compound to form diphenylarsenic acid. This acid was reduced to diphenylarsenous oxide, which with hydrochloric acid yielded diphenylchlorarsine. The chemical equations for the reactions will make clearer the steps involved.



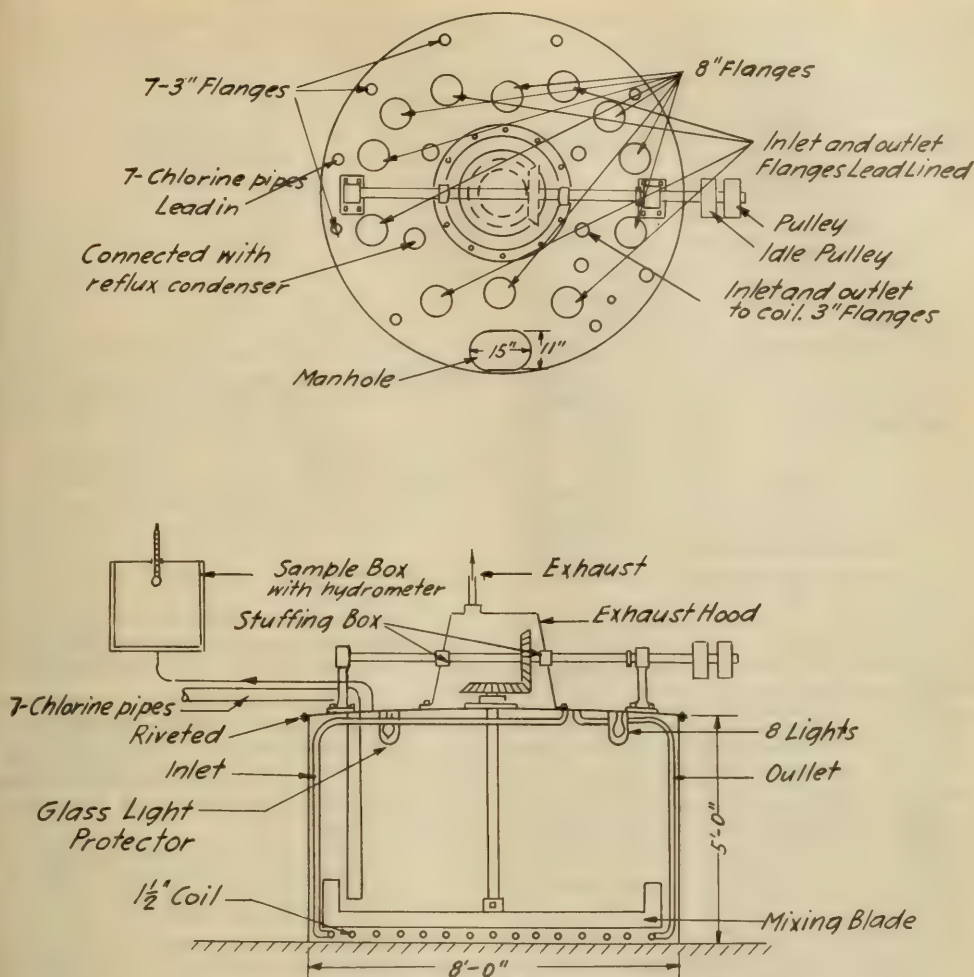


FIG 8—SUPRALITE PLANT AT HÖCHST-AM-MAIN. CHLORINATION TANK. 22 UNITS

The entire process was carried out at Höchst. Phenylarsenic acid was also made at the plants of Kalle and Company and the Badische Company. Diphenylarsenic acid was prepared by the Bayer Company. The processes at the several plants were similar. The method used at Höchst was as follows: In preparing the diazonium solution, 3 kg.-mols. of aniline were dissolved in 3000 l. of water and the theoretical quantity of hydrochloric acid. The temperature of the solution was reduced to between 0° and 5° and the theoretical amount of sodium nitrite added. The reaction was carried out in a wooden tank of the usual form for the preparation of diazonium compounds. A solution of sodium arsenite was prepared which contained 20 per cent excess of oxide over that required to react with the aniline used. The arsenous oxide was dissolved in sodium carbonate, care being taken to have enough of the alkali present to neutralize all of the acid present in the solution of the diazonium salt. To the solution of the sodium arsenite were added 20 kg. of copper sulfate dissolved in water, this being the amount

required when 3 kg.-mols. of aniline are used. The solution of the diazonium compound was allowed to flow slowly into the solution of the arsenite while the temperature was maintained at 15° . The mixture was constantly stirred during the addition which requires about 3 hrs. After the reaction was complete, the material was passed through a filter press in order to remove the coupling agent and the tar which had been formed. Hydrochloric acid was next added to the clear solution to precipitate phenylarsenic acid, the last portions of which were removed by the addition of salt.

The phenylarsenic acid was next reduced to phenylarsenous acid by means of a solution of sodium bisulfite, about 20 per cent excess of the latter over the theoretical amount being used. For 100 parts of arsenic acid, 400 parts of solution were used. The reaction was carried out in a wooden vessel and the mixture stirred during the entire operation. A temperature of 80° was maintained by means of a steam coil. Phenylarsenous acid separated as an oil. The aqueous solution was decanted

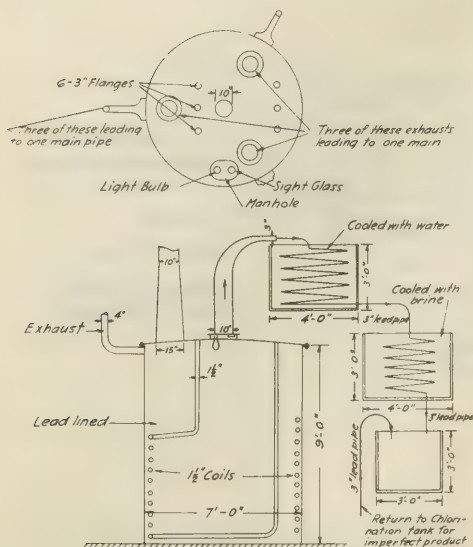


FIG. 9—SUPERPALATE PLANT AT HÖCHST-AM-MAIN
KETTLE. 2 UNITS

from the oil, which was dissolved in a solution of sodium hydroxide, 40° Bé. The solution of the sodium salt of phenylarsenous acid was treated with water so that the resulting solution had a volume of 6 cu. m. when 3 kg.-mols. of the salt were present. Ice was next added to reduce the temperature to 15° and a solution of benzene diazonium chloride, prepared in the manner described for the first operation, was slowly added. After the coupling, diphenylarsenic acid was precipitated by means of hydrochloric acid. The acid was removed by means of a filter press and dissolved in hydrochloric acid, 20° Bé. For one part of diphenylarsenic acid, 3 parts of hydrochloric acid were used. Into this solution was passed 5 per cent excess of sulfur dioxide over that required for the reduction. The sulfur dioxide used was obtained from cylinders which contained it in liquid condition.

The reduction was carried out in an iron tank lined with tiles and a temperature of 80° was maintained. About 8 hrs. were required for the reaction. The diphenylarsenic acid on reduction by the sulfur dioxide was converted into diphenylarsenous oxide which, in the presence of the hydrochloric acid, was converted into diphenylchlorarsine, which separated as an oil. The oil was next removed and heated in the best vacuum obtainable until it was dry and free from hydrochloric acid. The compound melted at 34°. It was placed in iron tanks for shipment. The yield of diphenylchlorarsine calculated from the aniline used was from 25 to 30 per cent of the theoretical. No marked trouble was observed in handling the materials and no serious poisoning cases were reported.

DIPHENYLCYANARSINE

This compound was prepared by treating diphenylchlorarsine with a saturated aqueous solution of potassium or sodium cyanide.



Five per cent excess of the alkaline cyanide was used. The reaction was carried out at 60° with vigorous stirring. The yield was nearly theoretical.

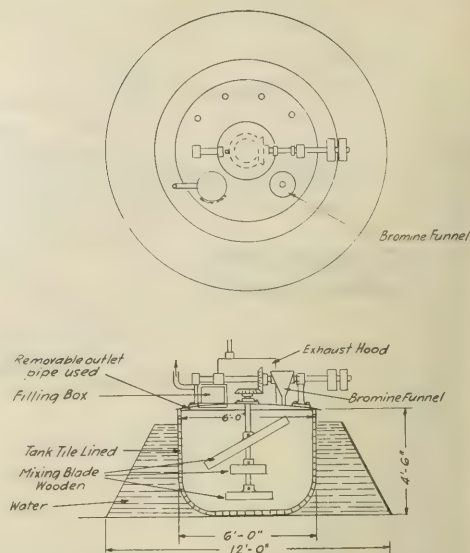
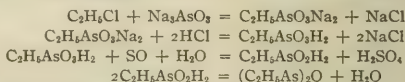


FIG. 10—BROMACETONE. 7 SMALL UNITS, 12 LARGE UNITS

ETHYLDICHLORARSINE

This compound was prepared at Höchst from ethylarsenous oxide which was obtained from the Badische Anilin und Soda Fabrik.

PREPARATION OF ETHYLARSENOUS OXIDE—The compound was prepared by treating sodium arsenite with ethyl chloride under pressure. The resulting sodium salt of ethylarsenic acid was converted into the free acid and reduced by sulfur dioxide. The ethylarsenous acid formed in this way lost water and was thereby transformed into ethylarsenous oxide. The reactions involved are as follows:



The ethyl chloride used in the preparation was in part made in this factory, and in part received from other sources. As ethyl chloride is an important product used in peace time, it is not, therefore, essentially a war product and its preparation was not described.

In preparing the solution of sodium arsenite, one molecular weight of arsenous oxide was dissolved in a solution containing 8 molecular weights of sodium hydroxide. The solution of the base was prepared from a 50 per cent solution of sodium hydroxide to which enough solid alkali was added to make the solution a 55 per cent one. In one operation 660 kg. of arsenous oxide were used. For 100 parts of arsenous oxide, 130 parts of ethyl chloride were used, this being the theoretical amount of the latter.

The reaction was carried out in a steel autoclave of about 300 l. capacity. The temperature was maintained at between 90° and 95°. The ethyl chloride was pumped in, in 3 or 4 portions, and the pressure in the autoclave was kept at from 10 to 15 atmospheres. The several portions of ethyl chloride were introduced at intervals of about 1 1/2 hrs. During the entire reaction, the contents of the autoclave were vigorously stirred. After all the ethyl chloride had been added, the ma-

terial was stirred from 12 to 16 hrs., at the end of which time the pressure had fallen to about 6 atmospheres. The excess of ethyl chloride and the alcohol formed in the reaction were next distilled off. At this point a sample of the solution was drawn off for testing. This was done by determining the amount of arsenite present in the solution. If not more than 20 per cent sodium arsenite had not reacted, the preparation was considered satisfactory. Water was then added to the contents of the autoclave in sufficient amount to dissolve the solid material. The product was next drawn over into a tank and neutralized with sulfuric acid. It was then treated with sulfur dioxide gas until there was an excess of the latter present. The mixture was then heated to about 70° when the ethylarsenous oxide precipitated out as a heavy oil. This was readily separated and shipped without further purification.

The yield of ethylarsenous oxide, from arsenic oxide, was from 80 to 82 per cent of a product which contained about 93 per cent of pure ethylarsenous oxide.

PREPARATION OF ETHYLDICHLORARSINE—The compound was prepared by treating ethylarsenous oxide with hydrochloric acid. The reaction is as follows:



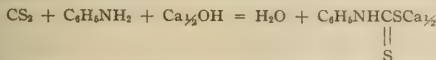
The operation was carried out in an iron kettle lined with lead, which was cooled externally by means of water and which was furnished with a lead covered stirrer. To the kettle, which contained from 500 to 1000 kg. of hydrochloric acid left over from the previous operation, were added 4000 kg. of ethylarsenous oxide. The gaseous hydrochloric acid was next led in. The kettle was kept under slightly diminished pressure in order to assist in the introduction of hydrochloric acid. The temperature during the reaction must not rise above 95°. When the hydrochloric acid was no longer absorbed and was contained in appreciable quantities in the issuing gases, the operation was stopped. This usually occurred at the end of from one to two days. The product of the reaction was drawn off by means of a water pump and heated in a vacuum until drops of oil passed over. The residue was passed over to a measuring tank and finally to tank-wagons made of iron. The yield of the product was practically the theoretical.

On account of the volatility of the compound and its poisonous character, the apparatus in which it was prepared was surrounded by an octagonal box, the sides of which were fitted with glass windows. Through this chamber a constant supply of air was drawn. This was led into a chimney where the poisonous vapors were burned. The gases given off during the distillation of the product were passed through a water scrubber.

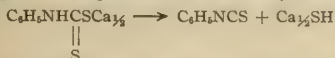
PHENYLIMINOPHOSGENE

The phenyl mustard oil required for this preparation was made by Kalle and Company and converted into the finished product by Meister, Lucius and Brüning at Höchst.

PREPARATION OF PHENYL MUSTARD OIL—In the preparation of the compound, carbon disulfide was allowed to interact with aniline in the presence of milk of lime, the reaction being as follows:



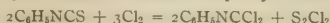
The resulting product was treated with zinc chloride and sodium hydroxide, as the result of which phenyl mustard oil and calcium sulfhydrate were formed. The product of the first reaction decomposes in the presence of the zinc salt, thus:



Six kilo molecules of carbon disulfide were mixed with the theoretical proportion of a 30 per cent milk of lime. To this mixture, which was contained in a closed iron tank, was added

a slight excess over 6 kg. mols. of aniline. The addition of the aniline required about 1 hour, while the mixture was stirred and kept cool by means of water circulating in the jacket. After the addition of the aniline, the mixture was stirred for about one day and the temperature maintained at about 25°. A solution of zinc chloride was next prepared in a wooden tank by dissolving enough zinc chloride to furnish 840 kg. of 100 per cent zinc chloride in the amount of water required to make a 50 per cent solution. To this solution were added 550 kg. of sodium hydroxide which was in the form of a solution of 40° Bé. strength. The product formed from the aniline and carbon disulfide was next pumped over into the alkaline solution of the zinc chloride and the resulting mixture was allowed to interact at a temperature of 30° to 40°. The mixture was then run into an iron still which was heated by a steam jacket and coil on the inside, and by direct steam. The phenyl mustard oil, which distilled over with the steam after passing through a condenser, was run into a series of three setting tanks from which the oil was drawn off. It was shipped without being further distilled.

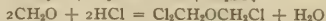
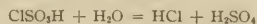
PREPARATION OF PHENYLIMINOPHOSGENE—The compound was prepared by the action of chlorine on phenyl mustard oil:



About 600 kg. of mustard oil were used in a single operation. This was contained in a lead-lined kettle of about 1000 l. capacity. The kettle was furnished with a lead stirrer and a lead coil through which cold brine was circulated. Chlorine was led into the coil and the temperature kept below 0°. When the specific gravity of the material was about 1.45, the reaction was complete, the time required being a little less than 24 hrs. The product was transferred to a lead-lined still which was furnished with a steam jacket, and the chloride of sulfur distilled off in a good vacuum. The residue was used without being distilled and always contained a small amount of chloride of sulfur. The yield of the phenyliminophosgene was about 90 per cent of the theoretical. The apparatus in which the operation was carried out was markedly affected by the chemicals used, and had to be frequently replaced.

DICHLORMETHYL ETHER

This compound was prepared by the action of hydrochloric acid on formaldehyde in the presence of sulfuric acid. As a source of hydrochloric acid, chlorosulfonic acid was used. The reactions involved are as follows:



The formaldehyde was used either in the form of paraformaldehyde or an aqueous solution containing 80 per cent of formaldehyde. The paraformaldehyde, however, is preferred.

The reaction was carried out in an iron kettle lined with acid-resisting tiles. It was furnished with a stirrer covered with lead, which had to be frequently replaced on account of the action of the acids upon it. The kettles were of 5000 l. capacity and were furnished with lead cooling coils.

In carrying out an operation, first, 1200 kg. of 70 per cent sulfuric acid, prepared from 85 per cent sulfuric acid recovered from a previous operation, were added to the kettle. Six hundred kilos of paraformaldehyde or an equivalent amount of a solution of formaldehyde were next added slowly while the mixture was well stirred. The addition of the aldehyde required from 3 to 4 hrs. Twenty-four hundred kilos of chlorosulfonic acid were next run in slowly, about 48 hrs. being required for this operation. The temperature maintained during the addition of the formaldehyde was between 5° and 10°, and that maintained during the addition of the chlorosulfonic acid was between 10° and 15°. During the whole operation, the contents of the kettle were thoroughly stirred.

At the end of the reaction, the kettle contains 2 layers: at the bottom, the sulfuric acid which contains the water formed in

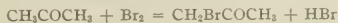
the reaction and on the top, dichlormethylether. The mixture is drawn from the kettle—first, the sulfuric acid and then the oil. The oil is run directly into tank-wagons of iron, care being taken to avoid the presence of any moisture. The dichlormethyl oxide contains free hydrochloric acid; but, in the absence of moisture, does not appreciably affect the iron tank. The yield of the oxide obtained was from 90 to 95 per cent of the theoretical.

DIBROMMETHYL ETHER

The process by which this compound was manufactured was identical with that used to prepare the dichlorether, except that ammonium bromide was added to the mixture of sulfuric acid and paraformaldehyde, instead of using chlorosulfonic acid. Six parts by weight of 70 per cent sulfuric acid were first added to the kettle. One part by weight of paraformaldehyde was then added. Ten per cent excess over two molecular quantities of solid ammonium bromide for each molecular quantity of formaldehyde was next added slowly. The time required for the addition of the ammonium bromide was 48 hrs., and the temperature was maintained at 15° to 20°. When all the substances had been added, the mixture was stirred for from 5 to 10 hrs. at 30°. The product formed was separated from the sulfuric acid and about 10 per cent removed by distillation in a lead-lined still. The yield of the residue, which was the compound sought, was between 70 and 80 per cent.

BROMACETONE AND BROMMETHYLETHYLKETONE

These two products were prepared by identical methods. About two-thirds of the product produced by the factory was prepared from methylethyl ketone which was obtained from the product resulting from the distillation of wood. The method employed was to treat an aqueous solution of potassium or sodium chlorate with acetone or methylethyl ketone, and then add slowly the required amount of bromine. The equation for the reaction in the case of acetone is as follows:



Ten kg.-mols. of acetone or methylethyl ketone were used in a single operation. About 10 per cent excess of chlorate over that required to oxidize the hydrobromic acid formed in the reaction was used. The relation between the water and the ketone was in the proportion of 2 parts by weight of the former to 1 part by weight of the latter. For 1 kg. mol.-wt. of the ketone, 10 per cent excess over 1 kg. atomic-wt. of bromine was used.

The reaction was carried out either in earthenware vessels or in iron kettles lined with earthenware (see Fig. 10). The kettles were furnished with a stirrer made of wood, and varied in capacity from 4000 to 5000 l. They were set in wooden tanks and cooled by circulating water. The chlorate was first dissolved in the water and then the ketone added. Into this mixture the bromine was allowed to run slowly while the solution was stirred and kept at a temperature of from 30° to 40°. The time required for the addition of the bromine was about 48 hrs. When the reaction was complete, the oil was drawn off into an iron vessel and stirred with magnesium oxide in the presence of a small amount of water in order to neutralize the free acid. It was then separated and dried with calcium chloride. At this point a sample of the material was taken and tested. The product was distilled to tell how much of it boiled over below 130° when methylethylketone had been used. If less than 10 per cent distilled over, the bromination was considered to be satisfactory. If, however, a larger percentage of low-boiling material was obtained, the product was submitted to further bromination. The material obtained in this way was found on analysis to contain slightly less than the theoretical amount of monobromketone.

It was finally transferred by suction or by pressure into tank-wagons. At first lead-lined tanks were used, but later it

was found that tanks made of iron could be substituted. In order to take care of the small amount of hydrobromic acid, which is slowly formed, a small amount of magnesium oxide was added to the material. The amount of the oxide used was approximately in the proportion of 1 part to 1000 parts of ketone. When the magnesium oxide was used, it was found that the bromketone kept without appreciable decomposition for about 2 months. The yield of the product from 580 kg. of acetone (10 kg. mol. wts.) was 1100 kg. The yield from 720 kg. of methylethyl ketone (10 kg. mol. wts.) was 1250 kg.

XYLYL BROMIDE

The process employed was to introduce xylene into iron or enameled stills fitted with a close-fitting stirrer and a coil for heating. The stirrer shaft had fitted to it a special lead-lined gland with a sulfuric acid seal. The xylene was heated to 115° and the bromine run in little by little. The hydrobromic acid gas was absorbed. The total amount of bromine employed was about three-fourths of the theoretical. Eight hundred kilos were used in each charge and there were six of these units. At the end of the reaction the xylene was distilled off in vacuum and the residual xylyl bromide packed without further treatment. The bromine was recovered from the hydrobromic acid by-product by means of chlorine and distilled off.

CHLORPICRIN

The process employed was to prepare an emulsion of bleaching powder and to add picric acid to it little by little, maintaining a temperature of about 30° by water-cooling. The chlorpicrin was distilled and the distillate drawn up to large tanks for separating the water. The reaction vessels consist of 6 units, 8 ft. in diameter and from 15 to 20 ft. deep. They were lead-lined and had coils on the side with a gate stirrer. During the reaction the manhole was closed by a glass cover to facilitate inspection.

PHOSGENE

Phosgene was manufactured in the works of the Bayer Company prior to the war. The plant is capable of producing about 30 tons per month. In the first instance, large quantities of phosgene were sent to the factory for filling and also for conversion into diphenylene. The method employed does not appear to be an economical one. The carbon monoxide is prepared by passing carbon dioxide, a by-product from the acidification of vat liquors, over wood charcoal contained in gas-fired muffles and the resulting carbon monoxide is washed with sodium hydroxide. The carbon monoxide and chlorine are bubbled through Woulff bottles and the speed regulated by inspection of these bottles and reading of flow meters. The mixed gases, at a short distance from where they were mixed, are passed downward through a layer of about 20 cm. of prepared charcoal contained in a cast-iron vessel 80 cm. in diameter and 80 cm. deep. The phosgene is led away by a lead pipe to which is attached a view pipe by means of which the color of the issuing gas may be watched. By regulating the mixture so that there is a slight excess of carbon monoxide, the phosgene is obtained with one-quarter to one-half per cent of chlorine. Stress was laid upon the method of purifying the carbon catalyst. Wood charcoal was washed with hydrochloric and other acids until perfectly free from soluble ash. It is washed and dried in vacuum. Animal charcoal is generally found better. The size of the granules was about one-quarter inch mesh. The life is about 6 months. The phosgene is liquefied by cooling with ice and salt. The phosgene plant remains intact ready for use. There are 14 units inside the building and 2 experimental ones outside.

CHARCOAL FOR GAS MASKS

In the first instance, the charcoal for filling the gas masks was supplied to the Bayer Company from Aussig in Austria.

but in the summer of 1916 the manufacture was started at Leverkusen. The average production was 30 tons per month.

The process consists of taking wood of even size, pieces of about one-fourth inch diameter, and soaking it in strong hydrochloric acid to which zinc chloride had been added. The acid was 20° to 40° Bé. in strength. The amount of zinc chloride added was indefinite and said not to be very much. The wood employed was generally pine wood but it made no difference what wood was used. The wood was soaked in the acid mixture for half an hour and upwards, a small quantity being mixed up at a time in lead-lined tanks. The acidified wood was packed into a closed muffle furnace lined with porcelain tiles and fitted with a stoneware flue pipe to a hydrochloric acid condenser plant. It is desirable that carbonization should take place slowly and very thoroughly.

The muffles were filled nearly full with a few inches of air space above. They were heated to a cherry-red and the heating continued for from 6 to 8 hours at least. It is most desirable to continue it long enough, otherwise the material would not be good. The muffle was about 24 in. square by 12 ft. long with an iron door through which the charge was introduced. The charcoal was washed with hydrochloric acid in lead-lined tanks 8 by 10 by 5 ft. The washing was continued until the soluble ash was reduced to a minimum and the finished charcoal contained about 0.01 per cent of zinc. It was finally washed free from acid. The time taken for washing was in all 2 or 3 days. The charcoal was next drained on a grill and transferred to a vacuum cupboard and dried at 70° or 80°. It was finally sifted on a rotary sieve to get rid of the dust.

The furnaces had a good life and lasted for about 2 years. The only replacements necessary were thought to be due to carelessness on the part of the workmen. No satisfactory test appears to have been arrived at but the charcoal was usually tested for its absorption of hydrogen or oxygen. They did not test it for absorption of phosgene. Berlin appears to have tested with phosgene and did not agree with the result obtained by the oxygen or hydrogen test. Experiments were made with sulfuric acid and with other salts, such as sodium chloride and calcium chloride, without good effects.

A visit was paid to the room in which the box respirators were packed but all the filling machines and test apparatus had been removed. We were, therefore, unable to get any information as to these. It was said that the number of respirators packed per day was 40,000.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

AN ARTILLERY GAS ATTACK

By B. C. Goss, Lieutenant Colonel, Chief Gas Officer, 1st Corps

Received May 29, 1919

Of all gas projectiles, artillery shell are most important either for producing casualties or for the purpose of assisting infantry operations. This fact is due to the long effective range of this weapon which makes its use less dependent upon wind and weather conditions than any other means of projecting gas.

The importance of this method of gas attack may be estimated from the fact that 90 per cent of the total gas casualties in the British army was caused by enemy artillery shell, and this in spite of the tremendous casualties incurred by the first unexpected use of cloud gas from cylinders in 1915 against troops wholly unprepared. Casualties in the British army due to gas artillery shell reached the appalling total of 170,000.

The use of toxic shell may be divided into three periods. During the first of these, from May 1915 to July 1916, only lachrymatory shell were used and while these lachrymators had considerable harassing power, no serious casualties or deaths occurred. The protection at this time consisted of goggles,

impregnated fabric helmets, such as the P. H., and cotton waste respirators.

Lethal shell came into use in July 1916 and from this time on until July 1917, in addition to the lachrymators, such shell were employed, containing phosgene, diphosgene, and chlorpicrin. At the beginning of this period only the fabric mask protection was available. The British box respirator was introduced in August 1916, and issue was completed early in 1917.

The third period began with the first appearance of mustard gas at Ypres in July 1917 and it was only during the latter part of this period that American troops came into the line. By this time a variety of chemical shell was being used by all the armies. The British army was completely equipped with the small box respirators and this form of protection was also adopted by the American forces. The French were using the so-called M₂ masks and a special Tissot mask for artillery and medical officers. It is only with this third period that this discussion will be concerned.

While the effect of H. E., or shrapnel shell, is ended immediately after the burst, that of a chemical shell has only just begun, and may continue, depending on the nature of the filling, up to a week or 10 days. Moreover, the effect is continuous over the limits of the area of spread; in the words of the trap-shooter, "There are no holes in the pattern." A bomb-proof shelter composed of barriers of concrete, steel, and earth, for protection against flying fragments, is of no avail against chemical shell, since the fumes can perfectly well pass around corners.

For these reasons, effects may be produced with gas shell which are impossible with others, but for the same reasons, the maximum effects can be produced only when the properties of the chemical are thoroughly known to those directing the operation. The behavior of the toxic cloud following the shell burst is dependent upon the physical properties of the chemical, upon the nature of the ground, temperature, wind and weather conditions, and the number, caliber, and kind of shell, as well as the rate and duration of fire; and the choice of shell is dependent upon the nature of the target and the end to be accomplished. From the standpoint of the artilleryman, chemical shell are divided into two great classes, depending on the purpose for which they are to be used. These may be called "lethal" and "neutralizing." With certain variations, it was the policy of all the armies to mark chemical shell on the basis of this difference in tactical use.

Lethal shell are used to produce casualties and this purpose immediately defines their manner of use. Such shell should be fired against occupied targets for surprise effect and, therefore, it is important that the greatest possible number of shell fall on the target in a minimum time. To accomplish this, all available batteries should be assigned and should maintain their maximum rate of fire until the required concentration has been built up. It is almost never profitable to fire lethal shell for more than a 2 or 3 minute period on one target since by this time the enemy masks would be adjusted and no further results could be expected. Chemicals used for this purpose are generally not persistent and the best example of this type is phosgene.

Neutralizing shell, on the contrary, are filled with chemicals which are persistent and vaporize slowly. As the name indicates, they are employed to interfere with the enemy activities by producing an atmosphere which is intolerable for unprotected troops. Suitable targets for such shell are lines of communication, camps, rest billets, important trench systems, cross roads, battery positions, or areas where supports or reserves may be concentrated. Instead of a burst of rapid fire, a slow searching fire should be maintained with such shell, scattered over the area to be neutralized. A low concentration of such gas gives just as good results as a high one, since it is desired only to force the enemy to wear respirators and thus cut down their efficiency in

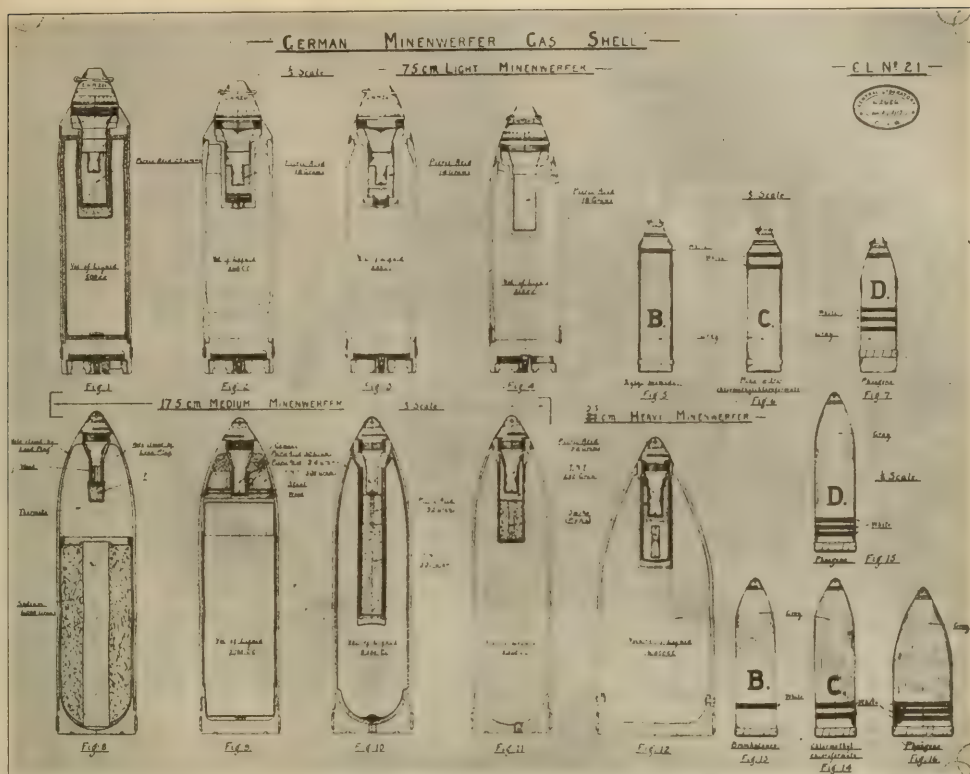


FIG. 2.—GERMAN MINENWERFER GAS SHELL

3—Lines of communications: to disorganize reliefs, hold up transport, ration, or ammunition parties, or runners.

4—Probable assembly or support positions: to deny to the enemy the use of ground such as woods, valleys, villages, farms, etc.

5—Working parties: to interfere with construction work and to prevent wiring of defenses.

6—As a creeping barrage preceding an advance: to compel the enemy to wear masks and so place them at a disadvantage.

7—As a standing barrage after infantry objectives have been reached: to interfere with counterattacking troops.

For all these purposes, except concentrated fire against occupied targets and the creeping barrage, persistent or neutralizing shell should be used, since they give the same results with one-fifth to one-tenth the ammunition expenditure.

WEATHER CONDITIONS: (1) *Wind*—The best effect with lethal shell can be obtained in winds of less than 3 miles per hour, and such shell should never be used if the wind velocity exceeds 7 miles per hour, except when the target is in a village or woods which is sheltered from the wind. Persistent or lachrymatory shell can be effectively used in winds up to 12 miles per hour.

(2) *Air currents*—Stability of air is necessary for a successful gas shoot. In hot, dry weather, convection currents rapidly carry the toxic cloud off the surface. This is particularly true of nonpersistent chemicals which are almost completely vaporized with the burst of the shell and they can, therefore, seldom be used on warm, sunny days. On the other hand, persistent

chemicals, with high boiling points, soak into the ground and vaporization would be improved on a warm day.

(3) *Humidity*—Forty to fifty per cent humidity is best for the use of gas since under these conditions a cloud is more readily formed. Moisture in the air tends to keep the gas cloud close to the ground and therefore keeps up the concentration. A light rain or drizzle is no disadvantage but a heavy rain washes down the gas. During the day a fog furnishes the best opportunity for a gas shoot since it not only stabilizes the cloud but serves as a screen.

Considering temperature, wind, and humidity conditions, the hours between midnight and daylight are usually the most favorable for a gas attack, and, in addition, surprise is more easily possible at this time.

TOPOGRAPHY—The behavior of a toxic cloud is greatly influenced by the earth's form, chiefly because of the alteration produced in air currents. While practically all the gases used are heavier than air, the effect of air currents is much more important in freeing high ground from gas than this difference in vapor density. Particular attention must be paid to any deviation of the local wind from the general wind direction. Cases have occurred where long, deep, and curving valleys have caused the return of gas to our own lines, causing casualties.

METHOD OF FIRE: (1) *Lethal shell*—Fire should be confined to small, definitely located targets known to be occupied and should consist of concentrated fire of 2 minutes duration. A certain minimum number of any particular kind of lethal shell

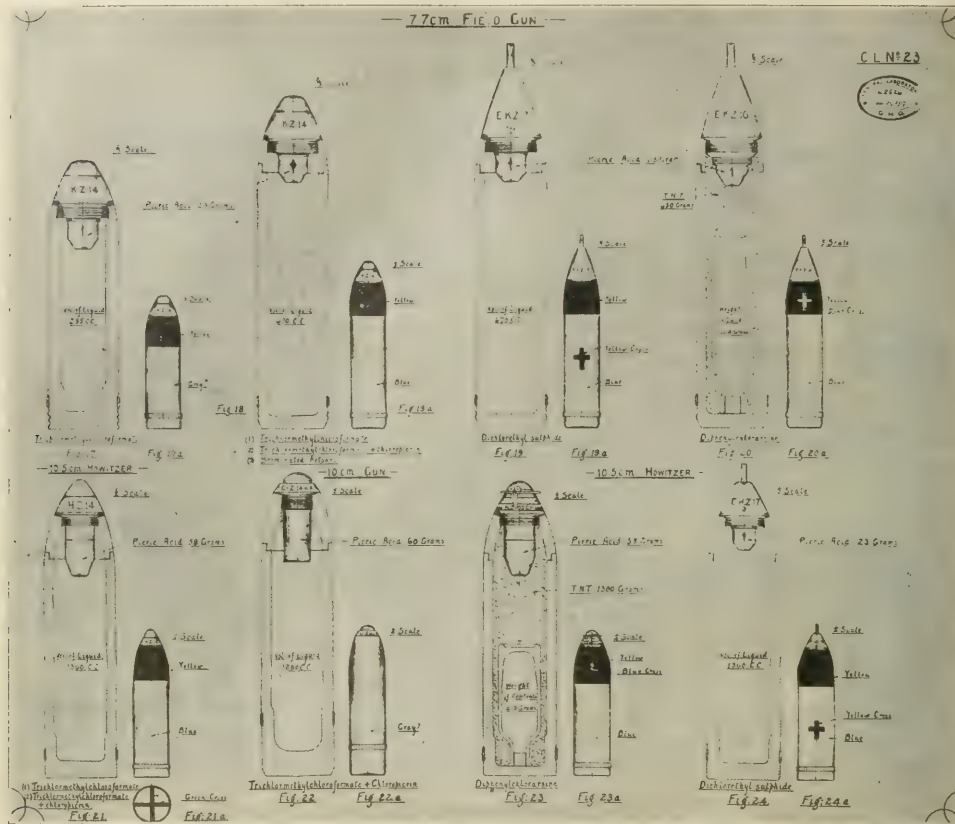


FIG. 3—GERMAN FIELD GUN AND HOWITZER GAS SHELL

must fall on the target within this period in order to produce the fatal concentration. It is still better to largely increase this minimum number by concentrating as many batteries as possible on the target. For a linear target, this minimum number is approximately as follows:

3.0 inch shell.....	100
4.5 inch shell.....	50
6.0 inch shell.....	25

Shells with the same filling should be used for any one target. Two shell fillings may be mixed to assist each other. Since it is necessary to concentrate more than one battery on a target, exact synchronization is necessary, in order to avoid giving warning by the arrival of a few shells in advance of the concentration.

If sufficient guns are available to allow more than one target to be engaged at a time, targets should be so chosen that the various clouds will assist each other. If the successive targets are to be engaged for lethal effect, the down-wind target should be taken first so as to avoid giving warning to the others.

Sufficient time should be allowed between bursts of fire with lethal shell, on one target, to permit removal of respirators by the enemy and the consequent possibility of surprise. Lethal shell cannot be effectively used following a shoot with persistent shell unless the atmosphere of persistent gas is kept up

long enough to out-last the endurance of the enemy in wearing respirators. Therefore, it is sometimes good tactics to fire a burst of lethal shell on the target followed by several hours of neutralizing fire with lachrymatory shell, and then to put down a second concentration of toxic gas.

(2) *Persistent shell*—Searching fire can be employed instead of concentrated fire, and area targets may be engaged without excessive ammunition expenditure, fire being distributed over the whole area.

If a large target is to be neutralized, fire should be opened on the windward edge so that the effect of the first rounds will be felt over as much of the area as possible.

While the number of shell required would vary greatly with the persistency of the chemical, the following numbers of shell containing a highly persistent lachrymatory would be required for average wind and weather conditions, for an area of 3000 square yards:

	First Half Hour	Subsequent Half Hours
3.0 inch shell.....	70	35
4.5 inch shell.....	40	20
6.0 inch shell.....	20	10

A certain effect will remain for several hours after the shelling ceases, but the above numbers would be necessary for effective neutralization.

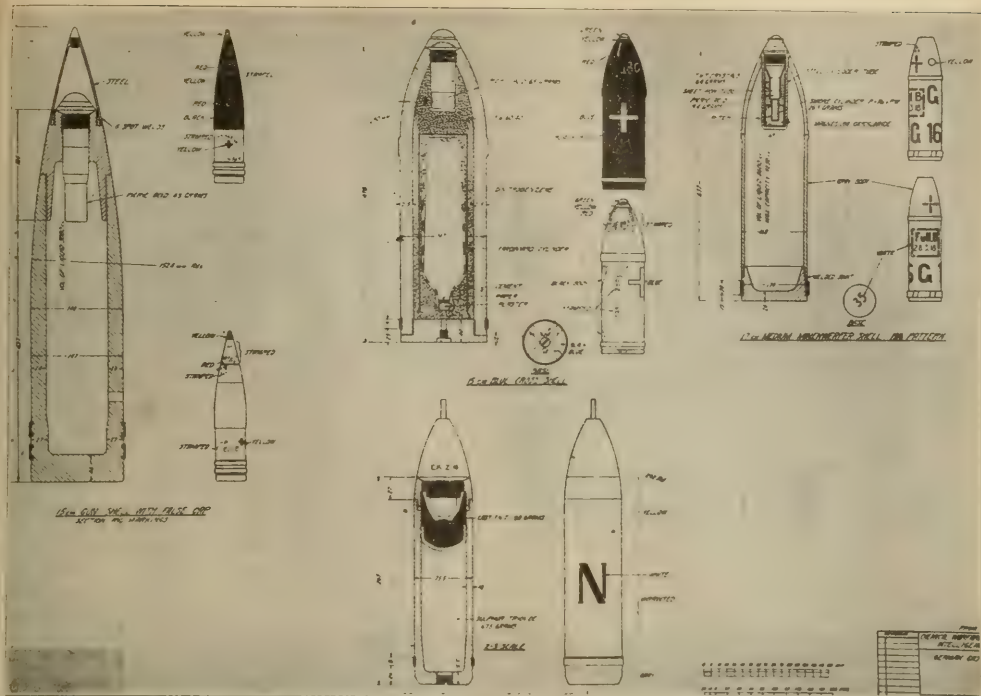


FIG. 4—GERMAN GAS SHELL

High explosive or shrapnel may be employed without harmful results either with persistent or lethal shell, since they add greatly to the confusion and difficulty of adjusting and wearing respirators. With lethal shell, however, it would seldom be advisable to use considerable numbers of high explosive shell during the first 2-minute burst of fire.

PRECAUTIONS—Chemical shell should never be fired on a target less than 200 yards from our own positions, regardless of wind direction. With the wind blowing toward our own lines, or during a calm or light variable wind, chemical shell should not be fired at targets closer to our lines than the following distances:

1—NONPERSISTENT

	Wind toward Enemy Yds.	Wind toward Own Lines Yds.
Small quantity (up to one hundred 75 shell or equivalent).....	200	500
Large quantity.....	200	2000

2—PERSISTENT

	300	500
Small quantity.....		
Large quantity.....	1000	3000

The time which must elapse before unprotected troops can safely occupy ground which has been bombarded with chemical shell varies with different shell, weather conditions, and nature of the ground. Sunshine, rain, and wind diminish the persistence while low temperature and absence of wind increase it. In dugouts or cellars gas may persist for days if the ventilation is poor and, likewise, slightly volatile chemicals may remain undecomposed below the surface of the ground for a week or more unless the ground is disturbed by digging. With a 3-mile-

per-hour wind the approximate times necessary before the gassed area may be occupied, are as follows:

	Open Ground	Woods
Hydrocyanic acid (Vincennite mixture).....	8 min.	30 min.
Phosgene.....	20 min.	3 hrs.
Chlorpicrin.....	1 hr.	20 hrs.
Ethylidiodoacetate.....	6 hrs.	36 hrs.
Mustard gas.....	24 hrs.	7-10 days

Following are some typical shoots with chemical shell, carried out by British batteries:

NO. 1—COUNTER BATTERY SHOOT WITH THREE 60-POUNDER BATTERIES
TARGET—Central battery of a group of 5 hostile batteries which were causing inconvenience.

VELOCITY OF WIND—2 m. p. h.

GUNS EMPLOYED—Three 60-pounder batteries (18 guns)

ZERO HOUR—11:00 P. M., June 16

PROGRAM—0.00-0.02 Phosgene-arsenic trichloride mixture. Two minutes' intensive lethal fire to catch the enemy before he can protect himself
 0.02-4.02 Ethylidiodoacetate. Four hours' slow bombardment to saturate battery positions and force the enemy to use up his drum
 4.02-4.12 Phosgene, arsenic trichloride chlorpicrin. Ten minutes' intensive lethal fire with P. S. and C. B. R.—P. S. to pass through the drum after four hours' wearing and cause coughing, and C. B. R. added for lethal effect

RESULT—The various batteries in the group did not open fire until the following times:

- 1— 8:36 P. M., June 19
- 2— 9:15 P. M., June 19
- 3—11:20 P. M., June 19
- 4—11:40 P. M., June 19

The central battery did not open fire till 11:29 A. M. on June 24, although it had not moved.



FIG. 6—WHERE GAS SHELL WERE STORED AT THE FRONT

borne in mind when considering the uses to which chemical shell were actually put by the American artillery.

A series of gas attacks against the German forces in Châtel-Chehery was made by American artillery during the second phase of the Argonne fighting. The enemy were holding out on the heavily wooded slopes of the Chene Tondou Ridge just to the west of the village of Apremont. This reverse slope, which was heavily undermined with concrete passages and

strongly fortified, could not be reached by our artillery, and as a result our line had passed several kilometers to the north of this position on the plain to the east, while the succession of ridges on the edge of the Argonne forest were still in the possession of the enemy who were able not only to prevent further advance of our line but were inflicting heavy punishment on the troops of the 28th Division in the neighborhood of La Forge.



FIG. 8—CONTROL OF ARTILLERY FIRE IN GAS

The village of Châtel-Chehery, Hill 180, Hill 223, and Hill 244, and the Bois de Taille l'Abbé were especially troublesome, and it was desired that the fullest possible use might be made of gas in order to reduce these positions. Accordingly, the Chief of Staff of the First Army Corps directed the Chief Gas Officer to station himself at the 28th Division headquarters in order to assist in this work. On October 2 the Division Commander authorized the Corps Gas Officer to make all necessary preparations for the gassing of Châtel-Chehery and the surrounding country and to arrange with the Division Artillery Commander regarding the kind and number of shell to be used and the conditions of fire. Orders were accordingly drawn up for gas attacks on three successive nights beginning at 2 A.M. on October 3. The first of these orders follows:

HEADQUARTERS 53RD F. A. BRIGADE
AMERICAN EXPEDITIONARY FORCES
FRANCE

MEMORANDUM No. 2

2 October, 1918
21.00 hour

1—A gas attack will be delivered on October 3, 1918, at 2:00 hour by the artillery units of this brigade.

2—Artillery participating:

109th F. A. U. S. Concentration on point X-97.80, Y-79.95
108th F. A. U. S. Concentration on point X-97.65, Y-79.30
238th F. A. French Concentration on point X-97.75, Y-79.65
108th F. A. U. S. Fire on zone 100 m. wide from X-97.50, Y-79.30 to X-97.60, Y-80.00.

3—The preparation will last from 2 till 2 hours 3 minutes.

4—Rate of fire: 75 mm.—5 shots per gun per minute.
155 mm.—3 shots per gun per minute.

5—Watches will be carefully synchronized.

6—Proper precautions for handling of gas shells during the service of the piece will be strictly observed.

BY COMMAND OF BRIGADIER GENERAL RICE
ROBERT G. MACKENDRICK
Major Adjutant

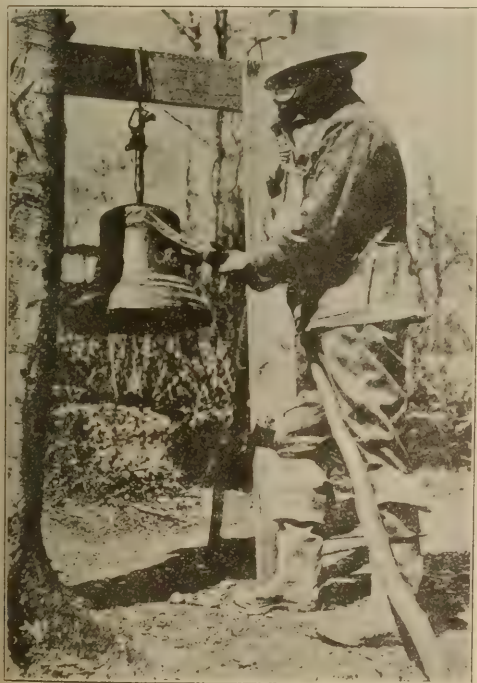


FIG. 7—A GAS ALARM AT FLUREY

The forward troops in the area of La Forge were notified of the proposed gassing and unit gas officers were instructed to take the necessary precautions to prevent injury to them in case of variable winds. At exactly 2 A.M., the three regiments of 75



FIG. 9—GAS OFFICER EXAMINING ENEMY SHELL FRAGMENTS TO IDENTIFY GAS

mm. guns and the regiment of 155's went into action simultaneously and eighteen hundred phosgene shell were poured into Châtel-Chehery inside of a five-minute period.

It was learned from prisoners' statements that a considerable number of casualties occurred as a result of these bombardments. A prisoner from a German machine gun company stated that his company was entering the village of Châtel-Chehery on the first night just as the bombardment began. He said that there was a perfect hurricane of shell and that the troops were thrown into confusion due to the fact that many of the men had either misplaced their respirators or had difficulty in adjusting them in the darkness. A quarter of his company was evacuated as casualties.

Similar attacks on neighboring targets were made on the two following nights. On the day following the third gas attack the Americans were to advance and at this time the artillery was ordered to fire phosgene shell with one battery firing at the rate of one round per gun per minute for ten minutes on each of the following targets: Chehery, Pleinchamp Ferme, Abbatiale Ferme, and Hill 180, all of which were occupied by enemy machine guns, for the purpose of forcing the enemy to put on their respirators but without producing a sufficient concentration of gas to be dangerous to our troops when they reached these objectives. At the same time two hundred phosgene shell were fired along the edge of the Bois de Taille l'Abbé, which was full of enemy machine guns, for a period of ten minutes. While it was impossible to determine the part played by any one factor in the advance, the objectives were reached and it is believed that gas played a considerable part. A record of the artillery shelling of those three days follows, together with a map of the area affected.

Oct. 3, 2:00 to 2:05 A.M. WIND S. S. E., 1 M. P. S.

CONCENTRATION

600 rounds—75 mm. No. 5's on 97.8-79.9 (vicinity Châtel-Chehery)
600 rounds—75 mm. No. 5's on 97.6-79.3 (vicinity Châtel-Chehery)
600 rounds—75 mm. No. 5's on 97.8-79.3 (vicinity Châtel-Chehery)
600 rounds—75 mm. No. 5's on 97.6-79.3 (vicinity Châtel-Chehery)
600 rounds—75 mm. No. 5's on 97.7-79.6 (vicinity Châtel-Chehery)

Oct. 4, 1:30 to 1:35 A.M. WIND N. N. E., 0.7 M. P. S.

CONCENTRATION

600 rounds—75 mm. No. 5's on Drachen, 96.7-79.0
600 rounds—75 mm. No. 5's on 97.45-79.7 (W. Châtel-Chehery)
600 rounds—75 mm. No. 5's on Cornay, 97.5-81.8

Oct. 4, 2:30 to 3:00 P.M. WIND N. W., 1.5 M. P. S.

HARASSING FIRE

40 rounds—75 mm. No. 5's on Hill 180, 98.5-80.9
40 rounds—75 mm. No. 5's on Abbatiale Ferme, 99.15-80.55
40 rounds—75 mm. No. 5's on Pleinchamp Ferme, 99.3-80.55
40 rounds—75 mm. No. 5's on Chehery, 99.1-80.3

Oct. 4, 3:30 to 3:40 P.M. WIND N. W., 1 M. P. S.

HARASSING FIRE

400 rounds—75 mm. No. 5's on N. E. edge Bois de Taille l'Abbe, 98.5-78.3

Oct. 4, 9:00 to 9:05 P.M. WIND N. W., 3.5 M. P. S.

CONCENTRATION

200 rounds—75 mm. No. 5's on Drachen, 96.7-79.0

Oct. 4, 11:00 to 11:05 P.M. WIND N. E., 2 M. P. S.

CONCENTRATION

400 rounds—75 mm. No. 5's on Cross roads, 96.4-79.3

Oct. 5, 2:00 to 2:05 A.M. WIND N. N. W., 1.5 M. P. S.

CONCENTRATION

600 rounds—75 mm. No. 5's on Cross Roads, 96.3-81.4

On the basis of the present development of toxic materials, 40 per cent of all shell should be chemical shell which should be divided as follows:

	Per cent
Mustard gas.....	24
Lethal gas.....	10
Lachrymatory gas.....	6

Lethal gas is of little value in long-range shell because it would be impossible to put a sufficient number of shell on the target simultaneously to produce a fatal concentration.

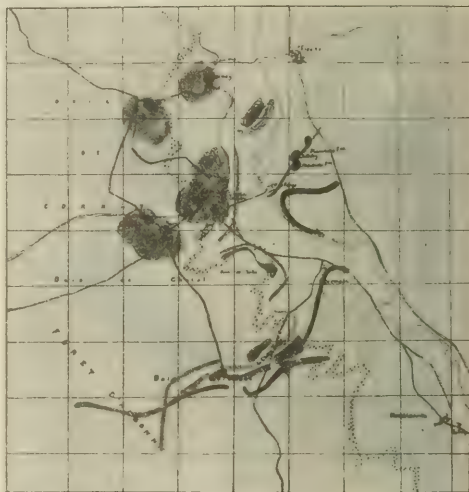


FIG. 10

The introduction of the "Yellow Lorraine Cross" shell by the enemy in the late summer of 1918 opened a new and important field. This shell contained mustard gas but differed from the usual type of chemical shell in that it carried a very heavy explosive charge in the ogive (see Fig. 5, lower row, Yellow Double Cross Shell, New Type). The effect of this was to atomize the shell contents in an upward direction and produce a cloud of fine mustard gas spray. With such shell a high concentration would be produced immediately and the casualties would be much more serious. By beginning a bombardment with this shell and continuing with the usual type, both the highly lethal and persistent effects could be obtained.

EXPERIMENTAL ENGINEERING LABORATORY
NATIONAL LAMP WORKS
CLEVELAND, OHIO

THE PRODUCTION OF NITROGENOUS COMPOUNDS SYNTHETICALLY IN THE UNITED STATES AND GERMANY

By ROBERT E. McCONNELL, Late Lieutenant, U. S. Navy

Received July 17, 1919

SUCCESS OF GERMAN TECHNISTS

Germany's sustained resistance during hostilities depended directly upon her own supply of raw materials. Her economic isolation, accentuated when Italy and Roumania joined the Allies, was one of the remarkable features of the war. The blockade against importations produced the inevitable consequences—a revolution in technology.

Nitrogenous compounds, which, in times of peace, are constituents so important to industry and agriculture, became, during the war, of prime necessity for the manufacture of munitions. In 1913 Germany imported three quarters of a million tons of sodium nitrate from the Chilean mines. A stock of half a million tons had been accumulated but this was insufficient for the production of munitions required by Germany on the western front in the year 1914.

For the past twenty years German technists have been active in developing processes for the manufacture of nitrogenous products synthetically, which would render the German government independent of nitrate importations, in the event of hostilities. Considerable secrecy was attached to these experiments, and since 1914 practically no information regarding the German developments had been obtainable. Through the Germans' success in synthetic nitrate production, which has replaced Chilean nitrate importations, the blockade against munitions of war has been rendered ineffective. It is stated conservatively, that without the product of these plants, Germany, through lack of munitions, would have been decisively defeated in 1915.

The production of nitrogenous products synthetically became of prime importance and the fact that successful development of efficient synthetic nitrate plants had been accomplished by the Germans could be stated conclusively in 1915 upon the sole evidence of Germany's sustained resistance.

It is significant that the assured success of German technists in the development of the Haber process for the manufacture of nitrogenous products synthetically was attended by declaration of war.

In the perfection of their synthetic nitrate program German technists have greatly depreciated the functional value of the huge and efficient British fleet. Great Britain is no longer able to embarrass her enemy's nitrogen supply by sea blockade, providing such an enemy is in possession of commercially successful synthetic nitrate plants or the ability and knowledge to build such plants in a minimum time.

UNITED STATES NITRATE PROGRAM DURING HOSTILITIES

During hostilities the United States and associated powers imported practically the entire output of the Chilean nitrate mines for the manufacture of munitions of war. The United States consumed 60 per cent

of this world's production in 1918, over 95 per cent of which was used in the manufacture of explosives and propellants. Notwithstanding this availability of the world's supply, the United States and associated powers became greatly concerned over the sufficiency of nitrates for munitions manufacture, and on account of this apprehension coupled with the realization of the success of German synthetic nitrate plants, instituted extensive effort and large expenditure toward synthetic developments.

A reasonably accurate forecast of military and naval methods and conditions which may prevail 5 to 15 years in the future, and provision of the means to contend with such conditions, constitutes a prime function of our military and naval authorities. At this time, upon the conclusion of the world war, conjecture has become an evident fact. The urgent importance of a comprehensive nitrate program appears clearly defined.

Shortly after the declaration of war by the United States, the President appointed a Nitrate Commission, the personnel of which included Rear Admiral Ralph Earle, Mr. Gano Dunn, Dr. Charles Parsons, Dr. A. A. Noyes, and Colonel Joyes. This Commission was delegated to submit recommendations upon the type, size, number, and location of nitrate plants required to insure an adequate supply of nitrogenous compounds for the manufacture of munitions of war. The problem which confronted the Commission involved the selection of the process best adapted to fulfill the needs of the moment. There were no commercial nitrate plants in this country. Any process selected by the Commission would have involved the solution of certain technical and mechanical problems which had not then been worked out in detail in this country. There existed two processes, however, which gave every reasonable assurance of dependable operation. These were known as the arc process and the cyanamide process, both of which required an enormous supply of electric power. The former process utilizes the electric arc directly in the fixation of atmospheric nitrogen and has been developed to a fair degree of success in Norway where electric power is very cheap. The cyanamide process makes use of the electric arc for making calcium carbide. The carbide is placed in an atmosphere of nitrogen, derived by the fractional distillation of liquid air, and under proper conditions will absorb a certain amount of nitrogen, forming a compound known as cyanamide. The cyanamide is then placed in immense vessels and steam is admitted which combines with the nitrogen, forming ammonia. The ammonia is then oxidized by passing over hot platinum screens and the oxides of nitrogen are absorbed in water, forming nitric acid. Of the two processes the cyanamide process requires less power.

There also existed two other processes, as yet in

the experimental stage, which gave promise of far greater economy of power and raw material requirements. These were known as the ammonia synthesis, or Haber process, and the cyanide process. It could not then have been positively stated, however, that either of these experimental processes could be successfully and promptly perfected so as to assure dependable large-scale production. Technists of the General Chemical Company's staff had demonstrated their ability to manufacture ammonia synthetically, in a more or less intermittent operation of their experimental plant on Long Island. It was known that the German chemist, Haber, had successfully developed this process and that large and efficient Haber plants had been constructed in Germany. The development involved the coordination of a great many very delicate and complicated mechanical details. The failure to perfect any one of the several difficult steps in the process would mean the failure of the whole scheme. The German scientists had been at work on the problem for years and with the generous support of their government had finally developed a successful process.

The Nitrate Commission, in view of the existing emergency, recommended that a cyanamide plant be immediately constructed at Sheffield, Alabama. It was realized that such a plant would require a large amount of power and that after the war it could not be expected to operate in competition with importations of Chilean nitrates. The Commission also recommended a smaller plant, adopting the ammonia synthesis process, to be constructed at Sheffield. A large-scale experimental plant for the cyanide process was built in North Carolina. In 1918 two more cyanamide plants were started in Ohio but the work was discontinued upon the signing of the armistice. The cyanamide plant at Sheffield was practically complete by November 1918. The first unit of the ammonia synthesis plant, embodying the General Chemical Company process, was finished in the summer of 1918 and several months were spent in experimental operation. These large-scale experiments demonstrated a great many serious faults in the process of the General Chemical Company, some of which have been successfully solved, but there remain other mechanical and chemical problems which have not been solved in this country. The American engineers and scientists are not to blame for this. The men who struggled with this process, including the Army and Navy technists, the General Chemical Company's staff, the engineers of the J. G. White Engineering Corporation's staff, and a number of special investigators are no less able, and are far more resourceful, than the Germans who have perfected the process. Our Government asked the American engineers to solve immediately exceedingly difficult technical problems which had taken the best talent in Germany years to solve. The German government has wisely aided and fostered this work for a good many years, fully realizing the difficulties involved, but also fully appreciating the advantages that would attend the success of her scientists and engineers.

The Navy Department has been cognizant for

the past 10 years of the probable nitrate developments, accentuated and emphasized in the war. In the year 1909 the subject received attention. Rear Admiral Ralph Earle, at that time Inspector of Ordnance of the Naval Magazine, Philippine Islands, took up the study of this subject. During the war, as Chief of the Bureau of Ordnance, he was instrumental in securing the appropriation of \$10,000,000 for the construction of the Navy nitrate plant to have been built at the Naval Proving Grounds, near Indian Head, Maryland. This appropriation passed Congress in July 1918. The General Chemical Company placed their staff and processes at the Navy's disposal. Preliminary plant design was completed in August by the J. G. White Engineering Corporation, which had contracted to undertake the design and construction of the plant. Upon the signing of the armistice a large portion of the equipment and machinery designed had been completed. Ground had been broken for the plant site and temporary buildings for housing construction workmen were nearing completion. On November 8, 1918, all work was discontinued, contracts were cancelled, and in December the officers of the section organized to execute this work had been demobilized or assigned other duties.

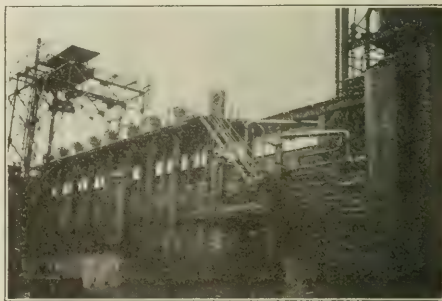


FIG. 1.—AT OPPAU. SEVEN COPPER SOLUTION TOWERS AND ONE CAUSTIC SOLUTION TOWER FOR THE REMOVAL OF IMPURITIES IN HYDROGEN-NITROGEN MIXTURE UNDER PRESSURE OF 3000 LBS. PER SQ. IN.

Shortly after the United States declared war the War Department organized a Nitrate Division, the main function of which became the construction of nitrate plants.

Approximately two hundred million dollars were appropriated for the construction of four Army plants. On the date of the armistice one Army cyanamide plant and the Army General Chemical Company plant were practically completed. The War Department had expended approximately one hundred and ten million dollars. The General Chemical Company plant was designed for adaptation of methods similar to those employed by the Germans. It is this type of plant which the Germans have perfected and by means of which they are able to produce large quantities of nitrogenous products at comparatively small cost. As a result the Germans have become independent

of nitrogenous raw material importations for munition manufacture, and it is the only country in possession of the knowledge and experience prerequisite to such independence.

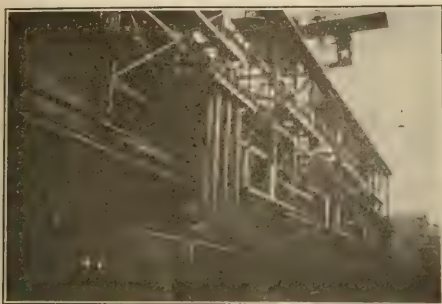


FIG. 2.—AT OPPAU. THE STEEL WORK CARRYING WATER COILS FOR REMOVAL OF AMMONIA FROM HYDROGEN-NITROGEN MIXTURE AFTER PARTIAL CONVERSION IN HABER CATALYST BOMBS

Following the completion, in the summer of 1918, of the United States Nitrate Plant No. 1, at Sheffield, Alabama, which employed the General Chemical Company process, a considerable array of talent and unstinted public expenditure was applied in the effort to effect successful and dependable operation. A number of complex technical problems have not been solved. The correlating of mechanical details involved have not yet been perfected. Upon the conclusion of the armistice the importance of the work had not diminished. Provisions for protection in the event of an attack on this country demand the perfection of the processes, dependable operation of the plants, and construction of larger plants to free us of dependence upon communication with Chile and further the mitigation of the Navy's obligation to maintain and hold this long and difficult ocean route during possible hostilities.

A thorough knowledge of German methods appears preëminently desirable as a measure of protection. The precarious position which will be occupied by belligerents in the future without this knowledge is manifest.

In the zone of occupation held by the French army there exists a Haber nitrate plant at Oppau, near Ludwigshafen, on the Rhine. The Army Nitrate Division requested permission of the Secretary of War to send a commission of army officers to inspect the plant. This permission was not granted promptly. Upon knowledge of this the Navy Department took immediate action to procure data on the German methods and the writer was instructed to secure this information. Undoubtedly, a number of brief, superficial inspections of this plant had been made immediately following the French occupation of that territory. So far as known, however, a thorough and complete study had not been attempted by experienced technists.

It was stated in March 1919 that the French had petitioned the Peace Commission for permission to

compel the German management to operate the plant and divulge the secrets involved. It is reported the American delegates opposed such action on the grounds of injustice and held that the plant products should not be considered of a military nature. The French strongly felt this to be a mistaken attitude and were anxious to convince the American peace delegates of the necessity of securing all the information possible. The French authorities in Paris were therefore pleased to learn of the interest manifested by the Navy Department, and authorization to "visit" the plant was granted the writer by the *Ministre de la Reconstitution Industrielle* on March 22. The French felt that little or no information of value could be obtained by an inspection of the idle plant, and were probably in hopes that the Navy Department, in realizing this, might then discuss the subject of operation with the American delegates.

The writer immediately undertook the examination of the Oppau plant, fully appreciating and deeply regretting the possibilities of interference and embarrassment to which such work could be subjected. Upon arrival at the plant the Germans displayed a polite but sullen attitude. They seemed willing to afford the opportunity of a cursory inspection, but strongly objected to a detailed examination. On the third day of the visit the writer was informed that his presence had become a source of serious objection and that if his examination were prolonged a formal complaint would be submitted to the Peace Conference.



FIG. 3.—AT OPPAU. WATER SCRUBBERS FOR REMOVAL OF CARBON DIOXIDE AT 25 ATMOSPHERES

The idle plant had proved a very valuable source of highly desirable technical and mechanical data and its similarity to the American plant, with which the writer had been identified, enabled him to secure valuable information in the time available. The examination was by no means complete, however, and with great reluctance it was decided unwise to remain longer at

the plant, under the existing conditions, without further instructions.

GERMAN SYNTHETIC NITRATE PLANTS

CAPACITY—During the year ending November 1, 1918, the Oppau plant of the B. A. S. F. Company produced 90,000 long tons of fixed nitrogen by the Haber process; that is to say, the capacity of this plant is equivalent to approximately one-fifth the total of 3,000,000 tons of sodium nitrate furnished by Chile to the entire world during the same period. This capacity is approximately ten times the anticipated capacity of the United States Nitrate Plant No. 1, at Sheffield, Alabama, or two and one-half times that of Plant No. 2 (cyanamide), at Sheffield.



FIG. 4.—AT OPPAU NITRIC ACID ABSORPTION AND NEUTRALIZATION TOWERS

It is reported that a similar plant, which has a rated capacity of 125,000 tons of fixed nitrogen per year, has been constructed near Halle. If this is true Germany's total capacity of 215,000 tons of combined nitrogen, by the Haber process, is equivalent to one-half of the total world's consumption of Chile nitrate.

It is interesting in this connection to recall the statement, reported by the Army Intelligence to have been made by the German Secretary of the Interior to the Reichstag, to the effect that nitrogenous products manufactured in Germany in the year 1916 contained 400,000 tons of combined nitrogen, an amount which is equivalent to 2,500,000 tons of sodium nitrate, which is practically equivalent to the total tonnage annually mined in Chile for the markets of the entire world. Germany is now in position to export nitrogenous products in amounts approximating her normal consumption of three quarters of a million tons annually.

The liquid ammonia has been shipped to Höchst,

near Frankfort, where it is oxidized by platinum catalyst converters.

PRODUCTS OF OPPAU PLANT

	Tons per Yr.	Tons Combined N per Yr.
Ammonium Nitrate.....	10,000	3,450
Sodium Nitrate.....	130,000	21,410
100 per cent Nitric Acid.....	40,000	8,890
Liquid Ammonia.....	40,000	32,950
TOTAL.....		66,700

COST—The cost of the Oppau plant has been variously stated from \$25,000,000 to \$50,000,000. It is understood that a capital increase of 90,000,000 marks was authorized for the erection of this plant. To what extent the government assisted the company is not known. The writer would estimate the cost of such a plant if constructed in the United States under normal conditions at not less than \$65,000,000.

ESTIMATED COST OF PRODUCTION—Regarding fuel the general manager supplied the following figures:

	Tons per Day
Lignite for producer gas engines.....	400
Lignite for steam to CO catalyst.....	1000
Lignite for steam power plant.....	350
TOTAL.....	1750
Coke for water gas producers.....	500

From the same source the following figures were obtained. (Assumptions are indicated by italics):

OPERATING FORCE		
1500 laborers at \$1.40.....	\$2,100	
3000 mechanics at \$2.25.....	6,750	
350 office force at \$3.25.....	1,137	
300 chemists at \$3.50.....	1,050	\$11,037
FUEL		
1750 tons lignite at \$4.00.....	\$7,000	
500 tons coke at \$8.00.....	4,000	\$11,000
INTEREST		
\$50,000,000 at 6 per cent.....	\$ 8,000	
Maintenance and removals at 10 per cent.....	14,000	
Overhead, taxes, pensions, etc., say.....	10,000	
TOTAL COST PER DAY.....		\$54,037

It was stated by the superintendent that the plant had operated continuously, with the exception of one twenty-four hour shut-down which was caused by one of the numerous air raids, in which a gas tank was punctured by a bomb fragment. During the war it is probable that repairs, adjustments, and renewals were postponed as far as possible and since the date of the armistice considerable of this work has been undertaken. It seems likely that such a plant operating in normal times would be shut down for repairs about 10 per cent of the total time. The total cost per day then becomes \$58,337.

$90,000 \times 2240 \div 365 = 553,000$ lbs. combined nitrogen per day.

The cost per pound of combined nitrogen is then $58,337 \div 553,000 = 10.55$ cents per pound, equivalent to NaNO_3 at 1.74 cents per pound.

If all the ammonia were converted to 100 per cent nitric acid at Oppau, it would be necessary to increase the size of the oxidation, absorption, and concentra-

tion plants threefold. The cost per pound of combined nitrogen in 100 per cent nitric acid may then become 12 cents, instead of 10.55 cents, which is equivalent to 2.68 cents per pound for 100 per cent nitric acid.

The above calculation is based upon figures which are, of necessity, very crude assumptions; however, it appears entirely probable that *this plant will be able to produce concentrated nitric acid at a cost not in excess of three cents per pound.*

In normal times, before the war, the cost of nitric acid, manufactured from imported Chilean nitrate, was five or six cents per pound in this country. The increase in labor, material, and freight rates will no doubt set a higher price on imported nitrates in the future. It seems improbable that the old prices of nitrogenous products from Chilean nitrates will be reduced even assuming that Chile will reduce or withdraw her export nitrate duties.



FIG. 5—ACID TOWERS AT HÖCHST WHERE AMMONIA IS CONVERTED TO CONCENTRATED NITRIC ACID

Germany can produce nitrates at one-half the cost of nitrates in this country which are manufactured from the imported Chilean product. Consider the consequences. The German farmer will be supplied with fertilizers, manufactured from synthetic nitrates, at one-half the cost to the American farmer. The advantage to Germany will be stupendous. If Germany succeeds in monopolizing this industry she can export nitrates at a price which would enable her to supply her farmers with fertilizers at practically no cost or she could undercut the price of nitrogenous products to such a point that it would be no longer profitable for Chile to operate her nitrate mines. If these mines are ever abandoned it would take years to reestablish the normal production. If this should happen and our Government were so short-sighted as to permit a German monopoly of the nitrate industry, Germany would also indirectly control the world's production of explosives and propellants. Our huge fleet and standing army would, of course, be utterly helpless without nitrates necessary for munitions of war.

Synthetic nitrate plants should be constructed and their success will grant assurance of our safety in times

of war, and in times of peace will provide the American farmer with fertilizer at almost one-half its present cost.

The program will require a high quality of scientific and engineering skill applied to a difficult series of problems over a period of years. There is no question about the ability of our American engineers to master the problems, the question is one of financial support and sane direction. The perfection of complicated mechanical devices and technical details is a slow evolution and requires patience and money as well as skill and ability. The very nature of the subject should place the program under strict government control.

In consideration of this subject attention is invited to the controversy arising over the proposed nitrogen monopoly, which was fathered by the German cyanamide industry and the Deutsche Bank, and presented to the Reichstag in March 1915. The German government appeared desirous of maintaining the new cyanamide industry in a healthy condition. These monopoly plans were to have authorized a commercial monopoly on mineral as well as artificial, inorganic, nitrogenous compounds, to be valid until March 31, 1922, and to be extended beyond that date by special law granting such authorization.

Confident of its ability, through the perfection of the Haber process, to supply nitrogenous compounds at prices far below those of the cyanamide industry, the B. A. S. F. people exerted their influence in objection to the proposed monopoly. As a matter of fact, the point has been demonstrated by the gradual reduction in market price of the nitrogenous compounds, made possible by the Haber plant productions, and the German government is probably convinced that the necessity of a nitrogen monopoly is no longer apparent, to the end that the idea appears now to have been abandoned.

OUR FUTURE NITRATE PROGRAM

It is estimated by the writer that a nominal expenditure in the United States Nitrate Plant No. 1, at Sheffield, would accomplish, under competent supervision, the necessary modifications of the General Chemical Company process and apparatus to permit of successful, economical operation, and production. Using this plant as a test or pilot plant, other plants, should be constructed until a capacity in excess of 200,000 tons per year of combined nitrogen has been reached in this country. In peace times the farmers' supply of essential fertilizers would be increased and the price reduced. In event of war our existence may be dependent upon such plants. In any event our security would be vastly increased, the burden of obligation carried by our fleet would be greatly reduced, and its functional, effective value doubled.

Further emphasis upon the great importance of our future nitrate program seems unnecessary.

ORIGINAL PAPERS

A RAPID METHOD FOR DETERMINING URANIUM IN CARNOTITE

By CLARENCE E. SCHOLL

Received March 31, 1919

Uranium in carnotite can be determined volumetrically or gravimetrically with accuracy if the impurities in the carnotite are removed previously. The impurities occurring commonly in carnotite and producing errors in analyses are iron, aluminum, and vanadium.

In the volumetric methods¹ the uranium is usually separated as the phosphate after precipitating the iron and aluminum with sodium carbonate. The main difficulties are the slow precipitation and slow filtration of the phosphate. These difficulties are greatly increased in some methods by the addition of hydrogen peroxide to test for vanadium or for oxidizing the iron. Hydrogen peroxide when added to a nitric acid solution of a uranium salt changes the uranium to an unknown non-ionic condition, in which state it reacts extremely slowly. Several hours boiling with nitric acid is necessary to change all the uranium back to the ionic condition.

In the gravimetric methods² the iron is removed by precipitation with sodium carbonate, the aluminum removed with ammonium carbonate, while the vanadium is precipitated as lead vanadate in an acetic acid solution, the excess lead being removed with sulfuric acid and evaporation, an exceedingly long method. Hillebrand attempts a short method by using ammonia in an ammonium carbonate solution. But here all the vanadium is not precipitated, causing real trouble.

The following method is adopted for eliminating these difficulties as far as possible without making an unreasonably long process:

To a sample of the material containing about 0.2 g. uranium oxide, add 25 to 50 cc. 1:1 nitric acid and heat until all the uranium is in solution. Keep warm over night if necessary. Dilute with warm water to about 250 cc. and filter. Add ferric chloride equivalent to about three times the weight of the vanadium present. Add slowly to the cold or slightly warm solution solid sodium carbonate until all the acid is neutralized, and then about 1 g. in excess, keeping the beaker covered with a watchglass. Place on a hot plate and heat to about 90° C., but do not boil. Keep it warm for at least 15 min. Filter. The precipitate contains all the iron and vanadium and most of the aluminum. Neutralize the filtrate slowly with nitric acid until uranium begins to precipitate, and boil to eliminate most of the carbon dioxide. Add sodium hydroxide in excess and boil 15 min. Filter. The filtrate contains the remainder of the aluminum and any vanadium not previously precipitated. Dissolve the precipitate in dilute nitric acid and heat to about 90° C. Add an excess of ammonia and boil. Filter, ignite, and weigh as uranium oxide (U_3O_8). In case of doubt as to the purity, treat the precipitate with dilute warm nitric acid. Filter, ignite, and weigh the insoluble matter. Subtract this from the previous weight and report the result as U_3O_8 . Some iron is usually found in the precipitate because the chemicals, especially nitric acid, usually carry iron as an impurity.

This method has been used in checking official analyses with the following results:

SAMPLE NO.	Official Result Per cent U_3O_8	Result Obtained Per cent U_3O_8
7	1.87	1.86
9	2.19	2.17
12	1.79	1.80
6	7.75	7.79
5	3.94	3.96
2	2.72	2.67

SUMMARY

A rapid and accurate method of determining uranium is given.

The elements producing difficulties are eliminated by adding ferric iron, followed by precipitations with sodium carbonate without boiling, and sodium hydroxide with boiling.

Hydrogen peroxide is not used, as it prevents the precipitation of uranium.

The method can be recommended for use in technical laboratories.

DENVER, COLORADO

PRODUCTION OF GLYCERIN FROM SUGAR BY FERMENTATION

By JOHN R. EOFF, W. V. LINDER AND G. F. BEYER

Received March 2, 1919

This problem was assigned to the Division of Chemistry of the Bureau of Internal Revenue by the Honorable Secretary of the Treasury under date of May 9, 1917. The following is an account of what has been done.

SELECTION OF YEAST

Requests for pure cultures of yeasts were sent to institutions throughout the country and a number of different species and varieties of yeast were obtained. All of these yeasts were tested for their powers of glycerin production, and finally two were chosen as being the best producers of glycerin. They were:

1—*S. Ellipsoideus* (var. Steinberg) obtained from the American Museum of Natural History, New York City, this being their Yeast 657.

2—*S. Ellipsoideus* (var. California Wine Yeast) obtained from the University of California, Berkeley, California, this being their Yeast 45.

Of these two yeasts the Steinberg variety was finally selected as the better glycerin former, and in most of the subsequent work this yeast was used.

THE METHOD OF FERMENTATION

A great number of experiments were made that in themselves were not productive of the desired results, but which were steps that led to a satisfactory conclusion. It is scarcely necessary to detail these preliminary experiments here.

It was found:

1—That more glycerin is formed by fermenting sugars in alkaline solutions than in either neutral or acid solutions.

2—That the yield of glycerin is increased by increasing the alkalinity of the fermenting solutions.

3—That the alkalinity of the solutions may be produced by the addition to the fermenting solutions of a

¹ Western Chem. Met., Nov. 1908; Am. J. Sci., 16 (1903), 229; J. Am. Chem. Soc., 33 (1901), 710.

² U. S. Bur. of Mines Bull., 70 (1916); U. S. Geol. Survey Bull., 262 (1905).

number of alkaline reacting substances, among which are sodium carbonate, potassium carbonate, sodium hydroxide, potassium hydroxide, and sodium perborate (borax).

4—That sodium and potassium carbonates are the most favorable alkaline materials to use and that sodium carbonate is preferable on account of the price of this material. Most of the experiments were conducted with the use of sodium carbonate in the form of soda ash as the alkaline material.

5—That in using sodium carbonate not much more or less than 5 per cent of this material can be added to the fermenting solution if the best results are to be obtained—a greater amount stops the fermentation permanently and a smaller amount does not produce the alkalinity necessary for the maximum production of glycerin.

6—That all of the sodium carbonate must not be added to the fermenting solution at one time, since if so added the fermentation is stopped permanently.

7—That the addition of the sodium carbonate to the fermenting solution should be made in portions that vary with the nature of the sugar mash. No fast rule can be given for the method of addition of sodium carbonate, but it should be added to the solution as soon as the fermentation is well started and in as large portions and as frequently as the yeast will stand, since the earlier the addition of the entire amount of sodium carbonate is made the greater the yield of glycerin will be.

8—That to produce the best results the yeast should be "worked up" by successive sowings of between 5 and 10 per cent until a starter (or yeast mash) representing 10 per cent of the final volume of the final mash is produced. The various sowings during the "working-up" process should be made when the yeast is *most active*. The yeast should be "trained" by adding to it at each stage of the "working-up" process from $\frac{1}{2}$ to 1 per cent of the weight of the solution of sodium carbonate.

9—That the fermentation should be vigorous throughout. A small amount of ammonium chloride in the fermenting solution appears to aid in the production of glycerin.

10—That the most favorable temperatures for the fermentation lie between 30° and 32° C. and should not for any length of time vary from these limits—a loss of glycerin and alcohol and the formation of objectionable materials accompany higher temperatures and less vigorous fermentations with leaner yields of glycerin follow the lower temperatures.

11—That the most favorable concentrations of sugar solutions lie between 17.5 and 20 g. of sugar per 100 cc.

12—That upon the completion of fermentations according to this method from 20 to 25 per cent of the sugar originally in the mash had been converted into glycerin and practically all of the remaining sugar had been converted into alcohol and carbon dioxide. Other products are undoubtedly formed, as is evinced by the odor, but no time has been available in which to determine either their character or their quantities. (We here ask that the right be reserved for us to investigate the nature and the amounts of these products.)

13—That when the sodium carbonate has been added

in sufficient quantity to a fermenting solution a copious precipitate is formed, the evolution of gas ceases and the yeast apparently lies dormant for a while. The precipitate eventually disappears and the fermentation again proceeds. It is essential that this precipitate form and that the mash lie quiescent for a while. The addition of the sodium carbonate in solid form has been found to produce better results than if added in water solution.

THE FERMENTATION OF A MOLASSES SOLUTION AND THE RESULTS OBTAINED THEREFROM

After having worked with various sugar solutions of volumes ranging from 400 cc. to 20 gal. and having obtained favorable results from (1) solutions of molasses, (2) mixtures of corn sugar and malt sprouts solutions, and (3) solutions of cane sugar and metallic salts, the investigation was carried into a commercial glycerin plant so that it could be worked out on larger scales with factory conditions.

Inedible "black strap" Porto Rican molasses offering the cheapest source of sugar, the first experiments were carried on with it. Tests on a scale of from 400 to 500 gal. were conducted and with very gratifying results as to the formation of glycerin, and very encouraging results were obtained in attempts to remove the glycerin from the fermented solutions. It has been demonstrated that glycerin can be distilled from the molasses solutions, but to date it has not been possible to make a crude glycerin from the molasses mashes, that is, of such a consistency and glycerin content that more than half of the glycerin present can be recovered.

Following are the descriptions of typical molasses fermentations as carried on in the glycerin plant, with a statement of the yield of glycerin from one fermentation.

YEAST STARTER OR YEAST MASH—Yeast 657 (mentioned above) was sowed with needle into 150 cc. sterile grape juice and allowed to ferment to maximum fermentation. At maximum fermentation 15 cc. of this was sowed into 150 cc. of sterile grape juice and when maximum fermentation was observed 75 cc. of this latter was sowed, when fermenting at maximum, into 800 cc. of sterilized "black strap" molasses solution of 21.2° Balling. When the 800 cc. of "black strap" molasses solution was fermenting briskly, 3 g. of soda ash were added and the bottle shaken until solution was complete. After resumption of fermentation to maximum these 800 cc. were added to 2 gal. of similar "black strap" molasses solution and treated at the proper time with soda ash in the same proportion. The 2 gal. were then sowed into 40 gal. of a solution as follows:

"Black strap" molasses was dissolved in sufficient water to make 425 gal. of Balling 21.2° at 25° C., 8 lbs. of ammonium chloride were added, and after sterilizing the mixture was brought back with water to a Balling of 21.2° at 25° C. This solution contained 16.85 per cent sugar.

FERMENTATION OF MAJOR MASH—The 40 gal. of this solution mentioned above were sowed November 17, 1917, at 9 A.M., and 2 lbs. of soda ash were added and

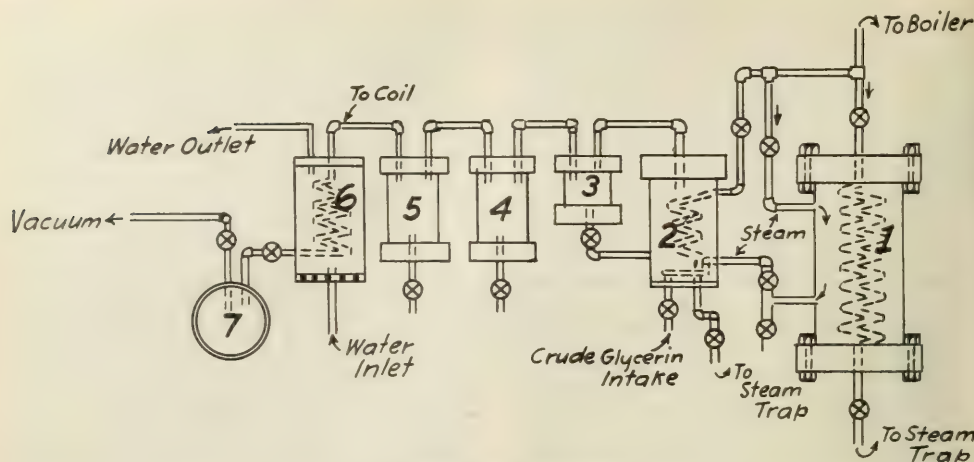


FIG. 1—EXPERIMENTAL GLYCERIN STILL

1—Called steam expander and reheater. Steam under 175 lbs. pressure entering coil in (1) of necessity expands as it there enters vacuum. Expansion causes cooling and condensation, therefore the jacket of (1), which is seen in picture, is kept under 175 lbs. steam pressure, thereby reheating the steam before it enters.
 2—Still. This has a closed circular coil, or spiral, extending nearly to the bottom of the still through which steam from the boiler circulates. There is a cross jet at the bottom of the still through which the reheated steam enters the still, this steam acting as a carrier for the glycerin.
 3—The runback. This small catchall is to take care of any material that is mechanically carried over from the still that is not wanted in the finished glycerin. What is collected there can be run back into the still by pipe that can be seen in picture.
 4—First catchall for glycerin. The best glycerin collects in this receiver. It is nothing but a cylindrical vessel with a sampler screwed in the bottom.
 5—Second catchall. Same as (4).
 6—Condenser for vapors passing from the rest of the system.
 7—Sweet water tank. This catches the condensation from (6), and will contain anywhere from a few tenths of a per cent of glycerin to 2 per cent. The sweet waters go through the system again after evaporation and mixing with crude.

dissolved at 3 P.M. of the same day. At 9:15 of the same day this 40-gal. yeast mash was sowed into 385 gal. of the molasses solution described above and the following treatment given:

Date	Time	Soda Ash Added and Dissolved Lbs.	Temperature Deg. C.
Nov. 18, 1917	12:30 A.M.	24	30
Nov. 18, 1917	3:30 A.M.	36	31.5
Nov. 18, 1917	5:30 A.M.	48	33 (Lowered to 30)
Nov. 18, 1917	11:00 A.M.	48	32.5 (Lowered to 30)
Nov. 18, 1917	5:30 P.M.	36	32 (Lowered to 30)

The fermentation from this point was allowed to continue to dryness, which took 5 days, and the temperature was held close to 30° C.

After the fermentation was complete, the mash was analyzed and the following results were obtained:

Glycerol.....	3.1 per cent
Alcohol.....	6.75 per cent by vol.
Sugar (apparent).....	0.86 per cent after acid inversion
Alkalinity solution.....	3.6 g. Na ₂ CO ₃ per 100 cc.

PURIFICATION OF MOLASSES MASH PREPARATORY TO DISTILLATION—3200 lbs. of the above fermented mash were placed in an iron tank and neutralized with sulfuric acid. 12 gal. of a saturated solution of copperas (ferrous sulfate, crude) were added and the solution brought to near boiling point, after which lime was added in the form of milk of lime until there was shown an excess of lime in the solution after a half hour's boiling with steam coil. It was then filter-pressed and the filter cake steamed. The solution was returned to the tank and the copperas and lime treatment repeated. Again it was filter-pressed and steamed. The solution was returned again to the tank and soda ash added until the alkalinity of the solution was 0.2 per cent after boiling, when it was filter-pressed and

steamed. The solution was then evaporated to thick sirup in a vacuum evaporator and the crude thus obtained, containing between 30 and 35 per cent glycerin, was distilled in a small still modeled after the Jobbin's still (Fig. 1). About 50 lbs. of dynamite glycerin were obtained from this distillation, which represented roughly about 50 per cent of the glycerin originally in the amount of mash taken. It was impossible with this distillation to recover the glycerin from the sweet waters as the small still had to be connected with the large still condenser, the sweet waters being lost. Working on this quantity of material with small filter presses, etc., a considerable loss of material was unavoidable during the clarification, etc. But little difficulty was experienced in distilling even as poor a crude as this, and it will be possible to produce any amount of glycerin from this process if it becomes necessary, so long as the molasses supply holds out.

The analysis of the distilled dynamite glycerin showed the following:

Specific gravity at 15.6° C.....	1.2616
Carbonaceous residue, per cent.....	0.058
Ash, per cent.....	0.009

The carbonaceous residue is high, but a redistillation of the glycerin would correct this difficulty and give a satisfactory glycerin. The color was good. A sample of this glycerin was submitted to E. I. du Pont de Nemours & Company for nitration test. Their report, made by Dr. A. M. Comey, was that the glycerin nitrated normally.

Many attempts to produce a perfect crude from molasses mashes have failed. Later tests have shown

that the second treatment with copperas and lime is superfluous.

After the fermentation and distillation of the above-described mash, it was deemed advisable to ferment several molasses mashes of larger volume. There were successfully fermented four mashes of 2000 gal. each. From a portion of one of these mashes we recovered 100 lbs. of dynamite glycerin which is now on exhibition in the laboratory.

Following is a description of the major fermentation of a typical 2000 gal. molasses mash; there is also included the analysis of the resulting material.

On April 12, 1919, a molasses mash was made containing 4856 lbs. "black strap" sterilized, and 11 lbs. of ammonia chloride added. The final volume was 2142 gal., Balling 21.7°, at 25° C. At 12 p. m. this was sowed with 200 gal. yeast mash, Yeast 657, at 32° C. Then the following treatment was carried out:

Date	Time	Soda Ash Added Lbs.	Temperature Deg. C.
April 13, 1918	2: 15 A.M.	124	30
April 13, 1918	4: 30 A.M.	186	32
April 13, 1918	6: 30 A.M.	248	32
April 13, 1918	10: 30 A.M.	248	35 (Lowered to 31.5)
April 13, 1918	5: 00 P.M.	186	33.5 (Lowered to 30.0)

The mash before fermentation contained 16.5 g. per 100 cc. of sugar.

It must be borne in mind that there is considerable alcohol produced in these fermentations. At the present price of alcohol and raw materials it is safe to say that the value of the alcohol balances the cost of all materials and overhead charges entering into the production of the fermented mash. This being true, then the slop from the alcohol distillation which contains the glycerin is obtained free of cost, so the only cost to be considered for the glycerin would be that of purification and distillation. This should not be great. No attempt has been made as yet to recover the alcohol, it being deemed a matter offering no difficulty. Laboratory tests show that foaming is the only trouble that will be encountered and this can be overcome by reducing the alkalinity with sulfuric acid of about 0.3 per cent.

FERMENTATION OF CORN AND CANE SUGAR SOLUTIONS

It was deemed expedient to pursue some experiments on a larger scale than 20 gal. with corn and cane sugar solutions. These sugars contained little or no impurities and it was believed that no great difficulty would be encountered with the glycerin recovered from such solutions if the fermentations could be carried out properly with yeast nutrients which could be removed easily.

Experiments showed, however, that in order to carry on the fermentation in such a manner that the glycerin would be produced one would have had to add to solutions of corn and cane sugars yeast foods in kind and amounts that would have deleteriously influenced the purification of the glycerin; therefore it was concluded that corn or cane sugar possessed no superiority over molasses for the fermentation for glycerin.

ACKNOWLEDGMENT

We wish to express appreciation of the interest shown by our immediate chief, Mr. A. B. Adams, towards this experiment from its instigation to its

close. At the same time we wish to say that the successful issue of our process is in great measure due to Mr. J. M. Doran, chemist in our laboratory, owing to his diligent search of the literature.

LABORATORY OF THE INTERNAL REVENUE BUREAU
WASHINGTON, D. C.

THE DETERIORATION OF MANUFACTURED CANE SUGAR BY MOLDS¹

By NICHOLAS KOPELOFF and LILLIAN KOPELOFF

Received February 3, 1919

The deterioration of food products has assumed an added significance during the war which it seems likely to maintain. This applies to sugar for the familiar reasons as well as the complicating problems of equalization, distribution, and reserve. When it is remembered that the bulk of sugar is sold on the basis of its polarization test, a small fraction of one per cent would represent an economic depreciation of considerable importance. According to the interesting discussion by Browne,² "allowing an average loss of 0.1 per cent sucrose during transit of the Cuban sugar importation would be a deficiency of \$320,342 at Cuban prices, which would make the total calculated loss from deterioration for the 1916 Cuban sugar nearly \$1,500,000."

HISTORICAL

Since the original observations of Payen³ and Dubrunfaut⁴ this problem has been considered by numerous investigators to be of a microbiological nature. Their contributions have been comprehensively reviewed by Owen⁵ and others, so that it is unnecessary at this point to do more than note that the emphasis in such investigations has been, to a great degree, on the bacterial flora involved. More recently, however, there has been an increasing tendency to regard the fungi (or molds as they are more commonly termed) as playing an important rôle in the inversion of sucrose which occurs in manufactured cane sugar.

Payen,⁶ as far back as 1851, noted irregular ridges and cavities on sugar crystals in which he found filaments and spores of two different molds.

Shorey⁷ isolated *Penicillium glaucum* from Hawaiian sugars, which he regarded as responsible for the deterioration of the latter.

Kamerling⁸ found in dried sugar a mold flora chiefly related to *Penicillium*. Over 20 varieties were observed, and not less than 19 belonged to this group. The author claims that during the course of deterioration of raw sugar, the first attack is made by the molds.

¹ This material was presented in part before the Societies of Bacteriologists and Phytopathologists, Baltimore, Md., 1918.

² "The Deterioration of Raw Cane Sugar," THIS JOURNAL, 10 (1918), 178-190.

³ "Note sur une Vegetation Microscopique que attaque le Sucre Solide," *Compt. rend.*, 33 (1851), 393.

⁴ *Ibid.*, 68 (1869), 663.

⁵ *Louisiana Bulletin*, 162 (1918).

⁶ The authors are indebted to Dr. C. A. Browne for this abstract of "Note sur une Vegetation Microscopique que attaque le Sucre Solide," *Compt. rend.*, 33 (1851), 393.

⁷ *J. Soc. Chem. Ind.*, 17 (1898), 555-558.

⁸ *Profstat. v. Suiker*, West Java, Kasog, Verslag, 1899, 97-104.

TABLE I—PER CENT OF SAMPLES SHOWING MOLD

SUGAR TYPE	Total No. of Samples	<i>Aspergillus niger</i>	<i>Cladosporium</i>	<i>Penicillium luteum</i>	<i>Citromyces I</i>	<i>Penicillium abort.</i>	<i>Unknown sterile II</i>	<i>Unknown sterile IV</i>	<i>Syncephalastrum</i>	<i>Sterile orange</i>	<i>Citromyces III</i>	<i>Unknown sterile III</i>	<i>Blue Aspergillus</i>	<i>Penicillium</i>	<i>Aspergillus flavus</i>
Plantation Granulated.....	18	170	106	17	17	58	39	28	67	72	17	71	88	22	28
Plantation Granulated, undried.....	3	100	100	33	0	0	67	33	0	67	0	33	100	0	67
Yellow Clarified.....	16	89	95	0	0	13	0	0	56	13	6	19	100	37	68
Standard Granulated.....	5	40	20	0	0	0	0	0	40	20	0	0	80	0	0
Cuban Raw.....	11	82	78	0	0	0	9	0	82	18	0	73	0	36	0
96 ^a Washed.....	5	100	80	20	20	0	80	40	40	0	40	100	60	80	25
2nd.....	8	100	92	8	0	13	42	33	8	50	8	33	92	50	25
AVERAGE, RELATIVE.....		98	100	25	25	0	62	25	12	50	62	50	100	8	75
				14	9	5	38	23	29	54	16	28	100	24	50

Greig-Smith¹ isolated *Aspergillus glaucus* from small-grained, moist, refined sugar, but did not consider its presence to be of as much significance as the potato group of bacilli.

Schöne² emphasized the importance of molds and torulae in inversion and noted the presence of *Penicillia*, especially *P. glaucum*, and *Mucor* in deteriorating sugar. He investigated the acidity produced by pure cultures of these organisms inoculated into sterilized sugar solution. In another connection he notes the isolation of *Penicillium* and *Rhizopus*.

Scott³ studied the development and inverting power of *Aspergilli* and *Penicillia* and cautions against permitting sugar to become infected with these organisms.

Amons⁴ has detected mycelial threads of mold in sugar as did Scott, and isolated *Aspergillus* and a *Rhizopus* as well as *Penicillium glaucum* and *purpurogenum*. By means of inoculation experiments he proved that *Penicillium glaucum* is capable of producing an appreciable deterioration. He believes with Browne and Noel Deerr that no single organism can be made universally responsible. Our evidence tends to corroborate this view.

Browne⁵ has recently isolated two *Monilia* from Cuban raw sugar which are capable of inverting sucrose in sugar solutions of high concentration. He also mentions the presence of other molds, *Penicillia*, etc., and notes their possible importance.

Owen⁶ has isolated a number of *Aspergilli* from a large number of Louisiana sugars and has studied their activity in pure culture on sugar solutions of high concentration. He regards the molds as the most dangerous group of microorganisms in sugar, because of their strong inverting power, their ability to exercise this power in highly concentrated solutions of sucrose of varying reaction, and also on account of their ability to develop on media which is very deficient in nutrients.

Blake⁶ has recently made a contribution to the deterioration of raw sugar, as has Prinsen Geerligs.⁷ They are especially interesting in that they represent observations made from the factory rather than from the laboratory standpoint.

OCCURRENCE OF MOLDS

It is evident from this brief review of the previous investigations that there is an informing body of data which makes it imperative to subject the molds to closer scrutiny with regard to their ability to deteriorate manufactured cane sugar. With this end in view, a comprehensive survey of the mold flora of cane sugars was undertaken. The samples under investigation included a variety of types of sugar from different sources and represented a considerable range in composition, age, and keeping quality. These representative sugars were plated in triplicate on eight different media (using a 17° Brix sugar solution as dilution water to prevent plasmolysis). Czapek's agar maintained the highest relative efficiency with regard to the largest variety of molds isolated, while a modification introduced by the authors was responsible for a more rapid colony development and therefore proved highly satisfactory. The composition of this medium (modified) is as follows:

Tap Water.....	1000 cc.
Sucrose.....	50 g.
Peptone.....	5.0 g.
NH ₄ NO ₃	1.0 g.
K ₂ HPO ₄	1.0 g.
KCl.....	0.5 g.
MgSO ₄	0.25 g.
FeSO ₄	0.01 g.
Agar.....	20.0 g.
Reaction.....	+ 1
Sterilization at 15 lbs. for 15 min.	

Table I shows the per cent of each type of sugar indicating the presence of the more important molds.¹ This represents a summary of more detailed data which will appear shortly in bulletin form.² Thus where *Aspergillus niger* was isolated from all 18 samples of Plantation Granulated sugar, its rating for that sugar type is 100. The relative average indicates quite clearly then that *Aspergillus niger* and *Blue Aspergillus*³ appear in practically every sample of sugar examined. *Cladosporium* appears in 90 per cent of the cases. *Aspergillus flavus* and the *Sterile orange* mold were isolated in about one-half of the total number of samples, while the other organisms noted appeared in the following order: *Unknown sterile II*, *Syncephalastrum*, *Unknown sterile III*, *Penicillium sp.*, *Unknown sterile IV*, *Citromyces III*, *P. luteum*, *Citro-*

¹ The authors are indebted to Dr. Charles Thom and Miss M. Church of the Bureau of Chemistry, U. S. Department of Agriculture, for the identification of cultures.

² Nicholas Kopeloff and Lillian Kopeloff, "The Deterioration of Cane Sugar by Fungi," *Louisiana Bulletin*, 196, 1919.

³ *Blue Aspergillus* now identified as *Aspergillus Sydowi* Bainier.

¹ Intern. Sugar J., 4 (1902), 430.

² Dent, *Zuckerind.*, 31 (1906), 1338; 33 (1908), 638; 36 (1911), 247.

³ Intern. Sugar J., 14 (1912), 582.

⁴ Med. v. h. Proefjes, v. d. Java Suikerind. Chem. Ser., 1917, No. 5.

⁵ Loc. cit.

⁶ Louisiana Planter, 61 (1918), 316-317.

⁷ Intern. Sugar J., 20 (1918), 543-546.

myces I, and *P. divaricatum*. Those which appeared in only rare instances are not tabulated. While no definite flora could be assigned to any particular type of sugar, the lower grades of sugar appeared to have the greatest infection with regard to both number and variety.

It is of importance to establish whether the molds in sugar are present in the spore stage chiefly, or whether mycelium could be detected. In several instances mycelium was found but the evidence was doubtful or negative in character in the majority of samples. Some striking preparations of mycelium stained with Conn's rose bengal¹ were obtained by Dr. Thom from lumpy samples of Cuban raw sugar and from sugars inoculated with pure cultures of molds which were employed in our later experiments. Thus it was proven conclusively that molds can grow in such a highly concentrated substratum containing a minimum of available nutrients.

DETERIORATION OF SUGAR BY PURE CULTURES OF MOLDS

Pure cultures of the molds mentioned above were inoculated into sterilized sugar and 10-g. portions of the latter used as an inoculum for 150-g. portions of sterilized sugar of the three principal types, namely: Plantation granulated, refined, and Cuban raw. The Erlenmeyer flasks containing the inoculated sugars were plugged with cotton and incubated at 27° to 30° C. for 4 mo. Under such conditions the sugars dried to such an extent as to make the moisture content negligible. At the end of the incubation period the sugars were analyzed and the results recorded as in Table II.²

TABLE II—ANALYSES OF SUGARS INOCULATED WITH FUNGI. PLANTATION GRANULATED

No.	Fungus	Presence after 4 mo. ¹	Single Polar.	Clerget	Reducing Sugar	Moisture
7	Check.....	—	99.2	99.26	0.16	0
10	Check.....	—	99.0	98.88	0.16	0
14	Check.....	—	98.9	98.73	0.15	0.07
AVERAGE.....		—	99.0	98.96	0.16	0.02
12	<i>Aspergillus flavus</i>	+	99.1	99.06	0.16	0.02
13	<i>Aspergillus flavus</i>	—	98.9	98.88	0.16	0
AVERAGE.....		—	99.0	98.97	0.16	0.01
16	<i>Blue Aspergillus</i>	+	98.9	98.27	0.17	0.11
17	<i>Blue Aspergillus</i>	+	98.6	98.50	0.16	0.02
18	<i>Blue Aspergillus</i>	—	99.2	99.12	0.15	0.07
20	<i>Blue Aspergillus</i>	—	99.1	99.22	0.16	0.12
AVERAGE.....		±	98.9	98.78	0.16	0.08
15	<i>Syncephalastrum</i>	—	99.0	98.88	0.13	0.08
21	<i>Syncephalastrum</i>	+	98.9	98.66	0.14	0.05
23	<i>Syncephalastrum</i>	—	98.5	98.94	0.15	0.08
25	<i>Syncephalastrum</i>	—	98.9	98.59	0.15	0.05
AVERAGE.....		±	98.9	98.77	0.14	0.07
4	<i>Aspergillus niger</i>	—	99.0	99.06	0.18	0
8	<i>Aspergillus niger</i>	—	99.4	99.25	0.15	0
28	<i>Aspergillus niger</i>	+	98.9	98.59	0.13	0.10
29	<i>Aspergillus niger</i>	+	98.8	98.43	0.15	0.04
AVERAGE.....		±	99.0	98.83	0.15	0.03

¹ Average of triplicate plates with two dilutions.

In discussing these data, it is well to bear in mind the general consensus of opinion both in the laboratory and the field, to the effect that the "factor of safety" is a fairly reliable criterion for the keeping quality of a sugar. In other words, it is generally conceded that the value of $\frac{\text{Moisture}}{100 - \text{Polarization}}$ should be

0.33 to guarantee the non-deterioration of raw sugars,

¹ N. Y. (Genesee) Tech. Bull. 64 (1918).

² The authors are indebted to Mr. E. C. Freeland, assistant chemist, for his assistance with the chemical analyses.

while the fraction is substantially lower than this for white sugars. A glance at the column marked "Moisture" in Table II indicates the presence of a very low moisture content, and the factor of safety or "moisture ratio" in this series would be considerably lower than 0.1. Therefore marked deterioration would not be anticipated. That such is actually the case may be seen in the polarization, Clerget, and reducing sugar values set forth. Practically all these determinations are within the limit of experimental error. Slight indications of loss of sucrose are perhaps to be noted in the case of the *Blue Aspergillus* (Flasks 16 and 17) and *Aspergillus niger* (Flasks 28 and 29). The same general negative evidence is to be gathered from Table III. However, in the Cuban raw series shown

TABLE III—ANALYSES OF SUGARS INOCULATED WITH FUNGI. REFINED

No.	Fungus	Presence after 4 mo.	Single Polar.	Clerget	Reducing Sugar	Moisture
2	Check.....	—	99.4	99.72	0.09	0.04
3	Check.....	—	99.7	99.84	0.05	0.02
5	Check.....	—	99.4	99.38	0.05	0.02
6	Check.....	—	99.4	99.49	0.04	0.03
AVERAGE.....		—	99.5	99.61	0.06	0.03
7	<i>Aspergillus flavus</i>	+	99.3	99.33	0.05	0.03
8	<i>Aspergillus flavus</i>	—	99.3	99.76	0.05	0.04
AVERAGE.....		+	99.4	99.52	0.05	0.02
14	<i>Blue Aspergillus</i>	+	99.5	99.90	0.04	0.03
15	<i>Blue Aspergillus</i>	—	99.5	99.46	0.04	0.05
16	<i>Blue Aspergillus</i>	+	99.3	99.26	0.04	0.04
17	<i>Blue Aspergillus</i>	+	99.3	99.16	0.04	0.04
AVERAGE.....		+	99.4	99.44	0.04	0.04
18	<i>Syncephalastrum</i>	+	99.6	99.61	0.04	0
19	<i>Syncephalastrum</i>	—	99.7	99.80	0.04	0
21	<i>Syncephalastrum</i>	+	99.2	99.04	0.04	0
23	<i>Syncephalastrum</i>	+	99.3	99.30	0.06	0
AVERAGE.....		+	99.4	99.44	0.05	0
26	<i>Aspergillus niger</i>	+	99.7	99.72	0.04	0
27	<i>Aspergillus niger</i>	+	99.7	99.80	0.04	0
28	<i>Aspergillus niger</i>	—	99.7	99.91	0.05	0
29	<i>Aspergillus niger</i>	+	99.6	99.65	0.05	0
AVERAGE.....		+	99.7	99.77	0.05	0

TABLE IV—ANALYSES OF SUGAR INOCULATED WITH FUNGI. CUBAN RAW

No.	Fungus	Presence after 4 mo.	Single Polar.	Clerget	Reducing Sugar	Moisture
1	Check.....	—	95.77	96.27	1.04	0.83
2	Check.....	—	95.79	95.99	1.09	1.06
4	Check.....	—	95.67	95.97	1.04	1.15
5	Check.....	—	95.7	96.05	1.06	1.14
AVERAGE.....		—	95.7	96.07	1.06	1.05
6	<i>Aspergillus flavus</i>	—	95.6	95.93	1.09	1.07
18	<i>Aspergillus flavus</i>	—	95.6	95.78	1.09	1.06
AVERAGE.....		—	95.6	95.86	1.09	1.07
7	<i>Blue Aspergillus</i>	+	95.0	95.51	1.13	0.96
8	<i>Blue Aspergillus</i>	—	95.0	95.51	1.04	1.00
10	<i>Blue Aspergillus</i>	+	95.1	95.54	1.56	1.14
AVERAGE.....		+	95.2	95.74	1.19	0.94
12	<i>Syncephalastrum</i>	+	95.1	95.48	1.23	1.01
13	<i>Syncephalastrum</i>	+	94.8	95.28	1.09	1.06
15	<i>Syncephalastrum</i>	+	95.4	95.86	1.09	1.10
16	<i>Syncephalastrum</i>	+	95.6	96.02	1.09	0.99
AVERAGE.....		+	95.4	95.86	1.09	1.07
26	<i>Aspergillus niger</i>	—	95.0	95.51	1.11	1.05
27	<i>Aspergillus niger</i>	—	95.6	96.01	1.11	1.23
28	<i>Aspergillus niger</i>	—	95.5	95.93	1.11	1.22
29	<i>Aspergillus niger</i>	+	95.6	96.01	1.14	1.29
AVERAGE.....		±	95.4	95.86	1.12	1.20

in Table IV, where the moisture content is appreciable, though well below the factor of safety limit, some evidence of the activity in inverting sucrose may be found in the case of the *Blue Aspergillus*, and to a lesser degree with cultures of *Aspergillus niger*. This experiment, consequently, may be regarded as establishing the lower limit for the deterioration of manufactured cane sugar by the molds employed.

All the sugars were plated out in triplicate on the authors' modification of Czapek's agar and the presence or absence of the inoculated organisms indicated in the third column of the foregoing tables. There is no consistency exhibited and there is furthermore no

indication of any multiplication of the molds involved. A microscopical examination failed to establish the presence of any mycelium in these sugars.

TABLE V—ANALYSES OF SUGAR INOCULATED WITH DIFFERENT FUNGI, PLANTATION GRANULATED

No.	Fungus	Presence after 4 mo.	Single Polarization	Clerget	Reducing Sugar	Moisture	Dry Basis		Moisture Ratio
							P.	C.	
103	Check.....	++	99.6	99.58	0.14	0.09	99.7	99.7	0.22
20	<i>Cladosporium</i>	++	98.7	98.86	0.25	0.19	98.8	99.0	0.15
21	<i>Asp. flavus</i>	++	99.0	98.73	0.15	0.03	99.0	98.8	0.06
22	<i>Blue Aspergillus</i>	++	98.5	98.54	0.44	0.19	98.6	98.7	0.13
23	<i>Penicillium</i> No. 2694	++	98.9	98.82	0.20	0.22	99.1	99.0	0.20
24	<i>Syncephalastrum</i>	++	99.3	99.23	0.14	0.06	99.4	99.3	0.09
24A	<i>Unknown I</i>	++	99.3	99.20	0.17	0.08	99.1	99.3	0.10
25	<i>Trichoderma</i>	++	98.7	98.63	0.31	0.20	98.9	98.8	0.15
26	<i>Citromyces I</i>	++	98.7	98.75	0.14	0.03	98.7	98.8	0.02
27	<i>Asp. nidulans</i>	++	98.8	98.87	0.15	0.09	98.9	98.9	0.07
28	<i>Citromyces II</i>	++	99.2	99.07	0.14	0.07	99.3	99.1	0.10
29	<i>Penicillium pinophilum</i>	—	98.8	98.83	0.28	0.23	99.0	99.0	0.20
30	<i>Citromyces III</i>	—	99.0	99.22	0.15	0.11	99.1	99.3	0.17
31	<i>Penicillium divar.</i>	—	99.5	99.54	0.19	0.09	99.6	99.6	0.06
32	<i>Unknown II</i>	—	98.4	98.29	0.14	0.11	98.5	98.4	0.06
33	<i>Sterile orange</i>	—	99.1	98.76	0.16	0.07	99.2	98.8	0.07
34	<i>Unknown III</i>	—	98.9	98.92	0.23	0.15	98.9	99.1	0.13
36	<i>Asp. niger</i>	—	98.5	99.50	0.15	0.06	99.6	99.6	0.04
37	<i>Unknown IV</i>	—	97.4	97.39	0.31	0.31	97.7	97.7	0.12
38	<i>Unknown V</i>	—	98.9	98.77	0.31	0.30	99.2	99.1	0.27

In Table V are presented the analyses of the sugars inoculated with the various molds which were isolated and which were to be used for inoculation. In this Plantation Granulated series, the moisture ratio was uniformly low and the amount of deterioration, in consequence, relatively slight, as will be seen from the values of sucrose Clerget on the dry basis (which represent the most adequate criterion for comparison).

TABLE VI—ANALYSES OF SUGAR INOCULATED WITH DIFFERENT FUNGI, CUBAN RAW

No.	Fungus	Presence after 4 mo.	Single Polarization	Clerget	Reducing Sugar	Moisture	Dry Basis		Moisture Ratio
							P.	C.	
104	Check.....	++	96.2	96.24	1.00	1.00	0.26	97.2	97.2
20	<i>Cladosporium</i>	++	95.9	95.74	1.09	1.07	0.26	97.0	96.8
21	<i>Asp. flavus</i>	++	96.0	95.93	1.09	1.26	0.31	97.2	97.1
22	<i>Blue Aspergillus</i>	++	92.3	91.07	2.28	2.28	0.30	94.5	93.2
23	<i>Penicillium</i> No. 2694	++	96.2	96.11	0.98	1.04	0.27	97.2	97.1
24	<i>Syncephalastrum</i>	++	95.9	95.81	1.09	1.18	0.29	97.0	96.9
24A	<i>Unknown I</i>	++	96.2	96.11	1.09	1.33	0.35	97.5	97.4
25	<i>Trichoderma</i>	++	96.2	96.11	1.09	1.35	0.35	97.7	97.4
26	<i>Citromyces I</i>	++	95.9	95.75	1.11	1.55	0.34	97.0	96.9
27	<i>Asp. nidulans</i>	++	96.2	96.13	1.09	1.26	0.33	97.4	97.3
28	<i>Citromyces II</i>	++	96.1	96.05	1.14	1.23	0.32	97.3	97.2
29	<i>Penicillium pinophilum</i>	—	96.2	96.13	1.09	1.26	0.33	97.4	97.3
30	<i>Citromyces III</i>	—	96.0	95.89	1.09	1.16	0.29	97.1	97.0
31	<i>Penicillium divar.</i>	—	95.9	95.75	1.09	1.00	0.24	96.9	96.7
32	<i>Unknown II</i>	—	96.0	95.75	1.09	1.30	0.32	97.2	97.0
33	<i>Sterile orange</i>	—	95.9	95.75	1.09	1.43	0.35	97.3	97.1
34	<i>Unknown III</i>	—	94.9	95.06	1.11	1.44	0.28	96.3	96.4
36	<i>Asp. niger</i>	—	96.1	96.05	1.09	1.33	0.34	97.4	97.3
37	<i>Unknown IV</i>	—	96.0	96.01	1.11	1.29	0.32	97.3	97.3
38	<i>Unknown V</i>	—	95.6	95.74	1.56	1.68	0.38	97.2	97.4

Some of the *Unknown sterile* molds, especially II, and the *Blue Aspergillus* caused an appreciable inversion. In the same way in the Cuban Raw series shown in Table VI, where the moisture ratio was considerably higher than in the preceding series, the greatest inversion, indicated by the lowest Clerget values, as well as the greatest amount of reducing sugars, was obtained with the *Blue Aspergillus*. Similarly, a number of other organisms were more active than in the previous set, accentuating again the im-

portance of moisture as a limiting factor in the deterioration of sugar by microorganisms. The mycological observations revealed the presence of organisms in a larger number of instances than in the preceding series where the moisture content was decidedly lower.

TABLE VII—ANALYSES OF SUGARS INOCULATED WITH FUNGI, PLANTATION GRANULATED

No.	Fungus	Mycelia	Single Pol.	S. Clerget	Reducing Sugars	Moisture	Moisture Ratio	Dry Basis	
								P.	C.
1	Check.....	—	98.6	98.5	0.25	0.47	0.34	99.0	98.9
2	Check.....	—	98.6	98.5	0.21	0.40	0.28	98.6	98.7
3	Check.....	—	98.5	98.2	0.23	0.43	0.30	98.9	98.6
AVERAGE.....			98.6	98.3	0.23	0.44	0.31	98.9	98.8
4	<i>Aspergillus flavus</i>	—	98.6	98.3	0.25	0.56	0.38	99.0	98.6
5	<i>Aspergillus flavus</i>	—	98.5	98.2	0.26	0.42	0.22	98.8	98.6
6	<i>Aspergillus flavus</i>	—	98.5	98.4	0.25	0.43	0.23	98.8	98.8
AVERAGE.....			98.5	98.3	0.26	0.47	0.31	98.9	98.7
7	<i>Blue Aspergillus</i>	++	97.2	97.1	0.57	1.00	0.35	98.1	98.0
8	<i>Blue Aspergillus</i>	++	97.0	97.1	0.75	0.64	0.21	97.6	97.7
9	<i>Blue Aspergillus</i>	++	97.2	97.3	0.74	1.00	0.37	98.1	98.3
AVERAGE.....			97.1	97.2	0.69	0.90	0.31	97.6	98.0
10	<i>Syncephalastrum</i>	—	98.5	98.4	0.26	0.36	0.24	98.8	98.8
11	<i>Syncephalastrum</i>	—	98.7	98.6	0.24	0.40	0.30	99.0	99.0
12	<i>Syncephalastrum</i>	—	98.6	98.5	0.23	0.35	0.24	98.8	98.8
AVERAGE.....			98.6	98.5	0.24	0.37	0.26	98.9	98.9
13	<i>Aspergillus niger</i>	+	97.9	97.7	0.44	0.63	0.30	98.5	98.3
14	<i>Aspergillus niger</i>	+	97.9	98.0	0.43	0.63	0.30	98.5	98.1
15	<i>Aspergillus niger</i>	+	96.6	96.0	0.44	0.68	0.20	97.7	97.2
AVERAGE.....			97.4	97.4	0.44	0.65	0.27	98.1	97.9

TABLE VIII—ANALYSES OF SUGARS INOCULATED WITH MOLDS, REFINED

No.	Fungus	Mycelia	Single Pol.	S. Clerget	Reducing Sugars	Moisture	Moisture Ratio	Dry Basis	
								P.	C.
1	Check.....	—	99.5	99.4	0.11	0.20	0.40	99.7	99.7
2	Check.....	—	99.6	99.4	0.11	0.12	0.30	99.7	99.5
AVERAGE.....			99.6	99.4	0.11	0.16	0.35	99.8	99.6
4	<i>Aspergillus flavus</i>	—	98.3	98.2	0.26	0.38	0.23	98.7	98.6
5	<i>Aspergillus flavus</i>	—	97.2	97.4	0.29	0.72	0.26	97.9	98.1
6	<i>Aspergillus flavus</i>	—	99.1	99.2	0.18	0.17	0.20	99.1	99.2
AVERAGE.....			98.2	98.2	0.24	0.42	0.23	98.6	98.6
7	<i>Blue Aspergillus</i>	++	98.0	97.9	0.57	0.56	0.28	98.6	98.4
8	<i>Blue Aspergillus</i>	++	97.9	97.9	0.51	0.63	0.30	98.7	98.0
9	<i>Blue Aspergillus</i>	++	97.9	97.8	0.56	0.70	0.33	98.6	98.5
AVERAGE.....			97.9	97.9	0.57	0.63	0.30	98.6	98.3
10	<i>Syncephalastrum</i>	—	99.2	99.3	0.23	0.22	0.28	99.4	99.6
11	<i>Syncephalastrum</i>	—	99.6	99.4	0.21	0.15	0.40	99.7	99.5
AVERAGE.....			99.4	99.4	0.22	0.19	0.34	99.6	99.6
13	<i>Aspergillus niger</i>	—	98.6	98.6	0.43	0.64	0.45	99.2	99.2
14	<i>Aspergillus niger</i>	—	98.8	98.9	0.43	0.52	0.43	99.3	99.4
15	<i>Aspergillus niger</i>	—	99.0	99.1	0.37	0.36	0.36	99.2	99.3
AVERAGE.....			98.8	98.8	0.41	0.51	0.41	99.3	99.3

In order to approximate more nearly the optimum conditions for the activity of these organisms, the following experiment was conducted in a manner similar to those discussed above, with one important difference, namely, the sterilized sugars (of the three principal types) were permitted to absorb moisture in the autoclave before inoculation. The incubation period in this case was reduced to one month, at the end of which time the sugars were analyzed and the results recorded in Table VII. It will be readily observed from the closely agreeing duplicate determinations that the *Blue Aspergillus* and *Aspergillus niger* are responsible for a considerable inversion as represented by the reduction in Clerget values as compared with the check. This is corroborated by the tripling and doubling, respectively, in amount of reducing sugars. The moisture ratio in this series approaches the critical value arrived at in the valuable contributions of Browne,¹ Owen,¹ and others. Two of the

¹ Loc. cit.

organisms, on the other hand, showed little, if any, power to cause inversion even under these favorable conditions. The Refined series, recorded in Table VIII, yields much the same evidence. Here again, where the moisture ratio is in the vicinity of 0.3 and deterioration is to be expected, the *Blue Aspergillus* and *Aspergillus niger* are active in inversion as evidenced by the low Clerget and high values for reducing sugars. *Aspergillus flavus* appears also to have some activity in the present series. In the Cuban Raw series in Table IX the results parallel those previously noted. The *Blue Aspergillus* and *Aspergillus niger* are very active, while *Syncephalastrum* exhibits some inclination to invert the sucrose present.

TABLE IX—ANALYSES OF SUGARS INOCULATED WITH FUNGI. CUBAN RAW

No.	Fungus	Mycelia	Reducing Sugars			Moisture Ratio			Dry Basis		
			Single Pol.	Clerget	Moisture	Moisture	Moisture	Ratio	P.	C.	S.
1	Check	—	95.1	95.2	0.92	1.97	0.40	97.0	97.1		
2	Check	—	95.1	95.2	1.00	2.01	0.40	97.0	97.2		
3	Check	—	95.2	95.3	1.00	1.96	0.40	97.1	97.2		
AVERAGE			95.1	95.2	0.97	1.98	0.40	97.0	97.2		
4	<i>Aspergillus flavus</i>	—	95.2	95.2	1.06	1.91	0.40	97.0	97.1		
5	<i>Aspergillus flavus</i>	—	95.3	95.3	1.02	1.84	0.39	97.0	97.1		
6	<i>Aspergillus flavus</i>	—	95.1	95.2	1.06	1.96	0.40	97.0	97.1		
AVERAGE			95.2	95.2	1.03	1.90	0.40	97.0	97.1		
7	<i>Blue Aspergillus</i>	—	92.8	94.0	1.89	2.39	0.33	95.1	96.3		
8	<i>Blue Aspergillus</i>	—	93.0	93.5	1.97	2.36	0.34	95.2	95.7		
9	<i>Blue Aspergillus</i>	—	92.2	92.9	2.17	2.75	0.35	94.8	94.8		
AVERAGE			92.7	93.4	2.01	2.50	0.34	95.0	95.6		
10	<i>Syncephalastrum</i>	—	94.7	94.9	0.98	2.07	0.39	96.7	96.9		
11	<i>Syncephalastrum</i>	—	95.3	94.9	1.00	2.20	0.48	96.4	97.0		
12	<i>Syncephalastrum</i>	—	94.7	94.8	1.04	1.83	0.34	96.4	96.6		
AVERAGE			94.9	94.9	1.01	2.03	0.40	96.5	96.8		
13	<i>Aspergillus niger</i>	—	94.5	94.7	1.06	2.17	0.39	96.6	96.8		
14	<i>Aspergillus niger</i>	—	94.5	94.9	1.11	2.01	0.36	96.4	96.7		
15	<i>Aspergillus niger</i>	—	94.8	94.7	1.09	1.86	0.35	96.5	96.7		
AVERAGE			94.6	94.8	1.09	2.01	0.37	96.5	96.7		

In considering the deterioration of sugar by the pure cultures of molds employed it is of paramount importance to note that the organism possessing the greatest power for causing inversion is the very one isolated with the greatest frequency from the large number of samples studied, namely, the *Blue Aspergillus*.

The mycological examination by plating at the end of the experiment resulted in the recovery of numerous organisms from all of the inoculated flasks, the checks remaining sterile. A microscopical examination revealed the presence of mycelia in several instances where deterioration had occurred. However, in other cases where deterioration was noted, no mycelium could be detected and only spores were present. This phenomenon is worthy of further study (which is at present being carried forward), for upon its interpretation depends much that is of economic significance. If it is possible for the spores of molds to secrete enough invertase to cause the deterioration of sugar without the development of mycelia, then sugar which has been properly dried and considered safe by virtue of its moisture ratio would, in reality, be likely to undergo deterioration depending upon the nature and extent of the infection. This would point indubitably, from a new angle, to the necessity for cleanliness in the sugar house. It leads directly into an investigation, now in progress, of sterilizing sugar in the centrifugals or reducing the infection by adequate protection at this point. For example, it

would be advisable, on the basis of the foregoing results, to have the centrifugals operating in a room having a concrete floor and where strict methods of cleaning and perhaps disinfection could be employed. From the broader viewpoint it is of prime importance to industrial mycology to have determined to what extent the spores of molds are capable of secreting enzymes without active growth, and it is hoped that experiments now being conducted in this laboratory will throw some light on this question. For the present, it may serve to interpret some peculiar phenomena. For example, in a recent conversation, Dr. C. A. Browne has suggested that it appeared to be a plausible explanation of the fact which he has often noted, namely, that some sugars which start to deteriorate at a high moisture ratio continue to do so in spite of the lowering of this ratio below the critical point of safety. The bearing that such a relationship might have upon the factor of safety rule is obvious and demands further attention. It may be necessary to introduce a revision of this rule based on infection.

MOLDS IN THE SUGAR FACTORY

Having isolated the molds which occur in the marketable cane sugars and determined their power to cause deterioration by inversion, it was of interest to trace the fate of the molds and bacteria through the process of sugar manufacture. With this in view, a daily bacteriological and mycological examination of each stage in the process was carried on throughout the past grinding season. In brief, the local process consists of crushing the harvested cane to extract the raw juice. This is treated with sulfur dioxide fumes and later limed to slight acidity and brought to a boil. The impurities are put through a filter press, the filtered juice joining the clarified juice in the storage tank. The juice is evaporated in the "effects" to a sirup by heating at 120° to 185° F. under a vacuum of 10 to 26 in. The sirup goes to the vacuum pan where the sugar is grained at 130° to 165° F. under 23 to 25 in. of vacuum. The massecuite (sugar coated with molasses) is run into the centrifugal, which permits the molasses to be thrown through the brass screen and holds the sugar crystals behind. A jet of water (about 1 lb.) is played on the sugar in the rapidly whirling centrifugal to remove some of the molasses, which results in a lighter colored sugar. Further methods of refinement were ordinarily not employed in our mill.

TABLE X—SUMMARY OF PER CENT OF FUNGI AND BACTERIA IN EACH STAGE OF THE MANUFACTURING PROCESS

SAMPLE	AVERAGE	
	Fungi	Bacteria
Raw juice	100.2	100
Sulfured juice	13.6	1.14
Limed juice	3.3	0.17
Filtered juice	1.6	0.51
Settled juice	0.0	0.28
Syrup	24.6	0.10
Massecuite	31.1	0.11
Raw sugar	91.8	0.06
Washed sugar	98.2	0.08
Molasses	28.0	0.29
Wash water	0.0	0.13
Air above centrifugal	11.5	0.001
Air below centrifugal	32.8	0.006

In Table X is presented a summary of all the data collected, which gives an adequate conception of the fate of the microorganisms in the mill. Considering the number of molds in the raw juice as 100, it will

be seen that there is a decrease of 86 per cent as a result of sulfuring, while the completion of the clarification process renders the juice practically sterile. However, when the massecuite is exposed to the air, and especially when it enters the centrifugal, reinfection takes place. The rapidly whirling centrifugal sucks air from below at great speed and any organisms on the floor or in the mill at large have an opportunity of gaining an entrance. This is corroborated by the fact that the air below the centrifugal has approximately three times the number of molds to be found in the air above the centrifugal. It might be well to keep the centrifugals covered as well as the mixer which brings the massecuite to that point. The bacterial counts follow the same general trend as the molds. *Blue Aspergillus* and *Cladosporium* were the predominating molds appearing under the local conditions. These were likewise found in two of the largest factories in Louisiana. The fact that the *Blue Aspergillus* is so universal in its habitat and so strong in its deteriorative power makes it advisable to develop methods for its elimination along with the other molds.

SUMMARY

1—The molds appearing with the greatest frequency in manufactured cane sugars of different grades belong chiefly to the *Aspergilli* and *Penicillia*.

2—The organism which appeared with the greatest frequency from all sugars, the *Blue Aspergillus*, also had the greatest deteriorative power.

3—Sterilized sugars inoculated with pure cultures of molds deteriorated rapidly where the moisture content was appreciable. Little, if any, deterioration occurred when the moisture content was reduced to a minimum.

4—Sugars ordinarily guaranteed against deterioration by virtue of the factor of safety rule are capable of undergoing deterioration if sufficiently infected with molds.

5—Molds cause an inversion of sucrose where only spores are present, as well as when mycelia are developed. It would appear, therefore, that some mold spores, as such, contain invertase.

ACKNOWLEDGMENT

The authors are appreciative of the assistance they have so generously received from Dr. C. A. Browne, Mr. W. L. Owen, Dr. Charles Thom, Assistant Director W. G. Taggart, Dr. F. Zerban, and Mr. E. C. Freeland.

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AMERICAN TOMATO SEED OIL¹

By GEORGE S. JAMIESON AND H. S. BAILEY
Received March 1, 1919

The object of this investigation was to prepare a number of samples of oil from tomato seed grown in various localities in the United States and determine the so-called constants for each sample of oil. Also it was proposed to make a study of the chemical composition of tomato seed oil in order to determine if it

contained any constituents in addition to those already known. In 1914, a brief report of the work which had been accomplished was made by Bailey and Burnett,¹ on the extraction and refining of tomato seed oil. It was shown at that time that the crude oil could be readily refined by the well-known alkali process and that by a subsequent treatment with fuller's earth, a very pale yellow oil was produced which appeared suitable for use as a salad oil. Since the above-mentioned report was made several more samples of oil have been obtained and studied.

While making a preliminary investigation of the chemical composition of the oil it was found that the Renard test indicated the presence of a considerable amount of arachidic acid. However, it will be shown that tomato seed oil actually contains a very small amount of arachidic acid. The Renard test was repeated several times but in each case the same result was obtained, although great care was taken to follow the directions given for this test in every detail. These results show that the Renard test when applied to unfamiliar oils cannot be relied upon to indicate the quantity of arachidic acid present. It is hoped that this important observation will be properly emphasized in the future editions of books on oil analysis. Several attempts were made at various times to separate the arachidic acid by fractional crystallization from 90 per cent alcohol, of the fatty acids obtained by the Renard test, but without success. Then it was decided to make an exhaustive study in order to determine if any arachidic acid was present in tomato seed oil, with the result that the completion and publication of these investigations were much delayed. Meanwhile a study on "The Utilization of Waste Tomato Seeds and Skins" was made by Rabak, of the Bureau of Plant Industry, the results of which were published in bulletin form in 1917.² This bulletin gives statistics on the amount of tomato seeds and skins, as well as the quantity of oil and press cake produced in Italy, and also indicates the amount of this waste product available in the United States. Since the bulletin gives a satisfactory description of the modern pressure and solvent methods for obtaining the oil on a commercial scale, it will not be necessary to discuss them here. The chemical investigation of the tomato seed oil extracted by solvents described in the above-mentioned bulletin showed that it contained 17.54 per cent of solid acids and 75.84 per cent of liquid acids. It was also shown that the oil had the following approximate composition:

	Per cent		Per cent
Olein.....	45.00	Palmitin.....	12.47
Linolein.....	34.20	Stearin.....	5.89

The remaining small portion consisted of free acids and unsaponifiable matter. In addition to these compounds Battaglio³ has shown that tomato seed oil contains a small amount of myristin.

A further attempt was made on much larger scale than in the first experiments to separate the arachidic acid from the palmitic and stearic acids by fractional crystallization. About 36 g. of the solid fatty acids

¹ Science, 39 (1914), 953.

² U. S. Dept. of Agr., Bull. 632 (Professional Paper).

³ Les Corps gras., 1901, 135

¹ Published by permission of the Secretary of Agriculture.

SAMPLE NUMBER	1	2 ¹	3 ²	4 ³	5	6	7	8	9	10 ⁴
Specific gravity at 25° C.	0.9191	0.9196	0.9189	0.9186	0.9189	0.9189	0.9190	0.9184	1.4725	1.4715
Refractive index at 25° C.	1.472	1.4722	1.4722	1.4723	1.4720	1.4728	1.4725	1.4725	1.4725	1.4715
Iodine number (Hanus)	121.5	117.5	122.5	122.6	122.0	125.0	125.0	122.5	125.0	122.0
Saponification number	187.5	187.0	187.0	186.3	192.0	192.0	192.0	192.0	191.0	188.2
Reichert-Meissl number	.....	.....	.....	.....	0.1	0.3	0.3	0.3	0.3	.....
Polenase number	.....	.....	.....	.....	0.6	0.6	0.6	0.4	0.4	.....
Acetyl value	18.5	11.5	11.4	10.0	13.1	14.1	12.3	12.8	17.6	20.5
Insoluble fatty acids, per cent.	95.8	96.6	95.3	95.4	96.0	95.5	96.0	95.7	96.1	95.0
Soluble fatty acids, per cent.	0.5	0.7	0.5	0.44	.....	.....	.....	.....	.....	.....
Unsaturated (liquid) acids, per cent.	77.0	79.0	79.0	84.7	77.0	77.0	79.0	77.6	76.1	80.2
Saturated (solid) acids, per cent.	16.0	15.0	16.0	14.7	17.0	16.7	15.5	17.2	18.0	15.0

¹ Expressed oil from V. D. Anderson Company.² Sample 3 is Sample 1 refined with sodium hydroxide, sp. gr. 1.1.³ This sample is Sample 3 bleached with fuller's earth.⁴ Oil extracted from tomato seed with petroleum ether.

were obtained from the tomato seed oil by the lead salt-ether method. This mixture of fatty acids was found to melt at 55°, while the acids obtained previously by the Renard test melted at about 58° C. After 6 crystallizations from 90 per cent alcohol the melting point was 69° C. and it was not raised by three recrystallizations, which clearly indicated that it was not possible to separate a small amount of arachidic acid from large amounts of palmitic and stearic acids. However, this fractional crystallization did effect the separation of some of the stearic acid free from palmitic as shown by the fractions which melted at 69° C. There are several possibilities by which the arachidic acid may have been lost. One is that on account of the small amount of acid present it was either held in solution by the solvent action of the other acids or even by the alcohol itself, while another possibility is that the arachidic acid was converted into its ethyl ester, which is much more soluble in alcohol than the free acid.¹ Precautions were taken during the solution of the acids in alcohol not to heat any longer or hotter than necessary to completely dissolve them.

However, it was found that arachidic acid could be obtained by fractional distillation of the methyl esters of the solid fatty acids under diminished pressure. The esters were prepared by heating 47 g. of the solid acids which were obtained from 300 g. of tomato seed oil by the lead salt-ether method, with 20 g. of pure methyl alcohol and 200 cc. of absolute ether for 15 hrs. in the presence of 2.5 per cent of anhydrous hydrochloric acid.² When the solution had cooled almost to room temperature, 400 cc. of ether were added and the contents of the flask were transferred to a separatory funnel. The ether solution was washed twice with 300 cc. portions of water in order to remove the uncombined methyl alcohol and most of the hydrochloric acid. Then the ether solution was thoroughly agitated with another 300 cc. of water containing 5 g. of sodium bicarbonate which removed the remaining hydrochloric acid and any free fatty acids. After washing once more with water, the ether solution was dried over calcium chloride for about 15 min. and the ether was removed by distillation. The methyl esters were then distilled under diminished pressure in the following manner: After the completion of the first distillation in which 12 fractions were collected, each fraction in turn was added to the distilling bulb as its former boiling point was reached and redistilled in order to secure as complete a separation as possible of the esters. In like manner the fractionation was

repeated 5 times. Since these distillations were made primarily to separate the arachidic ester from the other esters, only the last three of the final 12 fractions obtained are given in the following table.

FRACTION NUMBER	10	11	12
Boiling point, deg. C.	170-173	173-180	180-220
Pressure, mm.	3.0	3.0	3.0
Weight of fraction, grams	1.7	0.6	1.0
Melting points, deg. C.	31.0	35.0	40.0
Melting points of acids, deg. C.	69.0	77.0	77.0

When Fraction 12 was crystallized once from 90 per cent alcohol, the melting point was raised to 50° C. In order to get the free acids the esters were saponified with alkali and the fatty acids were precipitated by adding an excess of hydrochloric acid. The acids were filtered off, washed with cold water, and purified by crystallization from 90 per cent alcohol before taking the melting points. From Fractions 11 and 12, 1.2 g. of acid melting at 77° C. were obtained. Assuming this to be pure arachidic acid, it would indicate that the original oil contained at least 0.4 per cent of this acid.

Recently the methyl esters were again prepared from about 50 g. of the solid fatty acids and distilled. In this experiment the redistillation of the fractions was repeated only twice. The portion boiling between 190° C. and 197° C. at 6 mm. pressure was recrystallized from 95 per cent alcohol five times. The purified ester melted at 54° C. When this ester was mixed intimately with an equal amount of methyl arachidate which had been prepared from pure arachidic acid, the melting point was not changed. This proved definitely that the ester obtained by the distillation of the methyl esters of the solid fatty acids from tomato seed oil was methyl arachidic.

One of the objects of the investigation as mentioned above was to obtain the oil from a number of different samples of tomato seed in order to get more data upon the so-called constants of the American tomato seed oils and also to ascertain if there was much variation in the composition of these various oils.

The table at the top of this page gives the physical and chemical constants of oils obtained from different samples of tomato seed.

It should be observed that Samples 1, 2, 5, 6, 7, and 9 were pressed from the air-dried seed in the continuous type of press known as an expeller. The oil obtained by the expeller is light red in color and has a spicy taste resembling paprika. Also it will be observed that the refining of the oil with alkali and the bleaching with fuller's earth has not appreciably changed any of the constants of the oil except that of the acetyl value.

With the exception of Sample 2, the air-dried to-

¹ Lewkowitsch, 5th Ed., 1, 166² *Ibid.*, p. 665.

mato seed gave a yield of about 25 per cent of oil when extracted with ether and about 18 per cent of oil when the expeller was used. In this connection it might be of interest to note that the yield of oil obtained in Italy by pressing the tomato seed is about 18 per cent.

SUMMARY

The constants have been determined for nine different authentic samples of tomato seed oil.

It has been shown that tomato seed oil contains a small amount of arachidic acid.

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AN ELECTROLYTIC RESISTANCE METHOD FOR DETERMINING CARBON IN STEEL¹

By J. R. CAIN AND L. C. MAXWELL

Received June 18, 1919

INTRODUCTION

The purpose of this study was to investigate the accuracy, speed, and practicability of a method for determining carbon in steel, dependent in principle on passing the carbon dioxide produced by direct combustion of the metal into a solution of barium hydroxide of known electrical resistance; after complete absorption of this gas the resistance is again determined and from the increase in this (due to precipitation of barium ions) the percentage of carbon is deduced. This method is new in principle and it is believed that the principle can be applied generally in many cases where the substance being determined precipitates another substance from solution with resultant change in resistance. The assembly of apparatus for determining resistance is also new,² and offers many advantages for technical work over the methods hitherto in general use for measurement of electrolytic resistances, which require the use of induction coils or high frequency generators, tuned telephones, balanced inductances and capacities, etc. Other new features are the application of the nomograph³ for the graphical representation of resistance data and the use of special conductivity cells with adjustable electrodes to facilitate the manufacture of any number of such cells with the same cell constant.

Much work has been done by others on electrochemical analytical methods. In general, these fall into three groups in which an end-point is shown electrochemically by the following methods: (1) The unknown concentration is obtained from curves expressing a relation between cubic centimeters of titra-

ting solution and conductivity (or a related quantity) of the solution titrated;¹ (2) the unknown is obtained from curves giving the relation between cubic centimeters of titrating solution added and the corresponding electromotive forces of a cell composed of a normal electrode and an electrode not acted upon by the solution being titrated, the latter being the electrolyte;² (3) special application of Method 2 used for determining hydrogen ion in acidimetry and alkalimetry and in precipitations from neutralized solutions.³

Such methods suffer by comparison with the present for the following reasons: (1) A curve has to be plotted for every determination, which consumes much time; (2) the apparatus required to determine carbon with an accuracy of 0.01 per cent carbon would be too delicate and inconvenient of manipulation for every-day use; (3) the difficulty in some cases of fixing with sufficient definiteness the inflection or break in the curve denoting the end-point of the titration. Upon further comparing these methods with the present, it is seen that the latter dispenses with one operation common to all the others, namely, the addition of successive portions of a titrating solution and the determination of the resistance at each addition, resulting in additional time-saving.

From an inspection of the chemical equation for the reaction underlying the present method,



it is evident (when any given conductivity cell is used) that the only factors which act to change the conductivity of the barium hydroxide used for absorption are (1) the amount of carbon dioxide absorbed, which determines the disappearance from solution of the barium ion, and (2) the temperature. Since carbon dioxide precipitates barium without leaving reaction products in the solution to increase the conductivity (such as would remain if, for instance, sodium sulfate were the precipitating agent for the barium) it can be seen that the present method should give the maximum possible change of resistance for a given amount of barium removed—a condition tending to secure a high degree of sensitiveness.⁴ However, the temperature coefficients of resistance of barium hydroxide solutions in the range of concentrations herein employed (Fig. 2) average nearly 1.7 per cent per degree, hence it is evident that the accuracy of the method will be largely affected by temperature if due correction is not made.

In developing this method it was deemed necessary: (1) To construct the curve showing resistance as a function of concentration of barium hydroxide solutions ranging from very concentrated to very dilute and to select the portion of this curve showing the maximum change of resistance for a given change of

¹ Complete equipment for determination of carbon by this method may be obtained from Arthur H. Thomas Co., Philadelphia.

² The elements of this were described by Weibel and Thuras, *THIS JOURNAL*, 10 (1918), 626.

³ The mathematical work in constructing the nomograph shown in Fig. 4 was done by Mr. H. M. Roeser of this Bureau at the request of the senior author, who suggested its application to electrolytic resistance data. A paper on this subject is in preparation by Mr. Roeser. References on the nomograph are: "Traité de Nomographie," by M. d'Ocagne, Gauthiers-Villars, Paris; "Graphical Methods," by Carl Runge, Columbia University Press, New York; "Graphical Interpolation of Tabulated Data," by H. G. Deming, *J. Am. Chem. Soc.*, 39 (1917), 2388; "The Nomon, a Calculating Device for Chemists," by H. G. Deming, *Ibid.*, 39 (1917), 2137.

⁴ Harned, *J. Am. Chem. Soc.*, 39 (1916), 252; Findlay, "Practical Physical Chemistry," Ostwald-Luther, "Physikalisch-Chemische Messungen."

² Loomis and Acree, *Am. Chem. J.*, 46 (1911), 585, 621 (a bibliography is also given); Hildebrand, *J. Am. Chem. Soc.*, 35 (1913), 869; Kelly, *Ibid.*, 38 (1916), 341.

³ Hildebrand, *Loc. cit.* See also Weibel and Thuras, *THIS JOURNAL*, 10 (1918), 626, for another electrolytic method.

⁴ Compare the conditions in Harned's work with Ba(OH)_2 solutions. *Loc. cit.*

concentration; (2) to devise an apparatus which, when the selected barium hydroxide solutions were used in it, would completely absorb the carbon dioxide at the highest rates of passage of the gas current. The same absorption apparatus, in order that the method might meet the requirements of convenience and rapidity, should permit resistance determinations to be made without transfer of the solution to another vessel; it should also be easy to fill and empty; (3) to determine the temperature coefficients of the barium hydroxide solutions in the selected range of concentration;¹ (4) to prepare a chart enabling the operator to read directly therefrom the percentage of carbon, all temperature corrections being incorporated; (5) to design an apparatus for the electrical measurements possessing the necessary robustness, reliability, simplicity, and protection from corrosion by the laboratory fumes.

THE RESISTANCE OF BARIUM HYDROXIDE SOLUTIONS

A curve was prepared showing the relation between electrical resistance and barium hydroxide

Baker's analyzed barium hydroxide by diluting a stock solution of this with carbon dioxide-free water and determining their strength by titration against standard hydrochloric acid using methyl orange as indicator. The resistance measurements were all made in the same conductivity cell and at practically the same temperature (27° C.).¹ No great accuracy is claimed for these results, which are used only for establishing the form of the curve and selecting a portion of it for more exact redetermination. The portion of the curve selected for use in this method is that between A and B. This region gives the maximum change of resistance per unit change of concentration consistent with the use of solutions sufficiently concentrated to effect complete absorption of carbon dioxide under the conditions imposed. Comparing the resistance changes with changes of concentration of barium hydroxide corresponding to 1 per cent carbon on different parts of the curve, it is seen, for example, that these changes in resistance are approximately six times as great on the portion AB as on the portion CD. The use of the most dilute solutions possible is, of course, also desirable from the saving in barium hydroxide effected. Solutions to the left of A, even when used in very efficient absorbing vessels will not retain all the carbon dioxide except at rather slow rates of aspiration.

TABLE I.—DATA FOR RESISTANCE-CONCENTRATION CURVE FOR Ba(OH)₂ SOLUTIONS IN THE REGION 2 PER CENT TO 30 PER CENT CARBON EQUIVALENT STRENGTH

CELL CONSTANT = 0.715			
Ba(OH) ₂ per 200 cc. Soln. Grams	Equivalent ¹ Per cent Carbon	Temperature Deg. C.	Resistance Ohms
0.612	2.14	27.9	171.6
1.12	3.92	27.3	97.9
1.68	5.87	27.3	68.5
2.20	7.70	27.3	53.5
2.67	9.35	27.3	44.9
3.17	11.1	27.2	38.7
3.64	12.7	27.0	34.6
4.05	14.2	26.9	31.2
4.43	15.3	27.0	29.2
4.94	17.9	27.2	26.2
5.31	18.6	27.0	24.7
5.88	20.6	26.9	22.7
6.45	22.5	26.0	21.8
6.93	24.2	26.8	20.1
7.34	25.6	21.2	20.8
7.84	27.4	21.2	19.7
8.45	29.5	27.3	16.4

¹ The method used in Tables I and II and elsewhere throughout this paper for expressing the strength of the barium solution in terms of "equivalent per cent carbon" was chosen for convenience in using the nomograph described subsequently. By "equivalent per cent carbon" is meant the amount of carbon expressed as percentage on the basis of 2-g. samples being used, necessary to precipitate completely all the barium ions from the solution concerned. This amount of carbon is calculated from the equation: $\text{Ba(OH)}_2 + \text{CO}_2 = \text{BaCO}_3 + \text{H}_2\text{O}$. For instance, in the first horizontal column of this table it is seen that 2.14 "equivalent per cent carbon" corresponds to 0.612 g. Ba(OH)₂; the former figure was obtained by solution of the proportion:

Mol. Wt. Ba(OH)₂ :: At. Wt. Carbon :: Wt. of Ba(OH)₂ in 200 cc. Soln. : Wt. of Carbon in Sample

or

$171.38 : 12.00 :: 0.612 : X$
whence $X = 0.0428$ g. carbon
or the "equivalent per cent carbon" = $(x/2)100 = 2.14$.

The portion of the curve selected for use by this method is again shown in Fig. 2. The procedure used in determining the points on it was the same as for constructing the curve shown in Fig. 1, except that

¹ They were not corrected by any temperature coefficient since, as an inspection of Table I shows, they were made at near enough to one temperature to give roughly the form of the curve, which was all that was desired.

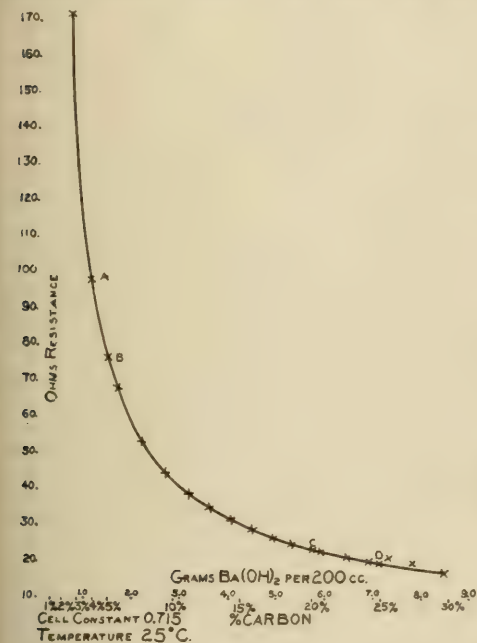


Fig. 1

concentration when the latter was varied from practically saturation to nearly zero. The data in the literature being insufficient for this purpose, the determinations were made by Mr. Louis Jordan of this Bureau and are represented in Fig. 1. The solutions for constructing the curve were prepared from J. T.

¹ There is some possibility of placing the absorption vessel in a constant temperature bath together with a compensating cell in the other arm of the bridge. This would remove the necessity for temperature correction. The method described herein, however, is believed to be simpler.

more care was taken to secure accurate readings and the results were corrected by the coefficients given under the heading "Temperature Coefficients." Table II gives the data used in constructing this curve.

TABLE II—DATA FOR RESISTANCE-CONCENTRATION CURVE OF Ba(OH)₂ SOLUTIONS IN THE REGION 4 PER CENT TO 5 PER CENT CARBON EQUIVALENT STRENGTH
CELL CONSTANT = 0.715

Ba(OH) ₂ per 200 cc. Soln. Grams	Equivalent Percent Carbon	Temperature Deg. C.	Observed Resistance Ohms	Corrected Resistance Ohms
1.164	4.075	23.6	100.9	98.49
1.198	4.194	24.2	97.4	96.08
1.239	4.337	24.2	94.6	93.26
1.242	4.348	23.2	95.8	92.81
1.280	4.482	24.4	91.4	90.52
1.286	4.500	26.6	87.6	90.01
1.301	4.553	27.5	85.3	88.92
1.303	4.559	26.4	86.8	88.79
1.346	4.712	25.1	86.0	86.06
1.385	4.848	25.8	83.7	83.90
1.403	4.912	24.4	84.2	83.94
1.460	5.110	23.1	82.8	80.11

THE ABSORPTION APPARATUS

The essential features desirable in the absorption apparatus are: (1) It must retain all carbon dioxide when gas passes at the rate of 300 to 400 cc. per min.; (2) it must permit resistance measurements to be made without transfer of the solution to another cell; (3) temperatures of solutions should be easily read to 0.1°; (4) the cell should be easy to clean and fill with fresh solution; (5) all cells should be built with the same cell constant,¹ or the latter should be capable of adjustment to one value for all, so that the chart or set of tables may be used for all cells.

Fleming² and others have shown that the combustion of a sample of steel and the sweeping out of the products of combustion from the apparatus where combustion tubes of the usual length and bore are used, can be accomplished in 5 to 6 min.; this requires passage of the oxygen at the rate of about 300 to 400 cc. per min. Soda lime has been found to absorb all the carbon dioxide at this and higher rates. However, barium hydroxide solutions of all concentrations are much less efficient absorbers than soda lime. The absorbing efficiency increases slightly with the concentration, but even when the most concentrated solutions were used it was impossible to absorb completely all the carbon dioxide in the usual types of gas absorption vessels, nearly all of which were tried. The method of testing these forms of apparatus was to burn a sample of steel, having a gas meter before the furnace to control the rate of passage of the oxygen, and to attach after the tube being tested a second absorption vessel containing a little clear barium hydroxide solution; a test was not considered satisfactory if the second tube showed any cloudiness.

Satisfactory absorption was secured in a vessel similar to that described by Weaver and Edwards,³ with suitable modifications, the details of which were developed by Mr. S. M. Hull, formerly of the Chemical Division of this Bureau. For use in the present work, electrodes were sealed into this absorption tube in the middle reservoir. In order always to secure the same cell constant, the area and distance apart of the elec-

trodes were originally adjusted before sealing into the reservoir. This was found to be an extremely uncertain and difficult operation, and this difficulty as well as the general fragility of the apparatus led to its abandonment and the search for something simpler. After the completion of investigations described in another paper,¹ it was found that by burning the sample as therein described (namely, by placing it on a preheated boat, allowing boat and sample to further preheat for a minute in the furnace and then admitting oxygen at 300 to 400 cc. per min.), it was possible to completely burn a 2-g. sample in 1½ to 2 min. Since the first few hundred cubic centimeters of oxygen combine with the iron, there is produced a much greater partial pressure of carbon dioxide than is secured where a sample burns slowly and this makes it possible to use a very simple absorption tube, such as that shown in Fig. 3, for the carbon dioxide.

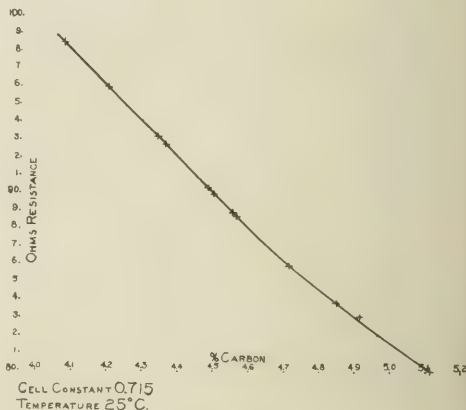


FIG. 2

It was also found simpler to build a cell whose electrodes could be adjusted to secure a given cell constant than to attempt to obtain the same result with the electrodes sealed in a fixed position in the cell. This fact and the use of the special method of combustion described led to the design of the apparatus shown in Fig. 3. This is not fragile and the glass parts can be built by any glass blower of ordinary skill; it meets all the listed requirements of the absorption apparatus.

The adjustment of the cell constant is made by moving the electrodes up and down after loosening the stuffing box; a marked change takes place as they approach the meniscus. Initial approximate similarity can be attained by the glass blower with comparative ease. Once the electrodes are set in the proper position, this is maintained by cementing with DeKhotinsky cement. The electrodes are platinized and the cell constant is determined as described under "Operating Suggestions." A certain amount of adjustment of the constant of the cell can be secured by removing or adding platinum black to one or the other of the electrodes during the platinizing operation by the use of an auxiliary electrode. Some cells in long use at the

¹ The "cell constant" is not a constant at all, as Washbourne and others have shown, but for want of a better term this expression has been used throughout this paper.

² Iron Age, 93 (1913), 64.

³ This Journal, 7 (1915), 534.

⁴ Cain and Maxwell, This Journal, 10 (1918), 520.

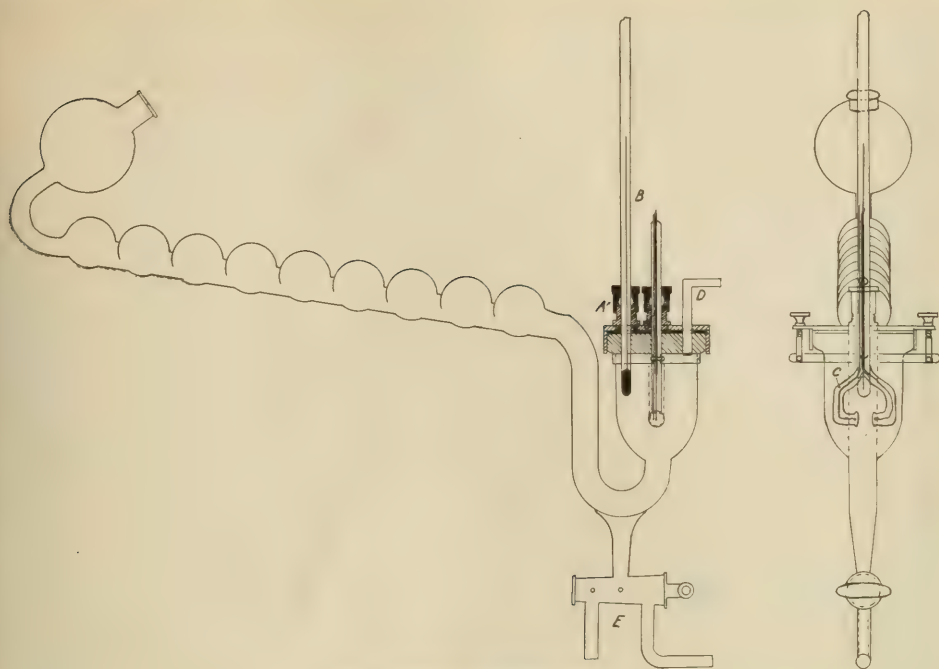


FIG. 3—DETAILS OF ABSORPTION VESSEL

Bureau have differed in cell constant by 0.04 without affecting the accuracy of results. Actually, it is easily possible to adjust cell constants within 0.005, and this practice is to be recommended.

TEMPERATURE COEFFICIENTS

The solutions for determination of these coefficients were prepared and standardized as already described. The conductivity cells used for the work were kept in a thermostatically controlled chamber where the temperatures were maintained within 0.01° C.

Resistances of barium hydroxide solutions equivalent to approximately 4.0, 4.25, 4.50, 4.75, and 5.0 per cent carbon were determined at 20°, 25°, and 30°. The experimental values and the corresponding calculated values for α and β are shown in Table III. These values for α and β were calculated by substituting the values for temperature and resistance from Table III

for t in the equation $\frac{1}{Rt} = \frac{1 + \alpha[t - 25] + \beta[t - 25]^2}{R_{25}}$, and solving for α and β .

METHODS FOR DIRECT READING OF CARBON PERCENTAGES

Several methods were tried for graphically representing the relation between carbon percentages and the corresponding observed temperature and resistance measurements. At first tables were constructed in which temperature corrections were calculated and applied for every tenth of a degree and every tenth of an ohm, but these were found to be too cumbersome.

Other tables were then constructed giving the temperature corrections only, with the idea of adding or subtracting these each time a reading was made. This condensed the tables very considerably but increased the amount of calculation necessary. A series of curves was then constructed showing the relation between resistance and per cent carbon, a curve being constructed for every tenth of a degree. Such curves are convenient to use only if they are plotted on an inconveniently large scale; even then it is very fatiguing to use them for many readings at a time.

TABLE III—DATA FOR TEMPERATURE COEFFICIENTS OF RESISTANCE

Concn of Ba(OH) ₂ Soln. ¹ Per cent C. Approx.	Temperature Deg. C.	Resistance Ohms	α	$\beta \times 10^{-4}$
5.0	20	135.25	0.01674	0.2687
	25	124.02		
	30	114.37		
4.75	20	142.18	0.01680	0.3505
	25	130.36		
	30	120.16		
4.50	20	149.07	0.01686	0.3085
	25	136.62		
	30	125.91		
4.25	20	156.18	0.01687	0.1652
	25	143.07		
	30	131.89		
4.00	20	165.18	0.01687	0.0898
	25	151.28		
	30	139.48		

¹ 200 cc. of the solution contained barium hydroxide approximately equivalent to the carbon in a 2-g. sample with 5 per cent C, or 100 cc. of the solution contained barium hydroxide approximately equivalent to the carbon in a 1-g. sample with 5 per cent C; or approximately 0.7125 g. Ba(OH)₂. The other solutions contained barium hydroxide approximately equivalent to 1-g. samples with 4.75 per cent, 4.50 per cent, 4.25 per cent, and 4.00 per cent, respectively.

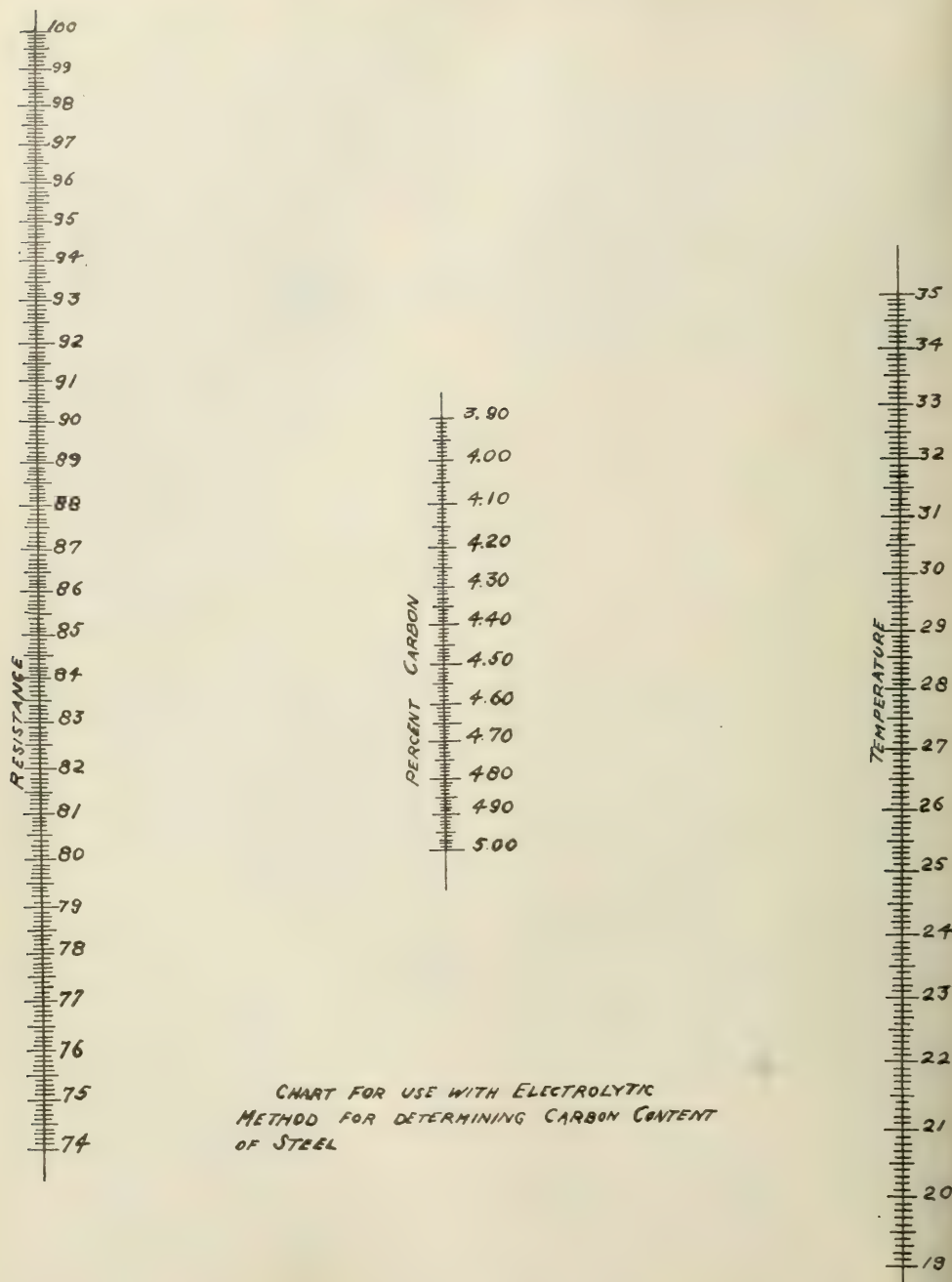


FIG. 4

After a little study it was found that the β term could be omitted from the equation for correcting temperatures to 25°, provided this equation is applied only between the temperatures 15° and 35°; at higher or lower temperatures the correction for the β term is appreciable. If the laboratory temperature is not within these limits, the stock solution in carboy F of Fig. 6 must be brought within this range by placing it in a bath of cold water. The equation

$$(1) R_{25} = R[1 + \alpha(t - 25) + \beta(t - 25)^2] \quad \text{then reduces}$$

to $R_{25} = R[1 + \alpha(t - 25)]$, in which $\alpha = 0.01681$, this value being taken from Table III. After trials of other forms of curves, it was found that the parabolic form answered the requirements of fitting the observations sufficiently well and of permitting the construction of a nomograph; the equation to the curve shown in Fig. 2 was calculated on the assumption that it was parabolic, using the methods of least squares and the observations shown in Table II. This equation was found to be

$$C^2 - 13.589 C + 63.191 - 0.2478 R_{25} = 0$$

or,

$$C^2 - 13.589 C + 63.191 - 0.2478 [1 + \alpha(t - 25)] = 0$$

whence,

(2) $C = 6.79 - \frac{1}{2}\sqrt{0.9912R(0.5798 + 0.01681t - 67.11)}$, C being the equivalent per cent of carbon in the sense already explained. From Equation 2 the nomograph shown in Fig. 4 was prepared. This nomograph can be used for all cells having cell constants not too different from 0.715, which was the cell constant of the cell used when data for the curve shown in Fig. 2 were obtained. As has been shown, the form of cell used (Fig. 3) allows the electrodes to be adjusted always to secure this result.

The use of the nomograph is very simple. A straight edge is made to connect the observed values for temperature and resistance and the intersection with the third (middle) ordinate gives the concentration of the solution in terms of carbon percentage; this may be termed the first concentration. After the combustion is ended a similar set of readings is taken and subtraction of the second concentration reading from the first gives directly the per cent of carbon if a 2-g. sample has been taken; or, if a 1-g. sample has been used, the result is multiplied by two. The scales can be read to 0.005 per cent C, 0.05° C., and 0.05 ohm. It was found by comparison of chart readings in a number of cases with the resistances computed by Equation 1 that the error of the chart is less than 0.005 per cent carbon.

APPARATUS FOR DETERMINING ELECTRICAL RESISTANCE

With the coöperation of the Leeds and Northrup Company, different forms of apparatus for measuring electrolytic resistances were built and tried. Two forms of high frequency generator in connection with tuned telephones were used; also one or two forms of induction coil as sources of alternating current, and an interrupter such as is used in wireless investigations; the latter was quite unsatisfactory, as might be expected, due to polarization. Good results were ob-

tained with the high frequency generators and tuned telephones, provided that inductances and capacities were used as directed by recent investigators. Such refinements are inconvenient in a method such as the present, intended for works use, and there are two other important objections from the same standpoint: (1) the difficulty of detecting a minimum in the telephone when working in a noisy place such as the usual works laboratory and the fatigue of the operator who would have to make possibly 80 or 90 determinations in an 8-hr. day, and (2) the liability to deterioration of a high frequency generator when operating continuously 24 hrs. per day as might happen in technical use. These considerations led to the development of a method of measuring electrolytic resistances by the use of commercial 60- or 25-cycle current. It was found after trial of the Weibel¹ galvanometer, a vibration galvanometer and of a direct current galvanometer operating off a crystal rectifier placed in the secondary of a transformer (the cell being in the primary), that the Weibel galvanometer offered a very satisfactory zero instrument for such measurements of electrolytic resistance as had to be made in this work.

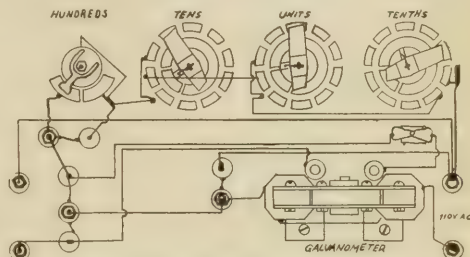


FIG. 5—DIAGRAM OF BRIDGE USED FOR RESISTANCE MEASUREMENTS

The bridge shown in Fig. 5 was accordingly constructed by Leeds and Northrup. The resistance coils and galvanometer are enclosed in a hermetically sealed box so that they are efficiently protected from corrosion. There are three dials—tens, units, and tenth ohms, respectively—and a fourth which adds 100 to the readings of the others, when this is desired. An accuracy of 0.1 ohm in the readings is all that is necessary, although much better than this can be done. This instrument has been in use several months and has been very satisfactory. A perfect minimum is always registered by the galvanometer, provided the electrodes are well platinized.

PROCEDURE FOR DETERMINING CARBON

A nichrome-wound furnace is used for heating. Porcelain or glazed quartz tubes may be employed; they should be fitted with a sheet nickel sleeve to protect internally from fused iron oxide which is thrown off from the burning steel. The two absorption vessels are filled to the 200 cc. mark with barium hydroxide solution from the stock bottle F (Fig. 6; see also Operating Suggestion 1). Oxygen or air freed from carbon dioxide is passed for a few seconds to mix the solutions and their temperatures and resistances are

¹ E. E. Weibel, Bureau of Standards, *Scientific Paper*, 297 (1917).

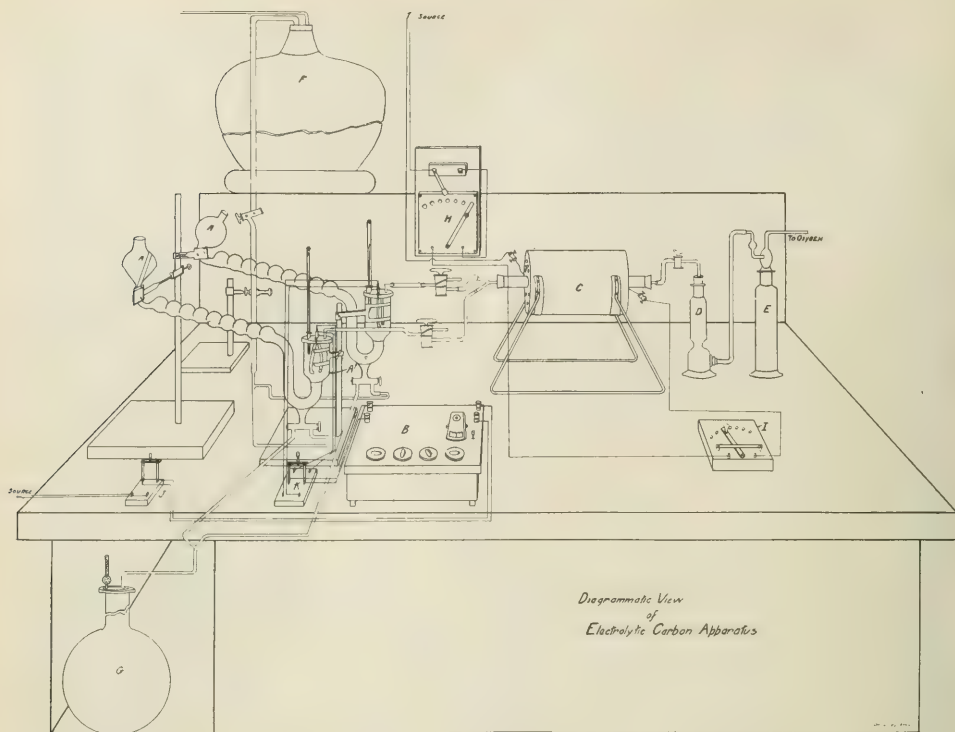


FIG. 6

then recorded. In the meantime the combustion boat filled with alundum sand has been preheating in the furnace, which for this work should be maintained continuously at 1050° to 1100° , preferably the latter temperature.¹ This is an extremely important point, for if the temperature is too low or the oxygen is not pure or is not admitted at 300 to 400 cc. per min. after the combustion starts, the rapid combustion essential to successful absorption cannot be secured. The boat is removed from the furnace and when at a low red heat the sample is distributed on the alundum² and the boat replaced in the furnace and left to preheat, without oxygen passing, while the next sample is being weighed. Oxygen is now passed at the rate of 300 to 400 cc. per min. for the next two minutes; then the stop-cock, Fig. 6, is turned to the position, which admits carbon dioxide-free air; this should pass at the same rate as the oxygen. During this combustion period, if directions have been followed, all carbon dioxide will have been removed from the furnace, but some still remains in the large bulb of the absorption apparatus. The air removes this. The advantage of

the use of air at this stage is obvious: a saving of oxygen is effected and the furnace is immediately available for burning the next sample. While air is passing through the first tube (requiring $1\frac{1}{2}$ to 2 min.) the combustion of the next sample proceeds as already directed, using the second absorption tube. The second reading of resistance and temperature on the first tube then follows, and if the solution is not too dilute it can be used for absorbing the carbon dioxide from other samples; otherwise, a little is allowed to flow into the reservoir G, and the tube is filled to the mark again with fresh solution. Of course it is an economy in time for the operator, wherever possible, to choose conditions (weight of sample, carbon content of same, etc.) so as to get the maximum number of determinations for a single filling, since in this way the second resistance and temperature readings serve as initial values for the next combustion and so on. The solution should not be used when it is more dilute than corresponds to 4 per cent carbon (*i. e.*, 99.5 ohms at 25° ; see nomograph, Fig. 4, for the limiting resistances corresponding to other temperatures), since its absorptive power at rapid rates of passage of the oxygen is then less, and some carbon dioxide may be lost. The data relating to combustions should be recorded as obtained. It is convenient to use a tabular form for record showing: (1) Designation of sample; (2) weight taken; (3) cell used; (4) initial temperature;

¹ The melting point of gold is a convenient temperature check. If this metal is not melted the temperature is too low. See cited paper by Cain and Maxwell.

² Experience has shown that no loss of carbon occurs unless the sample contains extremely fine particles; with most steels these can first be removed without causing an error in the carbon determination. This point should always be tested, however, in burning new steels.

(5) final temperature; (6) initial resistance; (7) final resistance; (8) initial concentration; (9) final concentration; (10) carbon percentage in sample; (11) remarks. There is ample time for entering this information while other operations are going on. A very good way is to enter "final temperature" below "initial temperature," and "final resistance" after "initial resistance" for each sample, since this relates these quantities in an easy manner for reading the nomograph.

The speed of the method naturally depends on the skill of the operator and the ingenuity displayed in arranging a cycle of operations which secures the best speed under his working conditions. Operators at the Bureau when working on a series of Bureau of Standards' analyzed samples averaged one determination per $4\frac{1}{2}$ to 5 min. The accuracy of results is shown in Table IV.

TABLE IV—RESULTS		BY ELECTROLYTIC RESISTANCE METHOD	
B. S. Standard Sample Used	Wt. Used Grams	B. S. Value for Carbon (Av. by Direct Combustion) Per cent	Value by Electrolytic Resistance Method
11a.....	2.0	0.223	0.21
11a.....	2.0		0.21
12b.....	2.0	0.409	0.41
	2.0		0.41
	1.0		0.42
14a.....	2.0	0.813	0.81
	1.0		0.82
	2.0		0.80
16a.....	0.5	0.990	1.00
	0.5		1.00
	1.0		1.00
	2.0		0.98
21a.....	1.0	0.617	0.62
	2.0		0.62
			Cain Maxwell
	Gram		Gram
Sugar.....	0.00421		0.0046
	0.00421		0.0042
	0.00421		0.0040
			Maxwell Maxwell

OPERATING SUGGESTIONS

1—Stock barium hydroxide solutions are conveniently made in one to two carboy lots by adding solid barium hydroxide to the carboy nearly filled with water (agitating with air) until the equivalent strength approaches 5 per cent carbon; subsequent additions can then be made by adding a saturated barium hydroxide solution. Of course, it is not necessary to make up exactly to the equivalent of 5 per cent carbon; an approximation to this is all that is desired. The strength of the solution is determined from time to time during the standardization by running a portion of the solution into the cell and measuring its resistance. If a set-up like that shown in Fig. 6 is used in measuring the resistance, it is not necessary to remove the carboy from the shelf or to break any of the connections during these operations. If it is desired to economize in the use of barium salt, the waste solution in reservoir G can be brought up to strength as described, after first decanting it off from the barium carbonate that has settled out. A still further economy can be effected by drying and calcining to oxide the precipitated barium carbonate; this oxide can then, of course, be used again.

2—The cell constants should be checked from time to time. This may be done (1) by burning standard samples, or (2) by determining the resistance of a $N/10$ solution of pure potassium chloride. This solution should be prepared on the day it is used,

since it has been found that stock solutions change during the course of this work. Table V shows the resistivities at various temperatures of $N/10$ potassium chloride solutions. The cell constant is computed from the formula $R = NS$, or $N = R/S$, where R is the observed resistance, N the cell constant, and S the resistivity, taken from Table V, for the same temperature. If a change in cell constant has taken place it is most probable that the electrodes need replatinizing. Directions for this are given below. If Method 1 is used, any marked deviation from the correct carbon value of the standard steel may be due to a change in the cell constant, and this should then be checked by Method 2, unless the error in the carbon determination is suspected to be due to some other cause. In the present work no deviation of cell constants has been observed until after several months' use, and then the change is sudden and erratic. When the cell constant changes it should be brought back to the original value by the methods already described under the heading "The Absorption Apparatus."

3—If the absorption vessels are not to be used for some time they should be cleaned with hydrochloric acid (not over 2 to 3 per cent HCl) followed by distilled water. Extreme care should be taken that none of the hydrochloric acid or chlorides enters the reservoir for waste barium hydroxide solution, if this is to be used again.

4—To platinize the electrodes, the cap carrying them (Fig. 6) is removed from the cell and they are first cleaned with sulfuric acid and chromic acid mixture followed by distilled water. Then they are immersed in a vertical position in a solution made of 100 g. water, 3 g. chloroplatinic acid, and 0.02 to 0.03 g. lead acetate. Current is passed through the solution by connecting the electrodes to three dry batteries in series; the current is passed for 5 min., reversing every half minute. Finally, an auxiliary platinum electrode is introduced and current passed with this as anode for another 2 min., after which the electrodes are washed thoroughly with distilled water and are then ready for use.

TABLE V—SPECIFIC RESISTIVITY OF $N/10$ KCl SOLUTION AT VARIOUS TEMPERATURES (FROM LANDOLT-BÖRNSTEIN PHYSIKALISCH-CHEMISCHE TABELLEN, 4TH ED., PAGE 1117).

Temperature Deg. C.	Resistance Ohms
15.0	95.42
16.0	93.28
17.0	91.32
18.0	89.37
19.0	87.49
20.0	85.69
21.0	83.96
22.0	82.30
23.0	80.71
24.0	79.11
25.0	77.64
26.0	76.16
27.0	74.79
28.0	73.42
29.0	72.10
30.0	70.82
31.0	69.59
32.0	68.40
33.0	67.20
34.0	66.09
35.0	64.98

SUMMARY

1—This paper describes the fundamental principles of a method for determining carbon dioxide by absorbing it in barium hydroxide solution and measuring

the resistance change of the solution in relation to its concentration.

II—A suitable absorption vessel with electrolytic resistance cell incorporated is illustrated and described.

III—Resistance measurements of barium hydroxide solutions varying in concentration from 3.08 g. $\text{Ba}(\text{OH})_2$ per l. to 42.25 g. $\text{Ba}(\text{OH})_2$ per l. were determined approximately, and determinations accurate within 0.01 ohm were made of the resistances of twelve different solutions varying from 5.820 g. $\text{Ba}(\text{OH})_2$ per l. to 7.300 g. $\text{Ba}(\text{OH})_2$ per l.

IV—Temperature coefficients of resistance of these twelve solutions were determined in the range 20.00° to 30.00° C.

V—Based on the measurements of resistance of the barium hydroxide solutions, solutions with concentrations varying between 5.820 g. $\text{Ba}(\text{OH})_2$ per l. and 7.300 g. $\text{Ba}(\text{OH})_2$ per l. were chosen as most suitable for this method.

VI—Special resistance-measuring apparatus was developed which simplified these measurements by dispensing with tuned telephones, high frequency generators, and balanced inductances and capacities.

VII—A convenient nomographic method of applying necessary temperature corrections to resistance measurements was developed.

VIII—The method permits of accurate determinations of carbon in steel (*i. e.*, within 0.01 per cent carbon), by the direct combustion method in $4\frac{1}{2}$ to 5 min.

ACKNOWLEDGMENT

The authors desire to acknowledge the work of Mr. H. E. Cleaves, former member of the Chemistry Division of the Bureau, who carried out some preliminary measurements, and the assistance of Messrs. Silsbee, Agnew, and Isler of the Electrical Division of the Bureau, who cooperated effectively in the selection of a suitable alternating current galvanometer. The Leeds and Northrup Company also cooperated fully by constructing and loaning electrical measuring apparatus for experimental work and by finally building in practical form the apparatus that was developed.

BUREAU OF STANDARDS
WASHINGTON, D. C.

THE DETECTION AND ESTIMATION OF SMALL AMOUNTS OF CERTAIN ORGANIC NITRO COMPOUNDS WITH SPECIAL REFERENCE TO THE EXAMINATION OF THE URINE OF TNT WORKERS

By ELIAS ELVOE

Received March 31, 1919

In connection with the sanitary control of munition establishments where trinitrotoluene¹ was employed, it appeared desirable to have a convenient

and fairly rapid method for the detection and estimation of small amounts of the trinitrotoluene in air. It was thought that the qualitative color test with alkali, which forms the basis of the so-called Webster¹ test for TNT in urine, might be developed into a quantitative method. As this test is ordinarily carried out, however, the color obtained is very fugitive and hence cannot well be utilized for making quantitative determinations colorimetrically. The best one can do is to follow the procedure of Webster, *i. e.*, adopt some arbitrary scale of one's own, such as "trace, 1, 2, 3, 4, and intense." It was primarily with the object of making this color test more nearly quantitative that this work was undertaken.

The Webster test to which reference has been made is carried out by first extracting the acidified urine with ether and then treating the extract with an alcoholic solution of potash. The latter is prepared, according to Webster, by dissolving 4 to 5 g. of caustic potash in 100 cc. absolute alcohol or by mixing 10 cc. of a saturated solution of caustic potash with 90 cc. of alcohol. Since these directions allow of a considerable variation in the concentration of the alkali and since in order to standardize the conditions it appeared desirable to fix more definitely the concentration of the alkali, some experiments were carried out with this object in view. An ethereal² solution of 2, 4, 6-trinitrotoluene was prepared containing 0.01 mg. of the trinitrotoluene in 1 cc. of the solution. A number of alcoholic³ potash solutions were also prepared containing different concentrations of the alkali. Each of 5 cc. portions of the ethereal solution was then mixed, at room temperature, with 5 cc. of one of these alcoholic potash solutions. The results obtained are given in Table I.

The results given in Table I show that the concentration of the alkali is a very important factor in controlling the stability of the color produced by the action of the alkali on the trinitrotoluene in the Webster test. They also show that by reducing the concentration of the alkali used by Webster to about that used in Expt. 3, we can obtain sufficient stability for the color to render it possible to utilize it for quantitative purposes.

In order to apply this alkali-trinitrotoluene color reaction to the detection and estimation of trinitrotoluene in air, it appeared best to substitute alcohol as the solvent in place of the much more volatile ether. In order, therefore, to determine the favorable concentrations of the alkali to employ when alcohol is used as the solvent for the TNT, experiments were carried out with varying concentrations of the alkali, using for each experiment 5 cc. of a solution of the trinitrotoluene in absolute⁴ alcohol, containing 0.01 mg. of the trinitrotoluene in 1 cc. of the solution,

¹ *British Med. J.*, 2 (1916), 845.

² The ether used was the ordinary ether of the quality described in the U. S. Pharmacopoeia.

³ Absolute alcohol or the ordinary alcohol which has been redistilled over lime was used in all this work. It was found that by using such an alcohol, instead of the ordinary 95 per cent alcohol, even the more concentrated alcoholic potash solutions were practically colorless when fresh.

⁴ The specific gravity of the alcohol used was 0.788 at 25° C.

¹ The trinitrotoluene which is ordinarily employed is the 2, 4, 6 variety. The specimen of this compound which was used in this work was obtained by several recrystallizations from a mixture of alcohol and benzene of a very pure sample which was kindly sent to this laboratory by the Bethlehem Steel Company, of New Castle, Delaware. A melting point determination carried out in this laboratory, by Dr. J. M. Johnson, on a similarly recrystallized product showed the melting point to be 80.9° C. (corr.).

and 5 cc. of an alcoholic potash solution, the concentration of the alkali varying in the different experiments. The results obtained are given in Table II.

TABLE I—EFFECT OF VARYING THE CONCENTRATION OF THE ALKALI ON THE STABILITY OF THE COLOR PRODUCED BY THE ACTION OF THE ALKALI ON THE TRINITROTOLUENE DISSOLVED IN ETHER

Expt. No.	Vol. of the TNT Soln. Cc.	Vol. of the Alcoholic Potash Cc.	Composition of the Alcoholic Potash ¹	Appearance and Duration of the Color
1	5	5	90 cc. alcohol + 10 cc. 10 N KOH ²	Decided purplish color, disappearing almost immediately after mixing
2	5	5	90 cc. alcohol + 10 cc. N KOH	Very decided purplish color immediately after mixing, gradually fading, and nearly disappearing at end of an hour
3	5	5	90 cc. alcohol + 10 cc. N/10 KOH	Very decided purplish color immediately after mixing. Distinct purplish color still remaining at end of 3 hrs. but nearly disappearing at end of 24 hrs.
4	5	5	90 cc. alcohol + 10 cc. N/100 KOH	Very decided purplish color immediately after mixing. Distinct purplish color still remaining at end of 2 hrs. but practically colorless at end of 24 hrs.

¹ In preparing these solutions and carrying out these experiments the aim was to adhere as closely as possible to the procedure given by Webster. Hence all the alcoholic potash solutions were prepared by Webster's procedure with the only difference that the strength of the potassium hydroxide solution was varied in the different cases.

² This concentration is really less than that called for by the Webster procedure, since this solution was prepared by diluting a potassium hydroxide solution which was not quite saturated at the room temperature, whereas the Webster procedure calls for a saturated potassium hydroxide solution.

TABLE II—EFFECT OF VARYING THE CONCENTRATION OF THE ALKALI ON THE STABILITY OF THE COLOR PRODUCED BY THE ACTION OF THE ALKALI ON THE TRINITROTOLUENE DISSOLVED IN ALCOHOL

Expt. No.	Vol. of the TNT Soln. Cc.	Vol. of the Alcoholic Potash Cc.	Composition of the Alcoholic Potash	Appearance and Duration of the Color
1	5	5	90 cc. alcohol + 10 cc. 10 N KOH	Very decided purplish color quickly changing to orange, gradually fading, and nearly disappearing at end of an hour
2	5	5	90 cc. alcohol + 10 cc. N KOH	Very decided purplish color, gradually fading, but still retaining considerable of the color at end of an hour
3	5	5	90 cc. alcohol + 10 cc. N/10 KOH	Very decided purplish color immediately after mixing. Distinct purplish color still remaining at end of 3 hrs. and distinct pink at end of 24 hrs.
4	5	5	90 cc. alcohol + 10 cc. N/100 KOH	Distinct purplish color immediately after mixing but nearly disappeared at end of 2 hrs.

The results given in Table II show that the concentration of the alkali is about as important a factor in controlling the stability of the color when alcohol is used as the solvent as when ether is used as the solvent for the TNT. Different concentrations of the alkali, however, do not in general have exactly the same effect on the color in the two cases. These results also show that in cases where the final mixture is largely alcoholic a concentration of the alkali corresponding to that used in Expt. 3 is very favorable towards increasing the stability of the color.

It was thought that from the point of view of

economy and also greater convenience, especially in field work, it would be desirable to reduce to a minimum the amount of absolute alcohol that would be required in carrying out the tests. Hence a series of experiments was carried out, similar to those above, with ether and alcohol, in which the solvent for the trinitrotoluene and also that for the alkali consisted of a mixture of alcohol and water in which the proportion of the latter was largely in excess. The concentration of the trinitrotoluene was the same as in the previous experiments, 1 cc. of the solution¹ containing 0.01 mg. of the trinitrotoluene. The results obtained are given in Table III.

TABLE III—EFFECT OF VARYING THE CONCENTRATION OF THE ALKALI ON THE STABILITY OF THE COLOR PRODUCED BY THE ACTION OF THE ALKALI ON THE TRINITROTOLUENE DISSOLVED IN A MIXTURE OF ALCOHOL AND WATER

Expt. No.	Vol. of the TNT Soln. Cc.	Vol. of the Alcoholic Potash Cc.	Composition of the Alcoholic Potash	Appearance and Duration of the Color
1	5	5	20 cc. alcohol + 70 cc. water + 10 cc. 10 N KOH	Decided pink color, quickly changing to yellow, gradually fading, and nearly disappearing at end of an hour
2	5	5	20 cc. alcohol + 70 cc. water + 10 cc. N KOH	Slight pink color immediately after mixing, developing rapidly into decided orange, finally changing to yellow, and retaining considerable of this color at end of 24 hrs.
3	5	5	20 cc. alcohol + 70 cc. water + 10 cc. N/10 KOH	Almost colorless immediately after mixing but developing a slight pink color after standing 15 min., finally changing to a slight orange-yellow and retaining considerable of this color at end of 24 hrs.
4	5	5	20 cc. alcohol + 70 cc. water + 10 cc. N/100 KOH	Colorless

The results given in Table III show that the concentration of the alkali plays about as important a rôle in controlling the stability of the color when the mixture is largely aqueous as when it is alcoholic. It is to be noted, however, that the color which is thus stabilized is not the same in the two cases. They also show that a concentration of the alkali corresponding to that used in Expt. 2 is quite favorable towards yielding a color which can be readily utilized for quantitative purposes.

On the basis of the above results, the following procedure was adopted and used in connection with a study of the vapor pressure of TNT at different temperatures and also for determining the amounts of this substance present in the air of a munition plant² under various practical conditions. A definite volume of the air under examination was passed, by means of suction, through a series of three³ small

¹ This solution was prepared by diluting 10 cc. of an alcoholic solution, 1 cc. of which contained 0.1 mg. of the trinitrotoluene, to 100 cc. with distilled water.

² It is expected that the results of these studies will shortly be published in a Hygienic Laboratory Bulletin.

³ While the aim was to always have one tube in the series which would remain free from TNT in order to have direct proof that the absorption was complete, it was found that in reality, under the conditions which were studied, the absorption was nearly always complete in the first tube, so that the second and third tubes were nearly always free from TNT.

test-tubes¹ of about 11 mm. internal diameter, each of which usually contained 5 cc. of absolute alcohol. These tubes were connected by means of well-fitting rubber stoppers and glass tubing. The latter was arranged in the usual form of inlet and outlet tubes, each inlet tube nearly reaching the bottom of the corresponding test tube. A portion of the contents² of each tube,³ the amount depending on the amount of TNT it was expected to contain, was then transferred into a narrow-form, 50 cc. Nessler tube, and diluted with a volume of water equal to the difference between the volume of the alcoholic solution taken and 5 cc. Simultaneously, several standards⁴ were prepared containing known amounts of the pure trinitrotoluene, which were judged to be close to that of the unknown and having all the other conditions exactly the same as in the case of the unknown. 5 cc. of *N*/10 NaOH were then quickly added to the unknown and to each of the standards, allowing the alkali to run down the side of the tube. All the tubes were then shaken together, so as to mix the TNT solution and alkali in the different tubes as nearly simultaneously as possible. After standing 10 min., the resulting colors were compared in the usual way. The standards which were usually employed varied from each other, by increments of 0.01 mg. of the TNT, from 0.01 mg. to 0.1 mg.

APPLICATION OF THE GRIESS NITRITE TEST TO THE
DETECTION AND ESTIMATION OF SMALL AMOUNTS
OF TNT OR ITS HYDROXYLAMINO
DERIVATIVE

In examining the urine of TNT workers by the Webster test to which reference has been made above, in addition to the lack of a fairly quantitative basis, there is also the weakness of the test in that the colora-

tion which occurs may not be due to TNT since there are other substances¹ which produce similar colorations when treated with alkali. It seemed desirable, therefore, to have a confirmatory test for the TNT or its closely related derivatives in such urines, and preferably one which could be regarded as closely specific for these compounds. In this connection, it occurred to the writer that we might be able to apply the very sensitive and characteristic Griess nitrite test, which is ordinarily employed in water analysis, for the detection and estimation of small amounts of TNT or its closely related derivatives which still retain one or more of the NO₂ groups. Of course, the fact that the aromatic nitro compounds in general do not behave as esters of nitrous acid saponifiable by alkali, was rather discouraging to such an idea. A previous attempt along the same line with nitrobenzene, which was not successful, also tended to add to this discouragement. But it was felt that in the case of TNT, containing as it does three NO₂ groups, we stood an excellent chance of getting at least a partial reaction with alkali which would result in the formation of at least a very small amount of nitrite. And since the Griess nitrite test is so sensitive,² we probably would be able to detect it. Furthermore, even if this reaction should proceed only to a very slight extent, we might still be able to standardize the conditions so as to make this test not only of qualitative value but also fairly quantitative. Without going into the details of the preliminary experiments which were carried out, it may be stated that the results obtained indicated that the Griess nitrite test can be applied to the detection and estimation of small amounts of TNT. The following experiment will illustrate how this may be done:

An ethereal solution of 2,4,6-trinitrotoluene was prepared, 1 cc. of which contained 0.04 mg. of the trinitrotoluene. Portions of this solution corresponding to 0.01, 0.02, 0.03, 0.04, 0.05, and 0.06 mg., respectively, were carefully measured out, by means of a graduated 1 cc. pipette, and transferred into shallow 100 cc. beakers. The ether was allowed to evaporate at room temperature. To each residue there were then added 5 cc. *N* NaOH, the residue was detached from the beaker, with the aid of a glass stirring rod, and mixed with the alkali. The detaching of the residues from the beaker and the mixing with the alkali were effected in all the beakers as nearly simultaneously as possible by working the stirring rod in each beaker for only a few seconds and then proceeding to the next beaker and repeating this process until the residues in all the beakers appeared well detached and mixed. After the alkali had acted on the residue for 40 min., the contents of the beaker were diluted with 35 cc. water and acidified with 2 cc. of 5 *N* acetic acid. Each solution was then transferred to a 50 cc. Nessler tube and made up to the mark with water. The contents of each tube were then

¹ The reason for using a series of small test tubes rather than some special absorption apparatus was that by such an arrangement the scheme adopted would be elastic and adaptable to a greater variety of conditions as to temperature and rate of flow of the air, since we would be at liberty to increase or diminish the number of tubes; and by always having at least one tube remaining entirely free from TNT, we would always have direct proof that the absorption was complete. Furthermore, the simplicity of such an arrangement makes it especially adaptable for field work.

² Also the tubing through which the air has passed, especially the first inlet tube, should be washed with alcohol so as to dissolve the TNT which may have condensed therein. The TNT thus found is then added to that recovered in the other alcoholic solutions.

³ The tubes which are used for the absorption should have marks indicating the height of the column of the 5 cc. of alcohol taken, so that its volume after the absorption could be compared with that originally taken and proper allowance made in case there is any appreciable difference. Such a correction, however, was usually found unnecessary in the work to which this procedure was applied, as no marked change in volume occurred.

⁴ The standards were usually prepared as follows: 50 mg. of the pure trinitrotoluene were dissolved in 50 cc. of absolute alcohol, thus obtaining a solution, 1 cc. of which contained 1 mg. TNT. This was designated as Solution 1. 10 cc. of Solution 1 were then diluted with water to 100 cc., thus obtaining a solution, 1 cc. of which contained 0.1 mg. TNT. This was designated as Solution 2 and was the one generally employed in the preparation of the final standards, although in certain cases where the amount of TNT was comparatively very small, a standard solution of still greater dilution was similarly prepared from Solution 2. These standards were kept in a dark closet, since it was found that light causes the TNT solutions, especially those of the higher concentrations, to acquire color on standing. That Solution 2, however, is fairly stable when kept in a closed bottle in the dark, was shown by a comparative test with a solution which was prepared on May 6, 1918, and another similarly prepared on June 27, 1918. On the latter date, 1 cc. of each of these solutions was mixed with 2 cc. absolute alcohol and 2 cc. water. Each mixture was then treated with 5 cc. *N*/10 NaOH in the usual way. After standing 10 min., no appreciable difference could be observed in the colors of the two solutions.

¹ For example, it has recently been pointed out by Tutin (*Lancet*, Oct. 26, 1918) that "various purgatives (rhubarb, senna, cascara, etc.) contain substances which, when excreted in the urine, give, under the conditions of Webster's test, a red or reddish violet color, which might be mistaken for that produced by TNT."

² Capable of detecting 1 part of nitrogen as nitrite in 1,000,000,000 parts of water.

mixed with 1 cc. of each of the Griess nitrite reagents.¹ After standing 30 min., even the solution which represented only one-hundredth of a milligram of the trinitrotoluene gave a distinct test for nitrite in comparison with the control, and the amount of color in the above series of tubes increased with the increasing amounts of the trinitrotoluene which they represented. In other words, this experiment indicated that even as little as one-hundredth of a milligram of the trinitrotoluene could be detected by means of this nitrite test and that small amounts of it could thus be estimated colorimetrically.

According to the British investigators² of TNT poisoning, when TNT passes through the body it is converted into the 2,6-dinitro-4-hydroxylaminotoluene. It became of interest, therefore, to find out whether the nitrite test could also be applied to this compound. The preliminary tests which were carried out gave encouraging results, but it was found that the test, when carried out by the above described procedure, is not so sensitive in the case of the hydroxylamino derivative as in the case of the TNT itself. As the result of some further experiments, it was found that the nitrite test can be applied to the hydroxylamino derivative in a somewhat different manner from that described above for TNT, which yielded much more satisfactory results. This modified procedure consisted in treating its ethereal solution with the alkali instead of applying the latter to the solid. This modification was found to be especially well adapted for the application of this test to the urines of TNT workers. Without going into the details of the experiments which were carried out, it may suffice in this connection to simply describe the procedure which was finally adopted and used in the examination of the urines of TNT workers.

APPLICATION OF THE NITRITE TEST TO TNT URINES

The procedure which was finally adopted and used for examining the urines of TNT workers was carried out as follows: Placed 20 cc. of the TNT urine in a pear-shaped separatory funnel of about 250 cc. capacity and acidified³ with 10 cc. of 2 *N* H₂SO₄. Added 10 cc. ether and shook thoroughly for 3 min. Allowed to stand until the ethereal and aqueous layers had completely separated. Drew off the aqueous layer and washed the ethereal layer twice, using 2 cc. H₂O for each washing. Added 5 cc. *N* NaOH to the ethereal extract and shook thoroughly for 3 min. Al-

lowed the two layers to separate completely and then drew off the aqueous alkaline layer into a 100 cc. measuring flask. Washed the ethereal layer twice, using 1 cc. *N* NaOH for each washing¹ and adding these washings to the first alkaline extract. After a definite interval from the beginning of the first shaking of the ethereal extract with the *N* NaOH (usually 1 hr. or 2 hrs.), diluted the combined alkaline extract and washings with 50 cc. H₂O, acidified with 2 cc. 5 *N* acetic acid, and made up to 100 cc. with distilled water. Simultaneously with the work on the unknown, a series of standards was prepared by adding known amounts of an ethereal solution of pure 2,6-dinitro-4-hydroxylamino-toluene² to 20 cc. portions of normal human urine and treating these in exactly the same way as the unknown. The amount of nitrite in the final solution,³ obtained as just described, was then compared with the amounts found in the standards.⁴ Some of the results thus obtained are summarized in Table IV.

¹ In all washing operations the shaking lasted 10 sec.

² This compound was prepared in this laboratory, by Dr. J. M. Johnson, as follows: 50 g. 2,4,6-trinitrotoluene were suspended in 250 cc. alcohol, 1 cc. concentrated ammonia water was added, and hydrogen sulfide gas was run in. The mixture was cooled with ice at first but later allowed to warm up during the addition of the gas, which was continued for about 2 hrs. The insoluble portion was then filtered off, using suction. The filtrate was poured into water. A bulky yellow precipitate was obtained. This was filtered off and dissolved in hot 95 per cent alcohol, adding bone char and filtering hot. The crystals obtained on cooling were filtered off and then recrystallized several times from benzene containing a very small amount of alcohol, and finally from alcohol. The product thus obtained weighed 10.5 g. and showed a melting point of 135-136° C. (corr.) which agrees with the melting point obtained by Anschütz and Zimmermann (*Ber.*, 48 (1915), 154).

³ The amount of this solution to take for the nitrite test depends on the amount of residual color it shows. If this is little, 25 cc. of this solution may be taken for the nitrite test, diluting to 50 cc. with distilled water and mixing with 1 cc. of each of the nitrite reagents in the usual way. If, however, the solution still retains considerable color, a greater dilution is usually necessary before applying the nitrite test. In the cases of certain TNT dog urines which the writer had occasion to examine, as little as 2 cc. of the final solution had to be diluted to 50 cc. with distilled water before applying the nitrite test.

⁴ The standards which were usually prepared in connection with this work were those which represented the zero control, 0.1, 0.2, 0.3, 0.4, 0.6, and 1.0 mg. of the hydroxylamino derivative, respectively, in 20 cc. of urine. The 0.1, 0.2, 0.3, and 0.4 mg. standards were prepared by adding to 20 cc. portions of normal human urine 0.5, 1.0, 1.5, and 2.0 cc., respectively, of a freshly prepared ethereal solution of the hydroxylamino derivative, 1 cc. of which contained 0.2 mg. of the solid, and shaking until the ethereal solution was dissolved, acidifying each with 10 cc. of 2 *N* H₂SO₄ and adding a volume of ether equal to the difference between 10 cc. and that which was added as ethereal solution of the hydroxylamino derivative, thus making these standards exactly comparable with the unknown. From this point the unknown and standards were treated exactly alike by the above described procedure. The other standards were prepared in the same way with the only difference that for the 0.6 mg. standard 2 cc. of an ethereal solution of the hydroxylamino derivative (1 cc. of which contained 0.3 mg. of the solid) were used; and for the 1.0 mg. standard, 2 cc. of an ethereal solution of the hydroxylamino derivative (1 cc. of which contained 0.5 mg. of the solid) were used. Similarly, for the preparation of standards of higher value, ethereal solutions of the hydroxylamino derivative of corresponding higher concentrations were used, the maximum volume of the ethereal solution used for the preparation of any one standard never exceeding 2 cc.

It is important that the final comparison be made with a standard, the nitrite color of which does not differ much from that obtained with the unknown, since although in general the amount of nitrite in the final solution increases with increasing amounts of the hydroxylamino derivative, it is not exactly proportional to it. When, however, the nitrite colors of the unknown and standard are not very far apart (not differing more than about 20 per cent), no new standard need be prepared, but the estimation may be made by carefully pouring off into a suitable measuring cylinder sufficient of the more deeply colored solution until the colors of the two tubes match and then calculating the result, in the usual manner, from the proportion of the lengths of the columns of the solutions, the colors of which match.

¹ The reagents used consisted of a 0.5 per cent solution of α -naphthylamine and an 0.8 per cent solution of sulfanilic acid, using 5 *N* acetic acid as the solvent in both cases. See "Standard Methods of Water Analysis," A. P. H. A., 1917, p. 22.

² "The Causation and Prevention of Trinitrotoluene (TNT) Poisoning," Special Report Series, No. 11, Medical Research Committee of Great Britain, 1917, p. 18.

³ As a result of some experiments, it was found that it is unnecessary to use either as concentrated or as much sulfuric acid as is called for in the Webster test, in order to liberate the hydroxylamino derivative. A number of TNT urines which were treated by the above procedure were afterwards subjected to a second similar extraction, but no appreciable test for the hydroxylamino derivative was obtained in the second extracts, thus showing that by the above procedure the extraction is practically complete in one operation. It is believed, however, that in general, 3 *N* H₂SO₄, in the same proportion as the 2 *N* H₂SO₄ which was used in this work, would be preferable, since that would allow a little greater margin for possible variations among different urines.

TABLE IV—SHOWING NITRITE-PRODUCING POWER OF SOME TNT URINES

TNT No.	Designation of Worker	Nitrite-Producing Power of 1000 cc. of the Urine in Terms of the Hydroxylamino Derivative of TNT as the Standard		Urine No.	Designation of Worker	Nitrite-Producing Power of 1000 cc. of the Urine in Terms of the Hydroxylamino Derivative of TNT as the Standard	
		Mg.				Mg.	
1	LI	48	3.9	31	MD	375	3.4
2	LI	638	21.9	32	SD	531	28.9
3	SF	231	12.4	33	MF	793	12.1
4	LD	8	7.7	34	KF	392	29.7
5	LK	16	40.0	35	LI	48	21.7
6	LK	401	38.5	36	LK	192	69.9
7	LK	87	12.1	37	LI	496	17.8
8	SF	205	5.0	38	LI	601	75.7
9	SD	524	1.8	39	LI	638	36.3
10	MD	733	7.4	40	LD	46	33.2
11	MD	133	2.0	41	LI	208	33.2
12	SF	348	2.2	42	LJ	310	2.8
13	SF	372	Negative	43	LD	569	21.1
14	MJ	613	5.0	44	LD	40	107.4
15	MJ	703	2.2	45	LD	314	10.0
16	SD	518	1.8	46	LK	401	15.9
17	SD	523	2.2	47	LE	543	7.5
18	MK	20	1.8	48	LD	568	27.7
19	MI	232	2.2	49	LI	631	80.7
20	MH	237	1.8	50	MK	12	30.0
21	MJ	519	7.7	51	MG	457	26.0
22	MK	195	18.8	52	MD	461	20.0
23	MF	217	31.5	53	LH	615	41.1
24	MF	56	2.9	54	SD	429	21.1
25	SK	146	Negative	55	MD	505	137.0
26	MK	153	3.4	56	MJ	12	8.0
27	MG	198	2.9	57	MI	17	21.1
28	MH	325	5.0	58	SK	146	5.0
29	MI	252	12.1	59	MI	149	21.1
30	MF	278	5.0	60	LG	199	35.5

The results given in Table IV show that the degrees of variation in the abnormality of TNT urines, as measured by the nitrite test, even when dealing with a comparatively limited variety of such urines, are actually more numerous than the comparatively small number of degrees which we are given by the Webster scale referred to above. Hence it is apparent that the procedure which was used in obtaining the results given in the above table enables us to recognize and record differences which by the Webster scale we are unable to handle. The above procedure has also the further advantage in that all the results are expressed in definite amounts of a definite substance and thus enables us to compare the results of different investigators.

Finally, it may be stated in this connection that it is the writer's intention to extend the study of the applicability of the nitrite test to other nitro compounds. In fact, a comparatively large number of experiments along this line have already been carried out. The results obtained thus far indicate that not only can the nitrite test be utilized for the detection and estimation of small amounts of many nitro compounds, but it may even be utilized for distinguishing between different members of this group.

HYGIENIC LABORATORY
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WASHINGTON, D. C.

LABORATORY AND PLANT

POTASH FROM KELP: THE EXPERIMENTAL PLANT OF THE UNITED STATES DEPARTMENT OF AGRICULTURE. PRELIMINARY PAPER¹

By J. W. TURRENTINE and PAUL S. SHOAF
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In 1911 Congress authorized the Bureau of Soils, of the United States Department of Agriculture to investigate the fertilizer resources of the United States.² This authority was granted largely in recognition of American dependence on Germany for all of the large quantities of potash entering fertilizers and the highly undesirable state of affairs resulting from that dependence.

¹ Published with the permission of the Secretary of Agriculture.

² The preliminary report of work done under this authorization was embodied in Sen. Doc. 190, 62nd Congress, 2nd Session, entitled "Fertilizer Resources of the United States," under authorship of F. K. Cameron, R. B. Moore, E. E. Free, J. W. Turrentine, W. H. Waggoner, C. L. Alsberg, W. A. Setchell, G. B. Rigg, F. M. McFarland, W. C. Crandall, E. C. Johnson, A. R. Merz, C. C. Darwin, J. G. Smith, and R. F. Gardiner. This document contained the result of surveys of certain of the areas of growing Pacific coast kelps and showed them to be of large potential importance as a source of potash. A second report was rendered embodying the results of surveys of all the main areas of kelp in American waters from the coast of Mexico to the northwest peninsula of Alaska and was published as Report 100, "Potash from Kelp," under the authorship of F. K. Cameron, W. C. Crandall, Geo. B. Rigg, and T. C. Frye.

ence. This authority was enlarged in 1916 by the enactment of legislation instructing the Bureau to develop methods for the commercial production of potash from an American source and carrying an appropriation of \$175,000. This enactment was consummated late in 1915 and had specific reference to the erection and operation of an experimental plant for the extraction of potash and other values from kelp, the most important source of American potash not under promising private development. The unexpended balance of this appropriation was made available for the fiscal year 1917-18, and in 1918 a new appropriation of \$127,600 was made.

In the fall of 1916 an investigation was made by one of the present writers, of the then incipient kelp-potash industry at that time under development due to a critical shortage of potash and the consequent extremely high prices, to see if this young enterprise bid fair to solve the problem of the establishment of a permanent industry and if the results at that time attained could be made to show aught as to the feasibility of the proposed permanent industry. Especial



FIG. 1—EXPERIMENTAL KELP-POTASH PLANT AS VIEWED FROM END OF PIER

attention was paid to the supply of kelp and the costs involved in securing it as a raw material. The favorable impression created by the survey of these operations led to the formation of definite plans of procedure which were embodied in a report and submitted to the Secretary of Agriculture. Shortly thereafter the order was issued to proceed with the erection of the plant.

PLANT SITE

As a first step, it was necessary to choose a plant site. Various collaborative schemes with other concerns were proposed and invitations to erect the plant at various places and in conjunction with other plants were considered. The kelp-potash industry, as then constituted, was centered around the two points, San Diego and San Pedro, the two most commodious harbors advantageously situated with respect to the supply of kelp. Adjacent to both of these harbors are large areas of growing kelp. In spite of the great advantages of safe harbor and proximity to industrial communities, with their skilled labor and supply houses, an unlimited supply of kelp, one that could be drawn upon without danger of competing with private concerns, was considered of greater importance. Accordingly, it was determined to erect the plant at Summerland, California, a village on the coast of Santa Barbara county, near the city of Santa Barbara, and a spot centrally located with respect to large kelp groves, not only along the coast to the east and west and immediately in front of the village, but also fringing the channel islands, lying twenty miles off shore, a location which at that time was one hundred miles distant from the nearest kelp-potash plant.

Summerland is situated on the coast line of the

Southern Pacific Railway. It affords telephone, telegraph, and electric lighting facilities and a water supply, and is a small producer of crude petroleum. Fuel oil is delivered by pipe line from refineries directly into the storage tank of the plant. It is also connected with both high- and low-tension electric power lines. While being only a small village and affording but limited housing facilities itself, it is connected with neighboring towns by bus lines, thus making it possible to draw upon the labor supply of the entire neighborhood. That part of the ocean upon which it fronts is known as the Santa Barbara channel. Here the coast trends in an east and west direction. Seven miles to the west it curves to the south to form the Santa Barbara point. To the north lies a mountain range several thousand feet in height; and twenty miles to the south, across the channel, lie the islands which are likewise high and mountainous. Thus a virtual harbor is formed, exposed only to winds from the southwest and, more particularly, the southeast. The most common winds are the afternoon breezes from the former direction, causing some inconvenience but little danger to marine equipment; but occasionally during the winter months infrequent storms of some severity are to be expected from the latter direction. These make necessary heavy moorings and no little alertness, and interfere with harvesting operations, but to date have not resulted in any serious damage to the plant's equipment.

The plant is built partly on the beach and partly on the level land lying above an abrupt bluff about 30 ft. in height. This fact has occasioned plans of construction that are not ideal and some resulting inconveni-

ence, but neither of a serious nature. That part of the plant which is on the beach is constructed on a foundation of piles driven through the sand to a solid stratum, and at such a height above the sand as to conform in level with a wharf which extends 700 ft. off shore. The latter reaches a depth of water not only ample for the draught of the kelp harvesters, but also sufficient to escape very materially the effects of the surge of the waves. Excepting times when there is a combination of very high tide and severe storm, the waves do not touch any of the stationary equipment.

PLANS OF PROCEDURE

The situation with respect to the kelp-potash industry as it existed at the time plans for this plant were being developed demanded that the experiments of the Government be directed in such a way that the results therefrom would be applicable to the processes already in vogue; that the plants already operating could be applied to the more elaborate processing of kelp by elaborating the plants rather than rebuilding them. With the single exception of the Hercules Powder Company, which was proceeding from the munitions point of view, all the concerns then entering the kelp-potash industry were developing a process which involved drying as a preliminary step, and all were employing the rotary direct-heat dryer. It was desirable, therefore, to develop a process which could be applied as an elaboration of that already about to be employed. Furthermore, it already has been demonstrated by a long series of experiments conducted on the laboratory scale that dry kelp could be further processed and made to yield potash in a high state of purity and simultaneously various other products probably susceptible of commercialization.

The situation demanded that a plant be constructed which could supply materials for use in experimentation in any quantity and at any time desired, and which could be made to serve as the foundation on which to build a commercial plant of any degree of elaborateness as the various processes, based on the results of the experimentation, were put into operation. The goal striven for was a plant in which kelp was to be processed and made to yield the greatest number of valuable products, all of which were to be produced in commercial quantities and of commercial grades and their cost of production determined. Every step was taken with that goal in view. The ultimate object being the establishment of an industry based on the extraction of potash from kelp, it was realized that to accomplish this end it would be necessary to show a profit obtained, not on paper, but in actual operation. It, therefore, was considered necessary to proceed on such a scale as not to preclude the possibility of producing values in paying quantities.

The purpose of the plant was first, experimentation, and second, production, the latter increasing as elaboration proceeded. It was to yield experimental results, efficiency data, and profits.

A plant was designed which would make possible the processing of 100 tons of wet kelp per day of 24 hrs., the least quantity, it was believed, which could be

treated without danger of precluding profits. This was a quantity which could be supplied by one harvester.

In designing the apparatus and plant lay-out it was deemed wise to adopt, in so far as possible, that apparatus and plan of installation which at that time was being adopted by the concerns then operating. No plant had solved entirely the problems incidental to the handling of kelp in any stage of treatment. Advantage was taken, however, of what was known, and all the information in possession of the majority of the private concerns was made available for the use of the Government. Collaborative relations of the most cordial nature were established with all but one of these organizations and the writers here express their hearty appreciation of the value of the assistance rendered. While following in the still fresh footprints of the other operators, where it appeared certain that improvements in design or character of apparatus could be introduced, the attempt was made without hesitation, although it was realized that time lost in experimentation with the simpler apparatus used in the initial steps of the process would possibly delay the establishment of refined products to an equivalent degree. While but little was known as to methods of handling this new raw material, that little was made of use. From the point where that information terminated it was necessary to proceed with the experience obtained in the handling of other materials of a nature approximating that of kelp, or entirely empirically.

PROCESS PROPOSED

While the plan of work called for the demonstration of various proposed processes, among which was the fermentation process, now happily worked out in magnificent detail by the Hercules Powder Company, the process considered of most immediate importance and probable usefulness, and the one, therefore, adopted, prescribed the harvesting of kelp, its chopping and storage in suitable quantities to make possible an uninterrupted operation of a plant; its drying and destructive distillation, the recovery of the ammonia and other volatile products and their refinement, the leaching of the resulting charcoal for the extraction of soluble salts, the refinement of the residual charcoal, the purification and evaporation of the resulting brine and the separation by fractional crystallization of the potassium and sodium chlorides and iodides, the process yielding, as a main product, high-grade potassium chloride, and, as by-products, salt, iodine, decolorizing carbons, ammonia, and whatever of value could be developed from the crude pitch, oils, and creosote recoverable from the condensable products of destructive distillation.

Construction was begun in March 1917 and the plant was put into operation in August of that year. Soon after beginning construction the entrance of the United States into the European war and the consequent great demand for materials of construction, tools, machines, and all other useful commodities tremendously increased the difficulties attending the construction of the plant, increasing the costs and the time consumed. At the same time interest and en-

thusiasm were enhanced. Of certain supplies the western markets were entirely stripped. It became necessary to enter into the most active competition with other buyers, to proceed in making purchases with the greatest celerity, and to enter the market for second-hand and used materials. A great deal of second-hand materials were employed, such as motors, tanks, iron pipe and fittings, corrugated iron, and various other supplies and apparatus, effecting large savings in money and time. In fact, in some cases, only second-hand materials were available at all, and to refuse them was to go without altogether.

THE PLANT, ITS PRESENT EQUIPMENT AND OPERATION

HARVESTING—The harvesting equipment consists of two harvesters, the "Joseph Priestley," of 100 tons capacity, and the "Mayflower," of 150 tons capacity. The former has been in operation from the beginning, the latter having been added recently as reserve equipment. Both harvesters are equipped with two internal combustion engines for propulsion and have twin screws. The engines are set well toward the stern. On the extreme bow is the cutting mechanism made up of a ten-foot horizontal and two five-foot vertical reciprocating knives, a vertical knife at either end of the horizontal one. These are set in place at the front end of a rectangular steel frame, 10 ft. wide by 20 ft. long, which is mounted in a horizontal plane on a transverse axis and is so pivoted that for cutting it may be tilted down into the water at such an angle that the knives are submerged in the water. This places the horizontal knife at a depth of about 4 ft. below the surface. The rectangular space described by the frame is taken up with a conveyor made up of wooden slats mounted on endless chains. The device is operated by a separate gasoline engine. When the mechanism is tilted into the water, the lower end of the conveyor is situated just behind the knives in such a position that it catches the severed kelp. This travels up the conveyor and from its upper end falls upon the deck. The three knives when submerged in the water together with the surface of the water describe a rectangle, 10 by 4 or 5 ft.; and as the boat, moving forward, shoves them through the water, they cut a rectangular swath through the mass of growing kelp.

Since a large portion of the kelp lies on the surface of the water in lengths of 10 to 75 ft., the yield from each plant is large, although from 40 to 75 ft. are left standing in the water. Thus, practically only the tops of the plants are recovered, a very unfortunate fact when it is remembered that after the growing tip of a kelp frond is severed, the balance of the frond probably dies and rots. It is probable, therefore, that not more than 50 per cent of the kelp plant is utilized, and will not be until some method of harvesting at a depth of 40 to 75 ft. is devised.¹

The kelp as delivered on board is distributed and stacked in the large deck space lying between the cutter on the bow and the pilot house on the stern.

¹ There are other considerations, which will not be presented here, which make it seriously doubtful whether a closer cropping would not do such damage to the kelp groves that any advantage gained would be nullified. This is a problem to be investigated.

The capacities given for the harvesters are the carrying capacities. They are able to harvest at a rate of 25 to 50 tons per hr., depending on the thickness of the kelp, the weather, tides, currents, and other factors. This may be an important matter since it makes possible the delivery of two loads per harvester per day with an almost 50 per cent decrease in harvesting costs.

The speed of the boats is about 7 knots. The harvesters are equipped with complete living quarters and carry provisions for a cruise of several days and any ordinary emergency. Where the situation demands, they go such a distance for kelp that two nights and a day may be consumed in the round trip. The cruising radius, therefore, is determined more by the spirit of the crews than by any other factor. The length of haul only adds that increase in cost per ton of kelp due to fuel consumption. Thus, a kelp plant with a sufficiently mobile harvesting outfit may regard the kelp areas of a very extensive region as its logical source of material.



FIG. 2.—UNLOADING KELP

UNLOADING—The harvested kelp is unloaded by means of an automatic fork which is operated after

the familiar manner of the clam-shell bucket, by means of a derrick and electric hoist. The fork, gripping with its prongs a mass of the long fronds of kelp, is able to lift about 1500 lbs. at a time. Each load is swung over the hopper of a chopper and dropped, the chopper clearing itself before the next load is delivered. Thus a harvester carrying 100 tons may be unloaded in about 3.5 hrs.

The chopper employed consists of a hopper, feeding rolls, and revolving knives, the latter of the type used in ensilage cutters. They revolve at such a speed relative to that of the feeding roll that the kelp is cut into about 6-in. lengths.

Derrick, hoist, and chopper are situated on the wharf at a height of 10 ft. above mean high tide, and at a distance of about 600 ft. from the shore. Drag conveyors of pindle-chain and wooden slats begin at the chopper and extend up the wharf to the top of a storage bin erected on the beach. They receive the kelp from the chopper and deliver it into the bin in a practically continuous stream. The juice from the kelp acts as a very effective lubricant and speedily covers the moving parts of the conveyor so that it operates with the greatest ease and minimum consumption of power. The cost of conveying kelp, it may be said in passing, is practically negligible when compared with other items of expenditure involved in connection with a kelp plant. In designing the lay-out of a plant, therefore, only secondary consideration need be given the matter of delivery of kelp into the plant.

STORAGE—The storage bin is divided into two compartments, each of a capacity of 300 tons of raw kelp. Its bottom slopes from two sides toward a central line along which runs, in a trough beneath the floor, a drag conveyor, which likewise passes through the bottom of discharging wells at both ends of the bins. The kelp slides upon itself and down the sloping bottom and thus delivers itself into immediate proximity to the conveyor. When the bin is full it is discharged through the wells at either end, and, when almost empty, through openings in the floor made by lifting boards which cover the conveyor trough. The rate of discharge is controlled accurately by a workman, called a feeder, who develops no little skill in maintaining the constancy of flow of the issuing kelp. This stream of kelp is maintained continuously day and night and is delivered by the conveyor into a distributor which divides it equally between two dryers.

The kelp on standing a few hours undergoes some fermentation, and under its own weight gives up large volumes of juice. This on analysis shows about the same potash and nitrogen content as the kelp itself. It, therefore, is conserved carefully and is charged into the dryers together with the kelp. Strictly fresh kelp is hard to dry uniformly, the thin leaves often being entirely burned up in drying while the stems remain wet. With a large part of the juice expressed and spread over the surface of the leaves and stems it is not difficult to get a uniformly dried product. Therefore the two bins are charged and discharged in rotation so that the kelp may be permitted to stand for at least a day before being delivered into the dryers, and it is

for this reason that a double instead of a single bin is used.

DRYING—Three dryers are installed. They are of the direct-heat, hot-air type, and are steel cylinders, 50 ft. long by 5 ft. in diameter, mounted in a sloping position on trunions and with a gear ring encircling the dryer so that they can be rotated. Longitudinal shelves are provided on the inside so that the material drying is frequently lifted and dropped as the cylinder rotates. They are operated countercurrentwise, hot air being blown into one end and raw kelp fed into the other. To overcome the opposition of the stream of air, the cylinders are mounted on a slant and the shelves are built with a lengthwise slope so that the kelp is forced toward the hot end of the dryer. Each dryer is provided with a furnace wherein hot air is generated by means of two oil burners each. The furnaces are large enough to make possible the complete combustion of the oil therein, so that no flame, and only hot air, enters the dryers. Low-pressure air is used to atomize the oil being burned, and a forced draught is admitted to the furnaces through the floors. The three dryers enter a common "dust chamber" built of concrete and wood, which in turn leads to a common stack, also of wood.



FIG. 3—INTERIOR OF EVAPORATOR HOUSE

The hot gases enter the dryers at 800° C. and emerge into the dust chamber at 50° C. This loss in heat has involved the absorption of so much water vapor that at the issuing temperature the gases have passed their dew point. Therefore they emerge from the stack as a cloud of mist.

The kelp is dried in two stages. This is to insure a properly dried material suitable for retorting. The stream of raw kelp coming from the storage bin is delivered in two equal parts into the first two dryers. It emerges from these with the greater portion of its water removed, and the combined stream from the two dryers is delivered into the third, where the drying is completed. All three dryers are partially insulated.

RETORTING—A single experimental unit of four retorts is now in operation. Each retort is made up of superimposed sections of fire-clay tubes of 12 in. internal diameter, to make a total length of 18 ft., and is mounted vertically. At bottom and top they are united to iron tubes of the same diameter, those at the bottom being provided with discharging mills

and short receiving hoppers, and those at the top with a sliding lid and a Y-branch for the escape of gas. The four are enclosed in a vertical furnace built on a steel platform and are heated with hot air from a small furnace adjoining. A storage bin for dry kelp is suspended above the tops of the retort so that they can be filled by gravity. A conveyor delivers the dry kelp from the second-stage dryer into this bin.

The gas evolved during distillation is passed immediately into small cyclone condensers, of which there is one attached to each retort, for the separation of the less volatile tar; thence the four streams of gas are led collectively into the bottom of a vertical sheet-iron condenser, which is provided with frequent horizontal baffle plates, and is designed for the condensation of the oily and aqueous constituents of the gas. The resulting condensate separates itself into two layers, one of oils and one of ammonia liquor. A slight vacuum is maintained on the retorts by means of a gas pump which maintains the circulation through the condensers and finally blows the gas through a gas burner into the retort furnace where it is consumed for fuel.

A temperature of about 980° C. is maintained in the space surrounding the retorts. As viewed from above, the empty retorts show a full red heat for a portion of their length and of course the entire portion of the tube inside the furnace is at a temperature approaching redness. The kelp fed into the top gradually works downward, shrinking in volume as it undergoes distillation. The volatile products are drawn upward and exhausted at the top. After passing the zone of most intense heat the char is discharged gradually into the small hopper constituting the bottom of each retort, where it partially cools, and at regular intervals is removed and cooled completely. After being ground, it is stored and is then ready for lixiviation.

The products yielded are heavy and light tar, separable into oils, creosote, and pitch; an aqueous distillate, containing ammonia and various other substances; and a combustible gas, as yet incompletely explored for useful constituents.

A great deal of work has been required to determine the nature of the various constituents of the products of distillation. This will not be gone into here even in summary, although it may be said that an ammonia liquor of full commercial strength results and the oils and phenol bodies give great promise of useful application. The tar is unlike either coal tar or wood tar, although it shows certain characteristics of both.¹

Both the crude tar itself and the oils obtained from its distillation show pronounced activity when used as flotation agents in the concentration of certain ores, amounts as low as 0.1 lb. per ton of ore being highly efficacious. The crude creosote likewise has been found to be highly toxic to bacteria and agencies of decay, especially as applied to wood as a preservative.

¹ This feature of the work was begun at the Forest Products Laboratory of the United States Department of Agriculture, Madison, Wis., by Dr. Geo. C. Spencer, organic chemist attached to this organization, where he enjoyed full advantage of the experience and equipment of the Madison organization. Later he continued the investigation in the laboratory at this plant and now is studying certain phases of it in the laboratories of the Bureau of Soils, in Washington, D. C.

It is evident that it will find a usefulness comparable to that of creosote from wood or other sources.

INCINERATION—The excess of dry kelp over that required by the retorts in the past has been incinerated for the production of kelp ash, a crude fertilizer potash of about 35 per cent K_2O content. For this purpose a rotary kiln is employed, 30 ft. in length and 4 ft. in diameter. It is lined with fire brick and is operated countercurrentwise. A small oil burner projects a flame directly into the kiln from the lower end while the dry kelp is delivered by a screw conveyor into the upper end. The products of combustion are exhausted by means of a fan and delivered into the several dryer furnaces, thence passing through the dryers and dust chambers. Thus the waste heat is utilized, the smoke consumed, and the dust settled. The kelp is reduced to a charcoal and flows out at a low red heat. If piled in heaps, it slowly burns to a loose gray ash, which is ground and sacked for market. It possesses those characteristics which make it a very acceptable potash carrier. It mixes well, does not cake, and contains no deleterious substances.

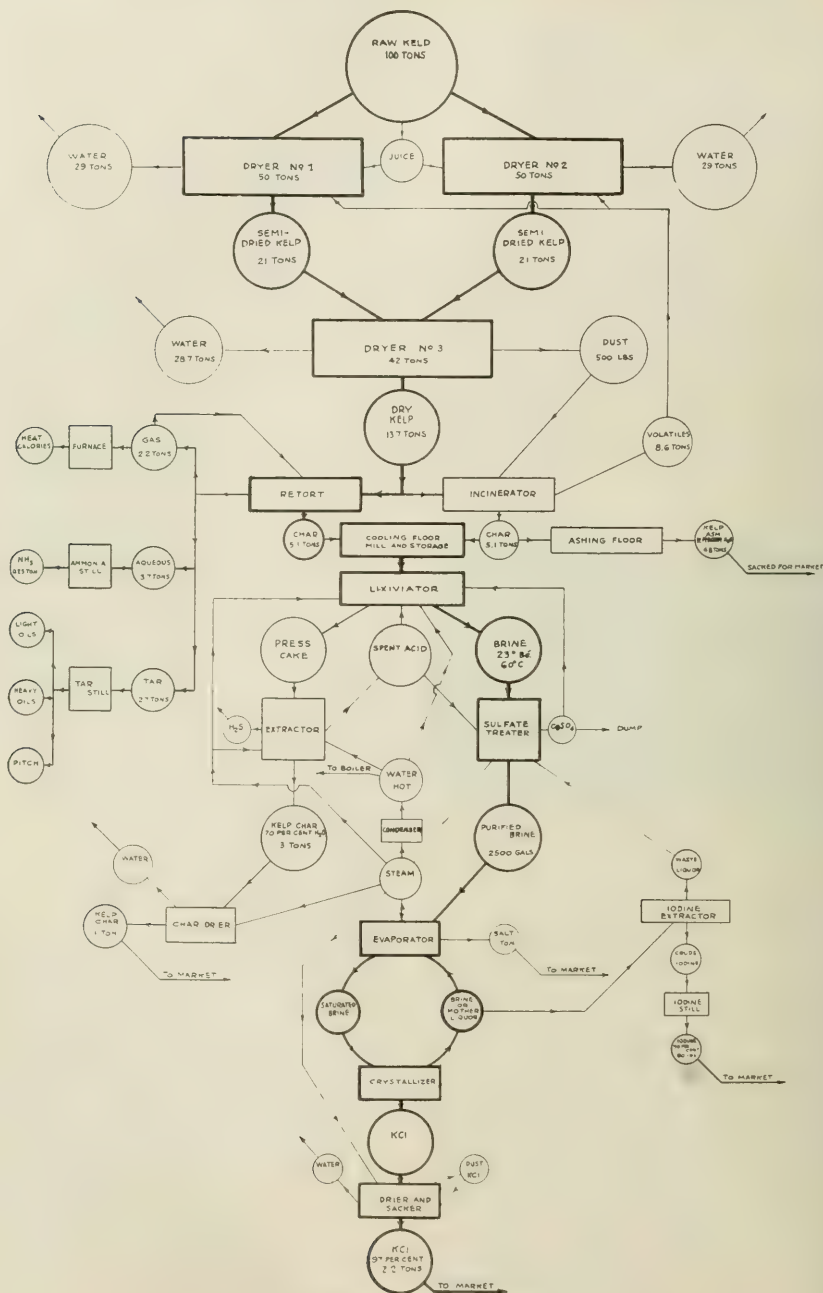
The material thus produced is the familiar kelp ash which, during the recent war, was the product of several kelp-potash plants of this region. Its manufacture at war prices, in certain cases, was highly remunerative.

At present the charcoal produced by the incinerator is quenched instead of being heaped for ashing and is ground and stored for leaching.

LIXIVIATION—The difficulties formerly encountered in the leaching of potash salts from finely divided material in such a way as to secure commercial leaching simultaneously with a highly concentrated solution have been overcome by a device, here installed, and now operated continuously for several months with the greatest success, wherein mechanical filter presses of the rotary, vacuum type, are combined with leaching troughs and in series with each other, so that the material undergoing extraction may be successively leached and filtered and may be passed through the apparatus by gravity in a continuous stream against a current of brine lifted by pumps operated as a part of the filter press equipment. Continuous, countercurrent leaching is effected in an entirely mechanical manner; kelp charcoal enters one end of the apparatus, and a commercially extracted press cake is discharged from the other. The final extraction is effected with fresh, hot water while the first is accomplished by leaching with a brine built up, and of that strength established by preceding extractions. A hot brine of a high concentration is secured, which, after treatment to remove undesirable impurities, is stored for evaporation.

EXTRACTION OF CHAR—The press cake from the lixiviator is further extracted successively with hot hydrochloric acid and water. It has been established by the valuable work of Messrs. Zerban and Freeland¹ that the retorting of dry kelp followed by the proper extraction may yield a charcoal of remarkable activity as a decolorizing agent for various organic liquids and of aqueous solutions of certain organic and inorganic

¹ THIS JOURNAL, 10 (1918), 812.



substances. The charcoal obtained from the retorts in use in this plant has shown an activity of the most encouraging nature, but varying in degree of activity over a considerable range of values. By a one-stage retorting operation carbon has been secured which shows an activity exceeding that of any other commercial carbon obtainable for comparison. It represents a by-product of value and of great usefulness in a variety of industries and offers promise of a highly remunerative product. Conditions surrounding its certain production in its highest state of activity are not yet fully established. In the meantime the lower grades of carbons are being extracted with hot hydrochloric acid and water. For this purpose the press cake, from which water-soluble salts have already been removed by the aforementioned lixiviator, is delivered into acid-proof tanks where it is given successive treatments with acid, sufficient to remove water-insoluble constituents of the char, and with hot water to remove the acid. It is lifted into the system of tanks as a sludge by means of a centrifugal pump, is heated by means of steam coils, is agitated by compressed air, and is filtered over vacuum. The entire treatment is effected by the manipulation of valves in their proper order. Finally, the carbon is dried and sacked for shipment.

EVAPORATION AND CRYSTALLIZATION—After the elimination of sulfates the brine resulting from the leaching of kelp charcoal contains only the chlorides of sodium and potassium, in the ratio of approximately one or two, respectively. These salts are easily separable by the so-called hot-cold method, by which is meant the alternate evaporation to the point of saturation with respect to potassium chloride and then cooling. Upon cooling, potassium chloride precipitates; while upon evaporating, after saturation with respect to sodium chloride has been attained, that salt precipitates.

The apparatus employed is the standard type of vacuum evaporator joined in circuit with a vacuum crystallizer. The former is provided with one salt filter and the latter with two. In operation the hot, concentrated brine from the storage tanks is admitted to the evaporator where it is raised by evaporation to the desired concentration with respect to potassium chloride. It is then drawn over into the vacuum crystallizer where it is cooled by boiling in vacuum, and potassium chloride crystallized. The cooled brine is returned to the evaporator for further evaporation, during which sodium chloride crystallizes. Thus sodium chloride is obtained from the evaporator and potassium chloride from the crystallizer. Circulation back and forth through the apparatus is continued until the mother liquor becomes sufficiently concentrated in salts of iodine to justify treatment for the recovery of that element, whereupon the liquor is withdrawn for storage.

The salts recovered are washed and partially dried in a centrifugal dryer and are then passed through a rotary, countercurrent, hot-air dryer and delivered into a sacker. They are packed for shipment in sacks of 100 lbs. each.

AUXILIARY OPERATIONS—A small laboratory, with working space for about six men and equipped for control work and some research, constitutes a part of the auxiliary equipment of the plant. Analyses are made to effect control of potassium and sodium salts with special reference to potash, water, and sulfur content; density and composition of brines yielded by the lixiviator, the evaporator, and crystallizer; the iodine content of the mother liquor and salts; the potash and moisture content of the press cake; the decolorizing properties of the extracted charcoal; the acid and potash content of the waste liquors from the char extractor; the determination of the ammonia content of the ammonia liquors from the retorts; and the testing of fuel oil and other supplies. In addition to the routine work conducted, special tests are frequently made of raw materials and products respectively entering and yielded by the various apparatus over definite periods of time in order to determine the performance of the apparatus and the efficiencies of the processes.

As additional equipment may be mentioned an office building, shop, supply and locker rooms, storage warehouse, transformer houses, a steam plant of 150 h. p. capacity, and storage tanks for oils and water. The total floor space of the buildings already constructed (exclusive of storage bin and wharf, 8,800 sq. ft.) is 13,800 sq. ft.

RESULTS

The operations of the plant and the products yielded are represented graphically by the flow sheet, Fig. 4. This is based on a daily treatment of 100 tons of raw kelp. In certain cases the quantities yielded are also indicated. In this schematic representation circles are made to express materials and products; rectangles and squares, apparatus.

From an examination of the plan it may be seen that two by-products, iodine and ammonia, of well-understood values, are established as obtainable in commercial form and quantities by the process employed. A third, a highly active decolorizing carbon, is likewise obtainable cheaply and in large quantities. But the certain adaptability of this material to the established industries wherein such agents are used can be shown only by the actual plant test, and that time has not yet permitted. Laboratory tests on a great variety of materials show this carbon to be highly efficient and of great potential value. Conservative estimates strongly indicate that its production as a by-product will be highly remunerative; and that it, combined with iodine and ammonia, may prove to be the solution of the problem of establishing by-products capable of producing revenue sufficient to carry the operating expenses of such a plant. In addition to these, but of less probable importance, may be mentioned the by-products, common salt (obtainable in a state of purity sufficiently high to warrant its exploitation for table use), and the oils, creosote, and pitch yielded by the distillation of the tar.

Fig. 5 illustrates the by-products and derivatives so far established as obtainable, and indicates the source and, in cases, the application of each.

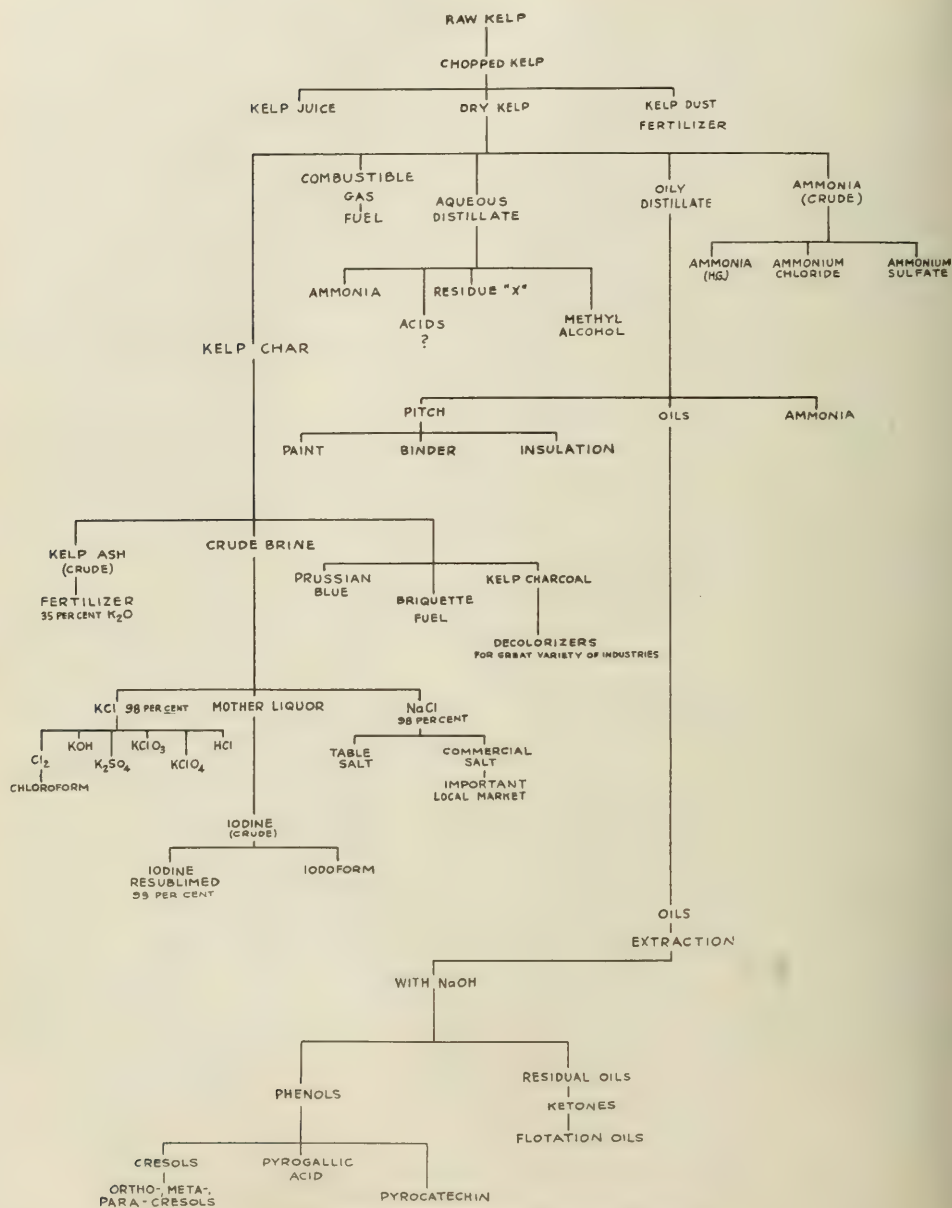


FIG. 5—CHART OF PRODUCTS OF DRY DISTILLATION PROCESS

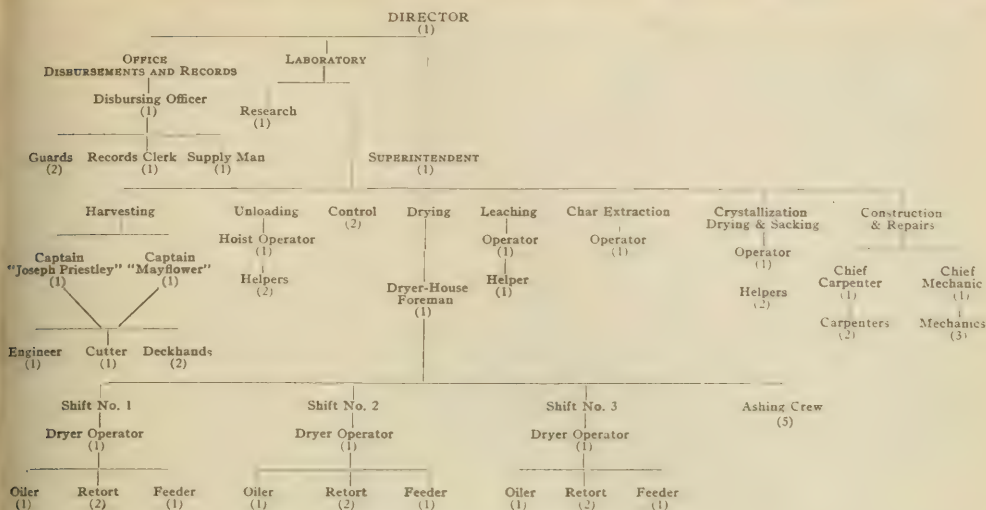


FIG. 6—ORGANIZATION AND PERSONNEL

It has been necessary to operate the plant in a manner as closely approximating that of a commercial plant as the nature of the enterprise would permit, in order to train and to maintain a force of trained operators, not only to provide materials as cheaply as possible but also to test machines and methods of operation, to determine efficiencies and inefficiencies in operation, and to obtain exact cost data as yielded by the large-scale application of methods. Efficiency data have been and are still being taken in detail and covering an increasingly long list of operations, from harvesting the raw kelp to packing the finished products. During the period of warfare just ended it was very gratifying to be able to produce even a small quantity of a commodity in great demand by the military, agricultural, and other industries of the nation. That produced incidentally has been marketed and made to yield a revenue of \$60,000.

Thus, while the main project, the extraction of potash in its most desirable form and the simultaneous development of by-products from kelp, has been under investigation, the plant has been in operation on a producing basis. The great difficulties inherent in the extraction of adequate values from a raw material of such low grade as raw kelp seem to be materially overcome. The results so far obtained—the by-products so far established and the cost data covering the operations yielding them so far determined—indicate in a positive manner the substantial nature of the profits ultimately to be expected from the operation of such a plant.

ORGANIZATION

The administrative and clerical, the research, construction, and operating forces constitute a personnel of about sixty men. Some of these are normal parts of any kelp-potash plant organization, while others are peculiar to such an organization as this where re-

searches are being carried on, test apparatus constructed and altered, and plant elaboration is constantly under development, all of which require a large supplementary force in addition to the normal operating one. Their distribution and duties are represented schematically by Fig. 6.

In addition to the foregoing there are other individuals and organizations with whom collaborative arrangements have been made looking to the investigation of certain problems and the testing of various products. This occasion is taken to express to each of these our heartiest appreciation of their efforts and the helpful results so far reported in connection with the various enterprises which they have undertaken in our behalf.

THE KELP-POTASH INDUSTRY

It was an early prediction that it would not be possible to produce potash alone from kelp in successful competition with foreign potash. Results obtained from the operation of these plants during the war period established cost data which showed the accuracy of this prediction. Of the various plants at one time in operation, only one was designed for by-products, and that one planned the production of materials principally of a war-time value. It being evident then that, without by-products, upon the restoration of pre-war conditions, profits would not be obtainable, as soon as it became evident that these conditions were about to be restored all the privately owned plants promptly suspended operations. During the war period kelp was second in importance among the American sources of potash.

The history of the plants has been enlightening. Aside from demonstrating the availability of kelp as an emergency source of potash, they have shown how it may be harvested and, what is more important, in what quantities. They have demonstrated in the most conclusive

manner that three to four harvests per year may be obtained from the areas of growing kelp, that the kelp promptly restores itself and can be made repeatedly to yield large quantities of raw material without apparent injury to the "stands." During nine months of the year of 1918, 400,000 tons of raw kelp were harvested from the kelp groves of Southern California. This represented repeated cuttings from the same areas. Methods of harvesting were being improved and the conservation of the groves was being practiced so that recoveries seemed to be on the increase. Groves subjected to the most severe cutting show no signs of damage. It may, therefore, be said with certainty that the amount of kelp in the waters of Southern California, immediately available for the purposes of the industry, which it is the design of this enterprise to establish, is 500,000 tons per annum, obtainable without further elaboration in harvesting methods. The kelp of Puget Sound and Alaska has not been subjected to such a test. However, the areas there are well known and it is possible to predict the yields there obtainable.

SUMMARY

I—The Experimental Kelp-Potash Plant of the United States Department of Agriculture, designed for the determination of the best methods of processing

kelp for the extraction of potash salts and the simultaneous recovery of other valuable products, was erected during the summer of 1917 and put into operation in the early fall of that year.

II—One hundred tons of raw kelp per day are subjected to a process involving drying, destructive distillation, lixiviation, evaporation, and fractional crystallization for the preparation of high-grade potassium chloride.

III—The by-products, kelp oils, creosote, pitch, ammonia, bleaching carbons, salt, and iodine are yielded in commercial quantities by this process. The main problem now in hand is their commercialization. It is confidently believed that they will be made to yield sufficient revenue to enable the main product, potash salts, to be marketed successfully in competition with potash from foreign sources.

IV—Complete operating cost data are being tabulated covering the various details of manufacture. These, together with full specifications and designs, will be made available for the use of the interested public.

V—The results obtained to date indicate that it will be possible to establish on kelp as the basic raw material a new American chemical industry of considerable size and of importance and usefulness to the nation.

SUMMERLAND, CALIFORNIA

ADDRESSES AND CONTRIBUTED ARTICLES

INDUSTRIAL AND AGRICULTURAL CHEMISTRY IN BRITISH GUIANA; WITH A REVIEW OF THE WORK OF PROFESSOR J. B. HARRISON

By C. A. BROWNE

Received July 17, 1919

During a recent visit to the British Colonies of tropical America, it was the writer's pleasure to observe some of the most interesting applications of chemistry to agriculture and industry which have ever come under his notice. The chemists of the United States, as a rule, have been so occupied in their own special fields that they have had little time to study the work of their English-speaking confrères farther south. Much of this work deserves to be better known, and in the present paper the writer wishes to describe a few phases of agricultural and industrial chemistry in British Guiana.

Although the first European settlements in British Guiana date back nearly three hundred years, the development of the agricultural and industrial resources of this section of South America can be said to have only begun. An area of over 90,000 square miles, equal to that of the states of New York and Pennsylvania, has a population of only about 300,000. Immense tracts of land are waiting to be cleared for cultivation, large areas of valuable timber remain to be utilized, vast deposits of mineral wealth are still unopened, while back of all these are almost inexhaustible supplies of energy, the water power of the great Kaieteur Falls alone exceeding that of Niagara. The great obstacles in the development of all this latent wealth have been chiefly two—difficulties of climate and scarcity of labor, the second of these factors depending somewhat upon the first. That the sanitary and other difficulties of a tropical climate need not impair the health or efficiency of labor has been sufficiently demonstrated by the building of the Panama Canal. With the example and results of this undertaking before us it is not

difficult to prophesy that a great industrial awakening in the tropical regions to our south will be an important factor in the newer developments which are to follow the recent European war.

The leading exports of British Guiana, in the order of their value, for the year 1917, are as follows:

Sugar.....	\$12,000,140
Distilled spirits.....	2,678,932
Rice.....	1,422,805
Balata.....	954,543
Gold.....	535,349
Diamonds.....	185,787
Sugar by-products (molasses, molascuit, etc.).....	103,535

In addition to the above there are exports of coconuts, coconut oil, coffee, rubber, timber, firewood, charcoal, cattle, hides, and other products with a value of over \$250,000.

A glance at these products of field, forest, and mine shows that the chief industries of British Guiana are agricultural. Descriptions of a few of these industries in their chemical aspects are given.

THE SUGAR INDUSTRY

Since 1664 when Jan Doenson built the first rude horse mill in Essequibo the chief product of British Guiana has been sugar, the value of which with that of spirits and other by-products made up in 1917 fully 80 per cent of the income derived from exports. Over one-third of the population of the colony is engaged, one way or another, in the sugar industry.

The sugar estates of British Guiana form a fringe along the north coast of the colony and for a short distance up the banks of the Essequibo, Demerara, Berbice, and Courantyne rivers. In 1917 there were 36 estates, which produced 114,007 tons of sugar, 3,415,921 gallons of spirits and rum, 149,940 gallons of

molasses, and 2,425 tons of molascuit. According to Professor Harrison, the possible annual crop of sugar in those districts of British Guiana where sugar cane has been cultivated could, with sufficient labor, capital, progressiveness, and scientific enterprise, be increased to upwards of 1,000,000 tons.

The greater part of the sugar output of the colony consists of the "gray" or "dark" crystals (the commercial raw sugar) which are exported to the United States and Canada for refining, and the well-known "yellow" or "Demerara" crystals which are exported to the United Kingdom for direct consumption. On account of reciprocal tariff relations about two-thirds of the sugar of British Guiana are sent to Canada.

Since much of the cane land of British Guiana is below the level of high tide a very expensive system of sea dams must be maintained. The low character of the land has also necessitated the laying out of numerous canals, ditches, and drains which serve the varying needs of drainage, irrigation, and transport. The sugar cane is carried from the field to the factory in large iron punts on canals, the latter in many cases also serving for the transportation of the produce of the estate.

The largest sugar factories of British Guiana have up-to-date milling facilities consisting of crushers and nine-roller mills. The equipment is mostly of British manufacture, although the difficulty of obtaining immediate delivery during the war necessitated the purchase of some machinery in the United States.

In the manufacture of raw sugar or "dark crystals" the cane juice is limed to alkalinity, and heated to boiling, the precipitate of impurities is removed in filter presses, and the clarified juice concentrated in the usual way. The average composition of British Guiana raw sugar, as received at New York, according to analyses made in the New York Sugar Trade Laboratory, is

	Per cent
Sucrose (Clerget).....	95.79
Invert sugar.....	1.40
Moisture.....	1.29
Soluble ash.....	0.60
Insoluble ash (dirt, scale, etc.).....	0.03
Insoluble organic matter (fiber, etc.).....	0.16
Gums, organic acids, etc. (by difference).....	0.73
TOTAL.....	100.00
Direct polarization.....	95.72

A distinguishing characteristic of British Guiana raw sugar

is the low optical activity¹ of the invert sugar, as shown by the slight difference between the direct polarization and sucrose. This characteristic, although not generally known, was observed long ago. Professor Francis, formerly government analyst of British Guiana, noticed this peculiarity in the cane juices and molasses of this colony in his report for the year 1886; Professor Harrison gave the writer similar results from his laboratory note-book of 1890, as for example:

	Polarization (Clerget)	Sucrose Sugar	Invert Sugar
	Per cent	Per cent	Per cent
First molasses, dark crystals (diffusion process)...	43.20	43.39	24.04
Second molasses, dark crystals (milling process)...	33.50	34.80	29.55
First molasses, yellow crystals (milling process)...	50.10	48.50	18.70

In the manufacture of yellow crystals, according to the method

on one estate, the cane juice is first treated with sulfur dioxide, using about $2\frac{1}{2}$ pounds of sulfur to 750 gallons of juice, then neutralized with milk of lime, and heated to boiling. The clarified juice is run off and the mud sent to the settling boxes, where it is boiled with open steam and resettled.

The clear liquid is removed and the mud sent to the filter presses, the liquid and filtrate being added to the main body of juice which is then evaporated to a sirup. When the latter is boiled in the vacuum pan a solution of stannous chloride of 55° Bé. is added in the amount of about one quart to the ton of sugar. The greatest part of the tin salt is washed away at the centrifugals into the molasses, only a trace being left in the sugar. The sulfur dioxide and stannous chloride exert a bleaching action upon the dark coloring matters of the juice, the crystals of sugar thus acquiring a brilliant yellow color.

According to some authorities the tin salt also acts as a mordant and fixes the yellow color upon the crystals. Other authorities, among whom is Professor Harrison, attach greater

¹ The cause of the low optical activity of the reducing sugars in the cane products of British Guiana is uncertain. The phenomenon is produced when an excess of lime is used in clarification but this would not explain its occurrence in the raw cane juice or in the molasses from yellow crystals. The writer observed the phenomenon in Louisiana in juice from canes of advanced maturity but not overripe, and this physiological condition may perhaps be common in British Guiana, where there are several grinding seasons in the year. Mr. Maurice Bird, chemist of the Port Mourant sugar factory in Berbice, British Guiana, suggests that the low optical activity may be due to the high saline content of the cane juice, which results from the excess of salts in the low alluvial soils.

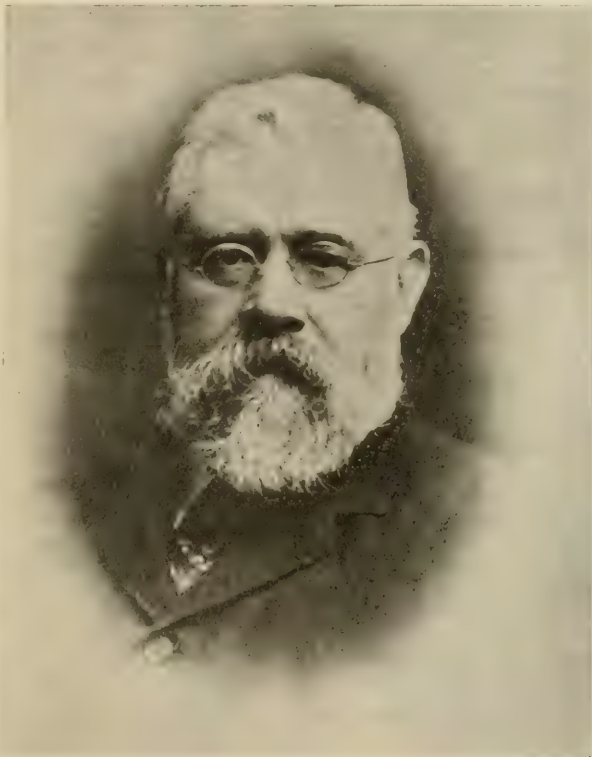


FIG. 1.—PROFESSOR JOHN BURCHMORE HARRISON, C.M.G., M.A. (CANTAB.)

weight to its retarding and preventing the action of the oxidase present in cane juice, and possibly retained in minute quantities in the syrup adherent to the crystals, and which would gradually cause a darkening of the coloring matters retained by the yellow sugars. The cost of manufacturing yellow Demerara crystals was said to be from \$12 to \$15 per ton higher than that of making dark crystals.

The present standing of the sugar industry in its cultural aspects in British Guiana is largely due to the appointment in 1889 of Professor J. B. Harrison to the head of the governmental Department of Science and Agriculture. It is doubtful if any appointee ever entered upon such duties with a better preparation. Before, and while a student at Christ's College, Cambridge, young Harrison came under the influence of such teachers as Gore of Birmingham and Living and Dewar of Cambridge who laid great stress upon the ability of students to devise their own methods and apparatus according to the needs of each special case. The system then in force gave an all-round training in several sciences and in that power of correlation which, as seen in such men as Darwin (also of Christ's College), has been the peculiar endowment of so many Cambridge alumni. After his graduation Harrison worked in 1878 and 1879 upon agricultural chemical research at the Cambridge University Laboratory and for a short time at the Experiment Station in Rothamstead under Sir John Lawes and Sir Joseph Gilbert, after which he entered upon his life work in the tropics by accepting an appointment to the position of professor of Chemistry and Agricultural Science in Barbados.

A very important line of agricultural research with which Professor Harrison became identified in Barbados was the development of new varieties of seedling canes. The ancient custom of propagating the sugar cane by germination of the buds upon the stalk had led to a general belief, notwithstanding occasional reports to the contrary, that the seed, which is borne on a plume at the end of the cane, was sterile. But all doubts as to the fertility of sugar-cane seed were finally overcome by the independent, and almost simultaneous proof of the fact by Soltwedel in Java in 1887 and by Harrison and Bovell in Barbados in 1888.

The discovery of the possibility of developing new seedling canes came at a most opportune time, for early in the nineties the old Bourbon cane, which for many generations had been the chief source of the world's sugar supply, began to degenerate. The cane gradually declined in vigor and succumbed to the attack of fungus diseases. Plantations which at one time made over two tons of sugar to the acre now made less than half of this amount. The sugar industry of British Guiana, threatened with extinction, was fortunately saved by the substitution of the youthful hardier seedlings, which Harrison had developed, to take the place of the old played-out variety. The changes which this development has brought about in British Guiana may be seen at a glance from the following table:

Year	Bourbon Cane Acres	Seedling Canes Acres
1897	70,000	600
1907	40,105	33,665
1918	8,350	69,475

Another very important line of experimental work which Professor Harrison has had under way for the past 30 years is the effect of chemical fertilizers upon the yield and composition of the sugar cane. Cultivated fields with a long record of uniform manurial treatment are the most valuable assets of any agricultural station and the experimental plots which the writer visited at the Botanical Garden at Georgetown have yielded results which have been of the greatest value to the sugar industry of British Guiana.

As regards nitrogen, Professor Harrison's experiments show that when applied to sugar cane in amounts exceeding 50 to

60 pounds per acre, sulfate of ammonia, in quantities of $2\frac{1}{2}$ to 3 hundred weights, is the most economical and efficient fertilizer for heavy clay, alluvial soils. Nitrate of soda under heavy applications is a much less certain source of nitrogen and if repeatedly applied may injure the texture and hence the productivity of the soil. The value with the varieties at present under extensive cultivation in British Guiana, in terms of tons of sugar cane, of 10 pounds of manurial nitrogen in various fertilizers has been estimated by Professor Harrison as follows:

	Tons
Sulfate of ammonia.....	2.00
Nitrolim (calcium cyanamide).....	1.94
Nitrate of potash.....	1.88
Nitrate of soda.....	1.84
Dried blood.....	1.80
Raw chinchas guano.....	1.76
Loloten fish guano.....	1.70
Nitrate of lime.....	1.60
Animal products manure.....	1.20
Stable manure.....	0.70

In connection with the above chemicals it should be mentioned that nitrolim in the hot, moist climate of British Guiana is very unstable and if stored for any length of time will lose the greater part of its nitrogen.

As regards phosphoric acid, the returns are less pronounced than in the case of nitrogen. Superphosphate of lime is the best form of phosphoric acid for long-cultivated fields with alkaline subsoil water, but on land which has not previously been cultivated with sugar cane, or which has been flooded for long periods, slag phosphate will as a rule give the best results.

In case of potassium the normal weathering of the soil constituents is found to set free more potash than is needed for crop requirements in British Guiana and the addition of potassium salts was found to produce little if any increase in the yield of sugar cane.

The work of the experimental plots at Georgetown is controlled by careful meteorological data, such as observations of air and soil temperatures, solar radiation, humidity, sunshine and cloudiness, rate of evaporation, and rainfall. In connection with this work Professor Harrison has made some interesting observations upon the composition of the various salts which are removed from the air by rain and dew—a line of investigation in which he first became interested at Rothamstead. The salinity of the rain water collected at Georgetown during the three years 1916–1918 was 8.76 mg. per l., the total rainfall during this period being 266.3 in. The percentage composition of the solids was as follows:

Ions	Percentage
Chlorine.....	32.26
Sulfate.....	13.99
Carbonate.....	10.56
Nitrate.....	9.46
Silicate.....	1.01
Iron (ferric).....	1.65
Alumina.....	0.35
Calcium.....	8.31
Magnesium.....	3.45
Potassium.....	2.01
Sodium.....	16.63
Ammonium.....	0.25
	99.93

A comparison of this analysis with that of the solids of sea water shows that only about 58 per cent of the saline constituents in the rain at Georgetown are due to the so-called cyclic salts derived from the fine spray of the sea, the remaining 42 per cent being due to terrestrial and cosmic sources.

The complexity of the composition of the salts in rain and dew explains its suitability for the growth of the microorganisms which have such a destructive action upon various commodities in the tropics and also how these precipitated salts aid in the nutrition of vegetation upon soils of exceptionally low fertility.

SUGAR BY-PRODUCTS—SPIRITS AND MOLASCUIT

Next in importance to sugar itself, among the exports of British Guiana, are the sugar by-products, alcoholic spirits and molascuit.

British Guiana is the largest producer of rum of all the West Indian Colonies, its production from pot stills alone being 12 per cent higher than that of Jamaica. The distilleries are of three kinds: (1) pot or vat stills, (2) pot stills combined with Coffey or other continuous rectifying stills, (3) Coffey stills alone. The majority of the stills are of the first kind. There are ten large continuous rectifying stills, such as the Coffey still, which were built locally, the columns being constructed of native lumber.

In setting up the wash for fermentation the molasses is diluted to about 1.060 specific gravity, one pint of concentrated sulfuric acid being added to every 100 gallons (British) of wash. This quantity of acid is sufficient to liberate more or less of the combined organic acids, without leaving any uncombined sulfuric acid in the wash. A certain degree of acidity is necessary in order to secure the best conditions for the alcoholic fermentation and to prevent the growth of injurious butyric organisms. In addition to sulfuric acid some distilleries add one pound of ammonium sulfate to every 100 gallons of wash in order to supply the yeast with readily available nitrogenous food. The fermentation of the wash is completed in 48 hours, except on the first setting up of the season, when about 72 hours are required. This is in marked contrast with the process in Jamaica which employs a fission type of organism in place of yeast and requires from two to three weeks for fermentation of the very acid wash. As a consequence of this difference in process the Demerara rums have an ester content varying from only 63 to 104 parts per 100,000 of absolute alcohol, while the Jamaica rums vary from 500 to 1500 parts.

The specific gravity of the wash at the end of fermentation is usually about 1.010, which corresponds to an attenuation of 50 degrees (1060 minus 1010). In case of molasses from the yellow Demerara crystals an attenuation of 55 or more may be secured. Good estates in British Guiana with modern stills are able to produce approximately one gallon of British standard proof spirit for each 5 degrees of attenuation from every 100 gallons of wash obtaining about 90 per cent of the theoretical yield. The distillate from the stills, if made into rum, is taken off at 47-48 overproof and is diluted to 42-43 overproof with water and caramel.

The caramel used for coloring the rum is usually made on the spot: 250 pounds of low grade sugar and 4 pounds of caustic soda melted down in an iron pot is the formula used in one distillery for making color. It was stated that about 17 pounds of sugar were used to make the color for a puncheon of rum (100-105 gallons). The addition of the caramel obscures the reading of the Sikes alcoholometer to a slight extent; this obscuration is not permitted, however, to exceed 1°.

Molasses being the chief material for fermentation, the distilleries of the colony are for the most part connected with the sugar factories. The yield of final molasses varies usually from 50 to 70 gallons per ton of sugar and the yield of 42-43 overproof spirits from 30 to 35 gallons per ton of sugar. The prices received f. o. b. Georgetown during 1918 were 5½ cents per pound for sugar and 60 cents per gallon of proof spirits.

Since 1904 a certain amount of the molasses of British Guiana has been used for making the cattle food called molascuit, which consists of a mixture of about 80 parts of molasses with 20 parts of the fine spongy tissue obtained from the bagasse of the cane mills. The product consists of a dry, brown-colored material of a fragrant odor and is greatly relished by farm animals. In the early days of the industry some trouble was experienced from spontaneous combustion of the product and steamers have come into New York with their cargo on fire from this

cause. The danger of spontaneous combustion of molascuit has been overcome, just as in the case of the beet molasses and alfalfa hay mixtures in the United States, by boiling the molasses to a density of 48° to 50° Bé. and mixing it hot with the dry absorbent. In this way the percentage of moisture in the final product is kept below 12 per cent under which limit there is no danger of heating from fermentation, and no exudation of molasses. A penalty is usually exacted from the seller in case the moisture content of molascuit exceeds 12 per cent. In some years the exportation of molascuit from British Guiana has exceeded 12,000 tons, but war conditions have lately reduced the production of this by-product.

BALATA

The collection of balata, the congealed latex of the tree *Mimusops balata*, is the fourth most important industry of British Guiana. The first sample of balata was sent to London in 1859. Manufacturers did not at first have much success with this substitute for gutta-percha, but later experiments were more favorable and since 1890 there has been a steady increase in the exportation. In 1911 over one million pounds of balata were shipped and this figure had increased in 1917 to 1,595,888 pounds. About 80 per cent of the output goes to the United Kingdom and the remaining 20 per cent to the United States.



FIG. 2—METHOD OF BLEEDING TREES FOR BALATA

The balata trees are bled by means of a cutlass, incisions being cut not more than 1½ inches wide, about 10 inches apart, in a "feather-stitch" pattern up one side of the trunk. No tree can be bled unless it has a girth of 36 inches, 4 feet from the ground, and no tree can be reworked until all the previous incisions are entirely healed, which is said to take 4 to 5 years. The latex runs zig-zag down the course of the cuts into a gourd-bash at the base of the tree from which it is collected into gauls or kerosene cans. After carrying to camp, it is poured into shallow trays which hold from 5 to 30 gallons. As the latex congeals it is taken off in successive sheets until only the mother liquor is left in the tray. The sheets of balata after draining are hung up in sheds to dry, and they are then ready for shipment. On their first cutting trees give an average of 1 gallon



FIG. 3—CAMP OF A SCIENTIFIC EXPEDITION TO THE NORTHWEST DISTRICT OF BRITISH GUIANA IN 1897

Seated, Left to Right: 1. An indian. 2 Prof. J. B. Harrison. 3 Dr. Kauffman, formerly assistant to Professor Harrison. 4. H. I. Perkins, formerly commissioner of mines in British Guiana. 5. J. J. Quelch (with the gun), zoologist and formerly curator of the British Guiana Museum. Standing in back are several Arawak indians, a black man, and an East Indian (with the butterfly net)

of latex, equivalent to 5 pounds of dried balata. Subsequent bleedings are said to give a smaller yield.

The collection of balata on the government lands is regulated by licenses which are issued for a term not exceeding 15 years and with the privilege of cancellation should the land be required for agricultural or mining purposes.

The composition of British Guiana balatas according to analyses by Professor Harrison is given in the following table:

BRITISH GUIANA BALATA. AIR-DRIED CONDITION. SAMPLES ARRANGED IN ORDER OF GUTTA CONTENT

Location of Sample	Water Per cent	Resin Per cent	Gutta Per cent	Impurities—				Color	Remarks
				Vegetable	Other	Pro-	Mat-		
				Per	Per	Mat-	Min-		
				Per	Per	ter	eral		
Courantyn District.	2.6	34.4	48.1	4.2	9.9	0.8		Dark brown	
Supenaam	6.0	38.2	47.1	1.8	6.3	0.6		Light mauve	No
Siparuni	2.4	37.5	47.0	4.4	8.0	0.7		Light brown.	No
Berbee River	2.9	39.7	45.5	3.4	7.8	0.7		Light color (brown).	No
Cuyuni River	3.1	35.2	44.9	4.3	11.2	1.3		Dark brown surface	air cells
Pomeroon River	3.5	38.8	44.5	2.1	10.2	0.9		Brown, white	slightly mouldy
Takatu River	2.8	38.5	42.7	2.3	12.8	0.9		Light brown in	air cells
								center to dark	
								at edges	
Rupununi River	2.8	37.2	42.4	5.0	11.9	0.7		Light purple	
Lower Essequibo.	3.2	41.6	42.3	3.2	8.8	0.9		Dark color (Purple)	No
								No air cells	

GOLD

After balata the next export of importance in British Guiana is gold. Although expeditions in search of this mineral had

been made as early as 1720 it was not until 1863 that any organized efforts were made in the way of prospecting. The actual operations of gold mining did not begin, however, until 1886, from which date the production of the metal steadily rose.

The gold of British Guiana is largely obtained from alluvial dredgings on the Konawaruk river and along the Mahdia and Minnehaha creeks and from alluvial placer workings on the Potaro, Mazaruni, Puruni, Cuyuni, and Barima rivers and their tributary streams. The placer washing is performed in small boxes called "toms" or in larger boxes called "sluices," the gold which is liberated being caught by mercury in "riffles" below the screen of the "tom" or along the length of the "sluice." At the end of the day the riffles are removed, the amalgam of mercury and gold is squeezed in chamois skin to remove the excess of quicksilver and the residue is roasted in a flat, iron dish until the mercury has volatilized. The gold remains behind as a dull yellow mass.

A reconnaissance of the gold-bearing formations of the colony has been made by Professor Harrison, who, among other scientific appointments, holds the position of Government Geologist. In his presidential address before the Royal Agricultural and Commercial Society in 1918, Professor Harrison had this to say about the auriferous deposits of Guiana:

At first sight it would appear as though the prospects of our country for the future production of gold are gloomy in the extreme. This is not so; and I am satisfied that sooner or later after the termination of the war the prospects will very greatly improve. There are—there must be—other valleys in the vast

interior of the colony having a structure similar to that of the Mahdia and Minnehaha valleys, a country of more or less auriferous aplite and aplitic granite intersected by the many feeders of one of the great sills of diabase which are so characteristic a feature of the interior of Guiana. The igneous and metamorphic rocks of the colony are practically all auriferous, carrying either original or far more usually secondary gold, the metal being of course present in them in only very minute proportions. The great geological age of the country has resulted in the destruction of the auriferous quartz-aplite veins with resultant concentration of their gold content in their remnants. This has given rise to reefs exceptionally rich in gold at their present outcrops owing to secondary enrichment, but becoming non-payable or petering out at depth. There must be other enriched masses and reefs not yet found to reward the future prospector.

BAUXITE

An industry of rapidly growing importance in British Guiana is the mining of bauxite, which has been found in various places extending a length of over 200 miles. The most extensive deposits known at present are in the Christianburg Akyma district of the Demerara river, where the bauxite has a thickness in places of some 18 to 24 feet. The discovery of these immense deposits was made by Professor Harrison in 1897, while engaged upon a geological survey of the Akyma district. The composition of the bauxite collected by Professor Harrison at the time of its discovery is given in his report of 1910, as follows:

	Christian- burg	Akyma
Quartz.....	0.42	0.67
Colloid silica.....	0.14	0.12
Combined silica.....	2.29	1.92
Aluminum oxide.....	67.28	64.86
Iron peroxide.....	1.53	0.85
Magnesium oxide.....	0.07	0.31
Calcium oxide.....	0.02	0.03
Sodium oxide.....	Nil	Nil
Potassium oxide.....	0.08	0.15
Combined water.....	25.46	30.47
Titanium oxide.....	1.07	0.75
Phosphoric anhydride.....	Trace	Trace
Manganese oxide.....	Nil	Nil
	100.36	100.13

The origin of the bauxitic deposits of British Guiana is a geo-chemical problem to which Professor Harrison has devoted a great deal of attention. The principal source of primary ferruginous bauxite or laterite, from which the gibbsite and other hydrates of aluminum are derived, appears to be rocks with from 48 to 54 per cent silica, such as diabase and epidiorite or hornblende schist, these latter rocks being metamorphoses of a gabbro or diabase of Archaean formation. A study of the composition of these rocks, of the layers of bauxitic laterite upon their surface, and of the seepage waters which flow therefrom, proves that the conversion of the rocks into bauxite is due to the action of carbonated waters, the iron, calcium, magnesium, sodium, potassium, and silica being removed in solution and the aluminum being left behind as a hydrate. Elsewhere in the Colony a similar action has resulted in the formation of vast surficial beds of concretionary or lateritic ironstone.

RESEARCHES OF PROFESSOR HARRISON UPON TROPICAL SOILS

The studies of Professor Harrison upon the decomposition of diabase and other siliceous rocks into bauxite are related to and arose from a broader and much more general research, upon which he has worked for nearly 40 years, *vis.*, the formation and composition of tropical soils. In its ultimate phase the study of soils is not simply an agricultural problem, as is sometimes imagined, but involves industrial and economic questions of the greatest significance, for the soil, in whatever way we consider it, is that upon which not only manufacturers and commerce, but all the phases of man's social life depend. Probably no other kind of research requires the correlation of so many sciences; questions of geology, mineralogy, chemistry, physics, and meteorology are mutually involved as well as those of biology and agriculture.

On his first visit to Professor Harrison the writer found him at his beautiful home in the Georgetown Botanical Gardens, of which he is in charge as Director of Science and Agriculture, engaged in a microscopic study of the natural decomposition products of rocks. As a prelude to describing his work he unfolded a large geological map and showed how the soil of lower British Guiana had been built up, by the deposition from the northwesterly Amazon current, of thick layers of clay and arenaceous earths upon a bedrock of Archaean complex and aided later by additions of alluvial deposits from the Essequibo, Demerara, and other rivers of more recent geologic time. The belt of coast and river land, which had thus been derived from the detritus carried by the Amazon current and that of the upper watersheds, is of exceptional fertility and probably among the richest in any part of the world. The wonderful fecundity of the alluvial lands, which are the first to meet the stranger's attention, seemed to many only a presage of even greater fertility in the great plateaus further back; these upper lands came thus to be regarded as of unusual richness. Professor Harrison, however, shortly after his arrival in British Guiana showed that this idea was a false one and, as is so often the case, gained no small degree of unpopularity by so doing.



FIG 4—PROFESSOR HARRISON IN HIS PRIVATE LABORATORY

The meteorological, biological, chemical, and physical forces which convert igneous rocks into quartz sand, kaolin, bauxite, limonite, and other residue, remove from these rocks by elutriation the lime, potash, and other elements essential to fertility, these elements after their removal contributing to the richness of the alluvial low land. The residual sand, kaolin, bauxite, etc., which are left on the uplands after this process of leaching, give rise to a soil of comparatively low agricultural value although it may be covered by a seemingly unexhaustible growth



FIG 5—SECTION OF THE GOVERNMENT LABORATORY, GEORGETOWN, BRITISH GUIANA

Left to Right the Men in the Laboratory are: 1. Mr. C. L. Bourne, scientific assistant. 2. Lt. L. S. Davis, second assistant analyst. 3. Mr. K. D. Reid, first assistant analyst. 4. Ragoen, laboratory messenger. 5. Mr. C. B. Anderson, third assistant analyst.

of timber. Professor Harrison mentioned the fact that great losses of capital had been incurred in certain tropical countries by attempting to raise economic products upon lateritic or kaolinic uplands, which, from their being covered with thick forest, were considered to be of great fertility.

A problem no less interesting than that of the formation of tropical soils is that of the chemical changes which take place within these soils as a result of cultivation. Under the favorable action of a humid tropical climate the processes of oxidation, hydration, and nitrification advance with great rapidity, the elements of plant food being unlocked and made available in a much shorter period than in temperate zones. This would be a decided advantage were it not for the fact that the forces which impair fertility are equally rapid. Moreover the soil waters of British Guiana contain in solution a high percentage of the chlorides, sulfates, and carbonates of sodium, potassium, magnesium, and calcium which tend to accumulate near the top of the subsoil as a result of capillarity and evaporation; the chemical changes which take place within the soil are therefore as complex as they are rapid. As one result of those changes the soils of the heavy clay sugar-cane lands in British Guiana become markedly alkaline during cultivation and this alkalinity may become so excessive during dry seasons that the growth of crops is affected. Constant drainage is needed to remove this accumulation of alkaline salts; periodic flooding of the land is also found to be beneficial. The alkalinity of Guiana soils is made most evident to the eye by the solution of humus which colors the drainage waters a dark brown, and it is imperative for the maintenance of fertility that the humus thus removed be made good. Professor Harrison's experiments show that when the soil contains much organic matter undergoing active

oxidation, the surface soil water during its concentration remains saturated with carbon dioxide and its evaporation takes place into an atmosphere of this gas. Under these conditions the calcium compounds in the soil water are retained in solution where they serve to modify the toxic action of the poisonous magnesium salts. When the soil, however, is deficient in humus there is not sufficient carbon dioxide to keep the lime salts of the soil water in solution, in which case the toxic action of the magnesium salts becomes very marked during dry seasons. Professor Harrison found the molecular ratio of calcium to magnesium in the surface water of a fertile field to be 1 to 2.40 and in that of a barren field 1 to 6.6.

THE WORK OF THE GOVERNMENT LABORATORY IN GEORGETOWN

A paper of this kind would not be complete without some reference to the chemical work of the Government Laboratory of which Professor Harrison is director. The government chemical work, which in a large country is distributed among many bureaus, must necessarily be concentrated in a small colony under one office. The chemical laboratory at Georgetown is engaged, therefore, in very diverse lines of work; it is a Bureau of Standards, a Customs laboratory, a toxicological laboratory, a food and drug inspection laboratory, a mineralogical laboratory, a hygienic laboratory, an agricultural and industrial laboratory, all in one. In the year 1916 the samples tested numbered 5,670, which included such a miscellany as foods, beverages, waters, drugs, oils, varnishes, medicines, petroleum, gasoline, tobacco, sugar canes, sugars, molasses, soils, fertilizers, minerals, balata, rubber, opium, testing viscera for poisons, and verifying hydrometers and other apparatus. For doing miscellaneous work of this description the governmental

laboratory at Georgetown is one of the best equipped which the writer has ever visited.

A tropical laboratory, being far removed from the manufacturing centers of apparatus, must of necessity be more self-dependent than laboratories which are more fortunately situated, and this is particularly true in the making of repairs. To mend a platinum dish and to blow an absorption bulb are among the lost arts for most chemists, yet they have become by necessity commonplace operations for Professor Harrison and his competent staff of assistants.

The overhauling and repairing of balances, polariscopes, and other apparatus which are used at mines or plantations is also a part of the work of the government laboratory. As regards polariscopes, microscopes, and other optical instruments, the necessity of repairs is not due so much to breakage as to a tropical mold, the mycelia of which will etch and corrode the calcite prisms or glass lenses unless immediately removed. The growth of this mold is due to the excess of moisture in the air, which, as Professor Harrison pointed out, condenses upon the surfaces of the glass or calcite and carries with it from the air enough of the sodium, potassium, magnesium, calcium, and ammonium salts to act as an excellent nutritive medium for the growth of microorganisms.

Manufacturers of apparatus for the tropics have unfortunately not taken into account the peculiar needs of tropical conditions. Polariscopes, spectroscopes, and other apparatus are shipped with their lenses and prisms so encased in protective devices, that the parts which require most attention are made the least accessible. As an example of this Professor Harrison pointed out a German saccharimeter with a specially designed tropical protective equipment of great complexity which was worse than useless, for the compartments which held the analyzer and polarizer became in reality inaccessible moisture chambers, especially suited for the development of fungi. In contrast with this instrument Professor Harrison took from his cabinet two French saccharimeters which had successfully withstood the effects of the tropics for over 35 years. The instruments were so designed that their parts were readily accessible and he dissected one of them completely in a few minutes without removing a screw or using a tool, all the parts slipping or screwing easily into place. With such an instrument it is easy to remove the lenses and prisms for cleaning or for placing in desiccators during periods of non-use; accessibility of parts and the employment of glass which will not devitrify under tropical conditions of heat and humidity are two chief requisites which manufacturers should consider in designing apparatus for tropical use.

Professor Harrison spoke of the immense and most attractive field of research which awaits the chemist who cares to investigate the gums, resins, waxes, alkaloids, glucosides, essential oils, and other organic constituents of the numerous tropical plants that have as yet remained unstudied. But researches of this kind must belong to the future. In his own pioneer investigations Professor Harrison very wisely selected the agricultural, mining, industrial, and hygienic problems which were of most pressing importance to his colony. For variety, scope, and economic value his 30 years of scientific work in British Guiana form a record without parallel and one of which a general paper of this kind can give but a fragmentary and imperfect picture.

Professor Harrison has been a member of the AMERICAN CHEMICAL SOCIETY for 25 years and it is a satisfaction to its members to know that he has accomplished so considerable a part of his scientific work during the time of this connection. His AMERICAN confrères extend to him on the occasion of this twenty-fifth anniversary their heartiest congratulations and best wishes.

NEW YORK SUGAR TRADE LABORATORY, INC.
80 SOUTH STREET, NEW YORK CITY

CHEMICAL LITERATURE¹

By HARVEY F. MACK

Chemical literature made its first appearance in Easton about thirty years ago, when Dr. Edward Hart brought out his first issue of the *Journal of Analytical and Applied Chemistry*. This journal, while small in number of pages—about 32 pages per issue—immediately gained favor and was readily sold. To-day unbound issues of it are unobtainable.

The present journal of the SOCIETY was printed in New York in 1892 and prior thereto, but in 1893 the printing and distribution of our journal, then a comparatively small affair, was undertaken by Dr. Hart, and his *Journal of Analytical and Applied Chemistry* was discontinued a few months later. Its continuous issue at this postoffice has been uninterrupted ever since.

With the appearance of two chemical journals, Easton became a center for chemical literature.

Easton had no other chemical journals until 1895, when Dr. Hart secured the printing of Dr. Ira Remsen's *American Chemical Journal*. While manufactured in Easton and essentially one of our products of chemical literature, it was not mailed at this postoffice, but was shipped by express to Baltimore and mailed from Johns Hopkins University. It was produced in Easton continuously until merged with the *Journal of the American Chemical Society* in 1914. While it deserved and enjoyed a place of merit in the family of chemical journals, it never gained a large circulation, but did have a small and select one. The largest edition printed did not exceed 750 copies with an average of 100 pages per issue.

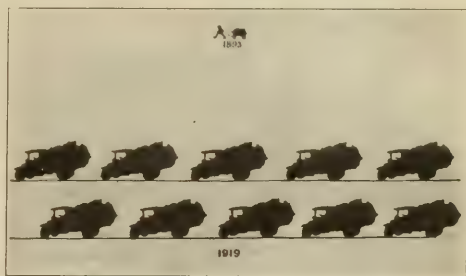


FIG. 1.—Above: Vehicle required to transport one month's issue of chemical literature in 1893. Below: Motor trucks required to transport one month's issue in 1919

1897 brought the *Journal of Physical Chemistry* here. It was then and is still printed here but shipped to Cornell University for distribution. It has an average of 500 copies of 90 pages for 9 numbers per volume.

The next journal to come to town was the *Journal of the American Leather Chemists' Association*. This, compared with our journal, is an infant, but yet occupies a necessary place in its chosen field. The monthly average is 650 copies of about 50 pages.

In 1907 the AMERICAN CHEMICAL SOCIETY started the first volume of *Chemical Abstracts*, issued semi-monthly. We, of course, know that this is the largest journal of its kind in the world. The year 1909 saw the first issue of the *Journal of Industrial and Engineering Chemistry*. This journal, issued monthly, is a peer in chemical literature.

One of the latest arrivals in Easton is the *Journal of the American Pharmaceutical Association*. The first issue of this journal was published here in 1917. This is the official organ of the

¹ Address before the Lehigh Valley Section of the American Chemical Society, at Easton, Pa., April 18, 1919.

American Pharmaceutical Association. It has a monthly circulation of 3,000 copies of an average of 116 pages. This association also issues a yearbook containing reports on the progress of pharmacy. It is a bound volume of 3,000 copies to the number of from 600 to 750 pages, and has been issued from Easton with one exception for the past five years.



FIG. 2—Book on left is one month's issue of chemical literature in 1893. Book on right illustrates size of volume which would be required to issue one month's chemical literature to-day.

Last year the American Ceramic Society, which always issued their proceedings and papers in a yearbook, started their monthly journal. Vol. I had an edition of 1,800 copies of an average of 84 pages per issue. Vol. II, 1919, has jumped to 2,000 copies with a tendency to increase the number of pages.

The latest babies to arrive are the *Journal of the Washington Academy of Science* and the *Journal of the Entomological Society*. They both contain 32 pages or less, the former 1,000 copies per issue twice a month and the latter 500 once a month.

The issue of chemical literature is not alone confined to the printing of periodicals. Easton is now known among the institutions of learning as a chemical printing center, and this draws many orders for university degree theses and chemical textbooks. Close to a hundred of theses and a dozen or more textbooks are issued annually.

QUANTITY PRODUCTION

The production of such a vast amount of literature entails the use of considerable tonnage of paper stock. Some may not sense the resources and to what extent they must be utilized in order to get Easton's present production of chemical literature into the hands of the reader. The employees of our post-office, however, are very intimately acquainted with its physical proportions. Some of the monthly requirements are as follows: Between $3\frac{1}{2}$ and 4 million ems of machine composition, 3,000 hours hand composition, 1,000,000 press impressions, 350,000 sheets to be folded, 40,000 pounds paper stock.

These figures are not estimated but are compiled from records available. They are very conservative and I am positive are considerably under the actual production. They cover only the chemical periodicals. The inclusion of theses, pamphlets and textbooks would probably add another 25 per cent.

COMPARISON WITH PREVIOUS YEARS

It might be interesting to compare some of the figures with those of thirty years ago.

When the first issues of Dr. Hart's *Journal of Analytical and*

Applied Chemistry were produced it was set by hand with foundry type. The supply of sorts was limited and not over 4 pages of about the size of our present *Journal of the American Chemical Society* were set and then printed, 2 at a time. In fact, occasions were rare indeed when there was enough type of all kinds in the case to set four pages without turning the letters. This turning of the letters was a treacherous practice in the shops of the olden days and involved many an annoying error. Should four pages use a greater number of a certain letter than usual, the compositor, in order to finish to a certain point, would use another letter of the same width and turn it upside down. This, in the proof, makes a rectangular black mark of the same dimensions as the body of the type and is readily seen. When other pages, which had been previously set and printed were distributed back into the case, these "turned letters" were removed and the correct characters substituted. You can readily see what was invited unless careful proofreading was exercised. In those days this was a luxury and the printer usually depended on the author and editor for this operation. After these four pages were set, the type was distributed and another set of four were set and printed. The sheets were 9 x 12 and the press was "kicked," i. e., run by foot power.

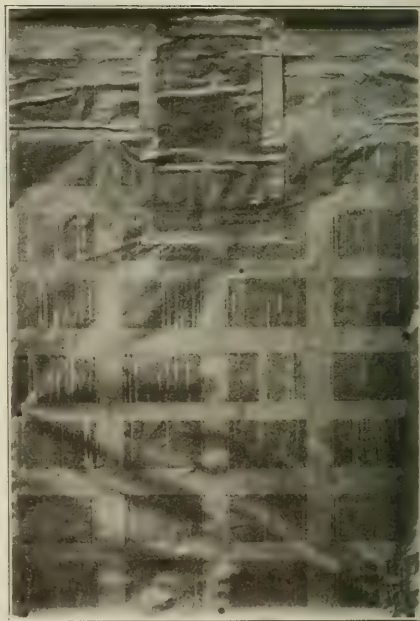


FIG. 3—The smallest sheet illustrates the manner in which the first chemical journal was printed in Easton in 1886 or thereabouts. The second form illustrates the manner in which the first *Journal of the American Chemical Society* was printed when it came to Easton in 1893 and the largest form illustrates the manner in which the same journal is printed to-day.

To-day all the copy is set by machine at one setting. It's a crime to turn a letter, and proofreading is not only not a luxury, but is as necessary as life itself.

Type is not bought, but matrices are made for the type-setting machine and the type is made in unlimited quantities as needed. A well-organized shop needs over 8,000 character matrices. The sheets printed to-day are 38 x 52 and are run on large automatically-fed cylinder presses. Our own journal,

when it came to town, was printed on a small power press four pages at a time on a sheet 12 x 18.

In 1893 our journal averaged 60 pages per issue of 500 to 700 copies per month; the weight mailed per month did not exceed 100 pounds. Contrast this with 40,000 pounds per month to-day. One government sack at that time held the total month's subscriptions to the first issue. To-day we need ten two-ton trucks to deliver Easton's monthly quota of chemical literature to the post office and railroad trains.

The first issue of the journal contained 60 pages, the type of which was 4 x 6 1/2. A journal similar in page size to contain all the chemical literature issued now in one month from Easton would have to comprise 2,000 pages.

Chemical Abstracts states there are throughout the world 789 journals which contain at one time or another papers bearing on chemical subjects, but for strictly chemical literature, I am persuaded Easton leads.

EASTON, PENNSYLVANIA

FOREIGN INDUSTRIAL NEWS

By A. McMILLAN, 24 Westend Park St., Glasgow, Scotland

THE BUCKINGHAM BULLET

One of the incendiary bullets used against Zeppelins during the war was that invented by Mr. J. F. Buckingham, of Dover Street, Coventry. Soon after the war broke out he devoted himself to the production of a small incendiary shell to be fired from rifles and machine guns, and decided on phosphorus as the basis of his incendiary composition. A form of construction he patented early in 1915 consisted of a roll of fine metal gauze, forming a kind of wick and saturated with phosphorus, which was enclosed in a hollow projectile with a hole in the base. In the same patent was also suggested the provision of a side outlet in the bullet, whereby the contents of the latter were protected against the propellant by the barrel of the gun during the passage of the projectile down the barrel. Later the charge of phosphorus was mixed with a small quantity of metal dust and was enclosed in a hollow bullet, sealed at the base with a metal plug. The outlet hole passed through the plug and was sealed by a lead diaphragm which was broken down on firing and thus allowed the phosphorus composition to emerge. In a still later design the bullet consisted of a cupronickel envelope, having two hardened lead plugs inserted. One of these was serrated, and the second, acting as a base plug, was tapered at its front end, thus forming an annular space, communicating with a side hole in the envelope, this hole being sealed with a fusible alloy which melted on firing. The base of the bullet was spun over and sealed by a special process. When the bullet was fired the phosphorus composition melted and ran down the serrations in the first lead plug into the annular space formed round the front of the second lead plug, whence it was ejected through the side hole in the envelope, igniting spontaneously on coming into contact with the air.

FLOATING TOOL HOLDER

In reaming operations some form of tool holder is required to hold the reamers in such a manner that they will be free to float and line up with the hole being reamed while under the twisting strain of cutting. In a tool holder designed by Messrs. Netherwood and Co. (Limited), Turnbridge, Huddersfield, England, friction is reduced by employing steel balls to give a rolling movement to the various parts; consequently an axial displacement between the shank and the socket may easily be made by the reamer when it enters the hole to be reamed. Four balls are employed, set in grooves at right angles, these grooves being cut in the ends of shank and socket and also in each side of a centerpiece and when the balls are in position sufficient clearance is given to allow of axial movement in all directions and also a swiveling movement on each set of balls. The weight of the reamer shank is supported with a spring, which may be adjusted to bring it into an approximate central position. The shanks are made either parallel or No. 3 Morse taper, the latter being more suitable for center lathes or drilling machines, while the reamers are held either in split parallel bored bushes or in a No. 4 Morse taper socket.

VACUUM ARRESTERS

Particulars of vacuum arresters for protecting telephone and telegraph installations and their users against high-tension discharges, whether due to atmospheric conditions, such as lighting or to the effects of neighboring power circuits, are given in a pamphlet sent by Messrs. Siemens Bros. and Co. It is claimed for this form of arrester that, owing to the opposing conductors being enclosed in a partial vacuum, they may be relied upon to break down at about 300 volts (R. M. S. value of alternating potential), so that all dangerous voltages are excluded from the line. The vacuum is designed to carry a current sufficiently great and of sufficient duration to blow fuses having a capacity higher than those usually employed in telephone or telegraph work. An insulation resistance of approximately 3,000 megohms is maintained right up to the point of breakdown. Owing to the relatively large separation of the electrodes permitted by the use of a vacuum chamber they do not become welded together with heavy discharges, nor have they to be renewed after discharge, though a damaged arrester can be readily removed and replaced by a new one. Being contained in a hermetically sealed vacuum chamber the appliance, besides being highly sensitive, is also protected against dust, damp, and insects.

ZIRCONIA

During the past three years, the exports of zirconia from Brazil have increased from 86,295 kilos to 2,141,182 kilos. The greater part of the mineral is sent to the United States while Great Britain takes about one-quarter of the total. A summary of the literature on zirconia and its uses is given in an article by A. Granger in the *Moniteur Scientifique*, January 1919. Among the chief minerals mentioned are the Brazilian deposits of zirkite and baddelegite, the former a complex silicate, discovered in the state of St. Paul. The working-up of the various minerals which are all compounds of zirconia and other oxides with silica can be effected by the aid of hydrofluoric or sulfuric acids or acid sulfates, by fusion with alkalis or by transforming the zirconia into a carbide. An often troublesome impurity is iron oxide which can partly be extracted by acids. The extraction is, however, incomplete and stands in the way of a much attempted utilization of zirconia as a medium for rendering fluxes of glass and enamel opaque. The minerals and zirconia are not satisfactory as abrasives on account of the difficulty of finding a suitable binder and this also prevents its use as a refractory material for which it is otherwise excellently suited. The author of the paper gives an account of his work with powdered zircon and also of his attempts to prepare zirconia crucibles and resistance furnaces. It is noteworthy that considerable economy was effected in a steel works in Westphalia by lining open hearth furnaces with zirconia bricks in spite of the high price. A lining was found to last eight months and was only one-half the thickness of the best firebricks. Zirconia bricks are, however, attacked by fluorides and acid sulfates. Tar was used as a binder.

ELECTRIC WINDERS

Of late years electrically-drawn winding engines have grown considerably in favor, and the progress made is illustrated in a pamphlet issued by the British Westinghouse Company, of Trafford Park, England, which contains pictures and brief details of a number of such installations already erected or now being erected by them. Of the sets listed, the majority appear to be for coal mines in England and Wales. The largest installation described is that at the Crown pit of the Great Western Colliery Company, which is driven by two direct-current motors of 1,800-2,700 h. p., direct-coupled and winding a net unbalanced load of 26,880 lbs. at a speed of 1,640 ft. per min. from a shaft length of 2,250 ft., the drum being of the cylindro-conical type with diameters of 12 and 18 ft. At the Maritime pit of the same company there is another installation, driven by a 700-1,500 h. p., direct-current motor which is designed to wind a net unbalanced load of 5,600 lbs. at a speed of 2,640 ft. per min. from a shaft length of 1,100 ft. Other British examples illustrated are at pits belonging to the Ebbw Vale Company, the Tridegar Company, the Horden Colliery Company, and the Wallsend and Hebburn Coal Company. South Africa provides instances of higher speeds and deeper shafts. Two sets at the Brakpan mines wind a net unbalanced load of 10,000 lbs. at a speed of 3,500 ft. per min. from a shaft length of 3,800 ft.

USES OF MOLYBDENUM DURING THE WAR

The war, says the *Engineering and Mining Journal*, March 1919, had a marked effect in stimulating the production of molybdenum. On the outbreak of hostilities the price of molybdenum suddenly rose in a remarkable degree, the reason apparently being that Germany, aware of the impossibility of laying up enough tungsten, was buying molybdenum to take its place. England and France also had recourse to molybdenum in the production of high-speed steel. The French used molybdenum in the breechblocks of some of their field guns but never, it appears, in shells, armor plate, or gun linings. Later in the war, it was proposed to make armor plate containing molybdenum, and contracts were entered in America to produce such plate. Steel companies were parties to large contracts for molybdenum, but before the steel was put to use the war ended. One of the companies concerned used molybdenum to the extent of less than 1 per cent in making crank shafts and Liberty motors.

AMMONIACAL SILVER OXIDE

The Department of Customs, Ottawa, says *Engineering*, 107 (1919), 705, directs attention to the handling of ammoniacal silver solution and emphasizes the dangers involved. Several explosions have recently occurred in the analytical laboratory of the department and it is pointed out that the exclusion of air does not prevent the formation of explosive silver nitride. The dangers are very real and it might be remarked that there are several explosive silver compounds involving silver and nitrogen and only one contains oxygen. The constitutions of these compounds are not quite settled though they are of theoretic interest. The nitride, generally called azide, Ag_3N_3 , is a salt of the acid NH_3 , which was first prepared by Curtius from organic compounds. The acid is a colorless liquid, safe in aqueous solution, but its vapors are poisonous and the anhydride is explosive. By treating silver oxide with aqueous ammonia the azide, Ag_3N_3 , is obtained as a black crystalline powder, which when dry is as explosive as the iodine nitride which was known before the azides. There is further the so-called silver fulminate probably an amide, AgNH_3 , and the silver fulminate proper. The fulminates are prepared simply by dissolving the metal in nitric acid and adding alcohol to the solution. They are isomeric with the non-explosive cyanates.

ARTIFICIAL MOTHER OF PEARL

Until a few years ago, says *British Trade Review*, 52, 205, a German manufacturer had the sole monopoly of the secret process by which artificial mother of pearl, luster, and iridescent sheet were manufactured. Thousands of these sheets were imported into Great Britain every week prior to the war, their principal purpose being in the making of fancy buttons and sequins for dress and hat trimmings, though they have a number of other uses such as for the backs of brushes, the handles of umbrellas, advertising signs, and for the fancy trade generally. After four years of almost constant experiment, the secret process has been discovered by an Englishman, who, it may be mentioned, invented and supplied to the War Office very large quantities of iron-flamcellulite used for the eyepieces of gas masks and for windows of hospital tents. During the war it has been impossible to obtain supplies of artificial mother of pearl but, now that the manufacture has been commenced in England, there seems to be a good prospect of this branch of trade being captured from Germany.

WATER- AND OIL-PROOF PAINT

According to an English patent, a paint which is water- and oil-proof and resistant to high temperature, for example, $180^\circ\text{C}.$, may be prepared as follows: Four mixtures are made up (1) containing 16 kilos resin dissolved in 10 liters of boiled linseed oil; (2) containing 75 kilos dry color (not white lead) mixed with linseed oil and petroleum to form a paste; (3) containing 5 kilos of lime slaked with water to a paste; (4) containing 10 kilos of yellow soap dissolved in boiling water and cooled so as to form a jelly. Mixtures (2) and (3) are added to part of the remainder of an original quantity of 40 liters of boiled linseed oil and 40 liters of petroleum. The soap-jelly (4) is added, then what remains of the linseed oil and petroleum, and finally in turn mixture (1) and 5 liters of terebine.

CHROME LEATHER WASTE

A German patent for the utilization of chrome leather waste has been introduced by A. Wolff, Hamburg. The waste is dissolved in sufficient sulfuric acid (about 5 per cent) at $80-90^\circ\text{C}.$, and, after the removal of the fat which separates, the chrome is precipitated as hydroxide together with calcium sulfate by the addition of an excess of lime and is then converted into chrome alum. The gelatin is recovered from the solution after precipitating the dissolved lime and calcium sulfate by treatment with carbonic acid and barium carbonate. For trimmings as obtained in chrome tanneries, the weight of 5 per cent acid used is equal to that of the waste, while for waste from shoe factories the proportion of 5 per cent acid is approximately three times as great.

CONCRETE BUILDING

In a system of concrete construction of which some details are sent by Mr. William Calway, of Swansea, the walls are formed of two webs, each $3\frac{1}{2}$ in. thick with a 2 in. cavity between them. The webs are tied together with concrete bonds about 2 in. in diameter and spaced at 2 ft. intervals, in which are embedded ordinary wall ties protected from corrosion by the concrete. The walls are molded *in situ* by a mold into which the concrete is consolidated in a plastic condition, section by section and course by course, until the whole wall is completed in one piece. No shuttering is required, only the traveling mold which is moved from point to point. It is claimed that under this system three men can do as much walling in an hour as a bricklayer and his mate will do in a day, and that with cement at \$15 a ton and aggregate which can be found in most districts at \$1 per cu. yd., there is a saving of at least \$1 a superficial yard as compared with a bricklayer completing 6 yds. of 9 in. walling a day, with bricks at \$15 per 1,000.

SCIENTIFIC SOCIETIES

FALL MEETING AMERICAN CHEMICAL SOCIETY PHILADELPHIA, PA., SEPTEMBER 2 TO 6, 1919

The 58th Meeting of the American Chemical Society will be held at the Bellevue-Stratford Hotel, Philadelphia, Pa., under the auspices of the Philadelphia Section, from Tuesday, September 2, to Saturday, September 6, 1919, inclusive. The Philadelphia Section, situated, as it is, so near the center of our chemical activities, is planning an extensive and unusual program.

The Rubber Division holds its first meeting, and a Dye Section is to be established which will function as a separate section this year. Philadelphia has a large number of chemical industries within its limits and in the surrounding territory, and its large and very enthusiastic local membership, together with the enhanced interest in chemistry manifest throughout the nation, insures a large gathering and an important program. It is already certain that the meeting will be one of the largest, if not the largest, in the history of our Society, for we have not only a continually increasing membership, but a continually increasing enthusiasm for the accomplishments of our profession.

Registration will take place at the Bellevue-Stratford, beginning at 3 P.M., Tuesday, September 2. Information Bureau will be located at the hotel.

CHAIRMAN OF LOCAL COMMITTEES

Executive: George D. Rosengarten
Finance: William H. Bower
Publicity: J. Howard Graham
Excursions: James E. Branegan
Registration and Information: William C. Carnell
Transportation: C. C. Tutweiler
Entertainment: Arthur H. Thomas
Banquet: Harry F. Keller
Smoker: W. A. Pearson
Entertainment of Ladies: Mrs. Harry F. Keller

GENERAL PROGRAM

TUESDAY, SEPTEMBER 2

4:00 P.M.—Council Meeting. Bellevue-Stratford.
7:00 P.M.—Dinner to the Council (tendered by the Philadelphia Section).

WEDNESDAY, SEPTEMBER 3

9:30 A.M.—General Meeting. Bellevue-Stratford.
Address of Welcome. Hon. Joseph S. MacLoughlin, Director of Supplies of the City of Philadelphia.
Address. Secretary of War, Newton D. Baker.
An address will also be given by a representative of the Navy Department.

2:30 P.M.—General Divisional Meeting.
8:15 P.M.—Smoker. Scottish Rite Hall, Broad and Race Streets.

THURSDAY, SEPTEMBER 4

9:30 A.M. to 1:00 P.M.—Divisional Meetings.

2:00 P.M.—Excursions, as follows:

The Atlantic Refining Co.—Fractional and destructive distillation of crude oil, pressure and steam stills, separation and refining of paraffin wax, manufacture of asphalt, etc.
Barrett Company, Frankford—Working up light oils from coal tar.
Curtis Publishing Co.—All departments open, engraving and four-color printing.
Dill & Collins Paper Mills—Soda pulp, rag pulp, variety of high-grade papers; electrolytic chlorine plant.
Electric Storage Battery Co.—Manufacture of storage batteries.
Robert H. Foerderer—Manufacture of vici kid (2 bath chrome).
Franklin Sugar Refinery—Refining of raw sugar.
Lee Tire and Rubber Co., Spring Mills, Pa.—Manufacture of automobile tires.
John T. Lewis & Bros. Co.—Manufacture of white lead, lead oxides, linseed oil. Dry colors.
Philadelphia Electric Co.—Either Schuylkill or Chester generating station.
Philadelphia Storage Battery Co.—Manufacture of storage batteries of various forms.
United Gas Improvement Co.—Coal gas, water gas, cyanide, sulfate and sulfuric acid.

Victor Talking Machine Co.

Charles Warner Co.—Lime and lime products.

Weisbach Light Co.—Mantles, rare earth salts, nitro-cellulose.

8:30 P.M.—President's Address: "Research and Application."

FRIDAY, SEPTEMBER 5

9:30 A.M. to 1:00 P.M.—Divisional Meetings.

7:00 P.M.—Banquet at Bellevue-Stratford.

SATURDAY, SEPTEMBER 6

10:00 A.M. to 4:00 P.M.—Boat Ride tendered by the Delaware Section.

DIVISIONAL PROGRAMS

The usual meetings will be held by all the Divisions, with the following special program:

THE DIVISION OF INDUSTRIAL CHEMISTS AND CHEMICAL ENGINEERS calls especial attention to its symposium on re-fractories being organized by Dr. A. V. Bleining, of the Bureau of Standards, and the discussion which will be held upon Dr. B. C. Hesse's open letter concerning annual patent renewal fees for the United States. The officers urgently request members of the division to contribute to the general program of the division to make the Philadelphia meeting a notable one.

THE DIVISION OF BIOLOGICAL CHEMISTRY will give much thought to chemotherapy, which is a matter of great interest to the country at present.

THE DYE SECTION, which will be organized at this meeting, is preparing an interesting program on the dye situation.

ENTERTAINMENT OF LADIES

The Ladies' Entertainment Committee is arranging an interesting program for the pleasure of visiting ladies. Details will be found in final program.

PAPERS FOR THE MEETING

THE DIVISION OF INDUSTRIAL CHEMISTS AND CHEMICAL ENGINEERS has a rule that abstracts of papers to be presented in its program must accompany titles, if these titles are to appear in the final program, and, further, the time limit for the presentation shall be five minutes, unless special arrangements are made with the Secretary of the Division.

By vote of the Council no papers may be presented at the meeting, titles for which are not printed on the final program.

"By Title" should be placed on the announcement of any paper where the author is to be absent, so that members may understand in advance that the paper will not be read.

ADDRESSES OF DIVISIONAL SECRETARIES

Agricultural and Food Chemistry: T. J. Bryan, 4100 Filmore St., Chicago, Ill.

Biological Chemistry: R. A. Gortner, University of Minnesota, University Farm, St. Paul, Minn.

Fertilizer Chemistry: H. C. Moore, Armour Fertilizer Works, Atlanta, Ga.

Industrial Chemists and Chemical Engineers: H. E. Howe, care American Chemical Society, Box 1505, Washington, D. C.

Organic Chemistry: Harry L. Fisher, Columbia University, New York City.

Pharmaceutical Chemistry: George D. Beal, University of Illinois, Urbana, Ill.

Physical and Inorganic Chemistry: W. A. Patrick, The Terraces, Mt. Washington, Md.

Water, Sewage, and Sanitation Chemistry: W. W. Skinner, Bureau of Chemistry, Washington, D. C.

Rubber Chemistry: A. H. Smith, Goodyear Tire and Rubber Co., Akron, Ohio.

Dye Section: R. Norris Shreve, 43 Fifth Ave., New York City.

PUBLICATION OF PAPERS

The Society reserves the right of original publication in its official journals of all papers appearing on the program of its General Meetings, Divisions, and Local Sections. The Editors are requested to inform authors promptly of the decision re-

garding publication of such papers. This decision can be facilitated by authors sending duplicate copies of their papers in advance to the Editor of the journal in which publication is desired.

ABSTRACTS FOR "SCIENCE"

A short abstract (about 100 words) should be handed to the Secretary of your Division at the time of presentation, so that it may appear in *Science*.

PATENT LEGISLATION

Three bills of importance to our Society and to every member in it are before Congress. They are:

House Bill 5011, being a Bill "To establish a Patent and Trade-Mark Office independent of any other department and to provide for compensation and infringement of patents in the form of general damages, and for other purposes;" House Bill 5012, being a Bill "To establish a United States Court of Patent Appeals, and for other purposes;" and House Bill 7010, being a Bill "To provide for increases in personnel and in the salaries paid in the Patent Office."

These bills are the result of careful thought on the part of the Committee on Patents and Related Legislation of the Society with which a similar committee of the National Research Council unanimously agrees. They have received the approval of the President and the Advisory Committee of our Society and it is important to all chemists that they pass Congress. Congress is always anxious to know the opinion of its constituents. It is accordingly suggested that each one of you write to your congressman and to each of the two senators from your state regarding these bills. The Advisory Committee hopes that every member of the American Chemical Society will favor their passage and that every member of the American Chemical Society will write to his congressman.

THE INTERALLIED CHEMICAL CONFERENCE

The delegates of the Federated Chemical Societies of America, Belgium, England, France, and Italy met in London, July 14 to 17, 1919. The interallied countries were represented as follows:

Belgium: M. Lucion, past president of the Société Chimique de Belgique; M. Timmermanns, associate professor in the University of Brussels. **France:** M. Moureu, member of the Institute of France and professor at the Collège de France; M. Kestner, president of the Société de Chimie Industrielle; M. Béhal, member of the Académie de Médecine and professor at the École Supérieure de Pharmacie de Paris; Dr. Marquis, chief editor of the Bulletin de la Société Chimique; Dr. Marie, general secretary of the Société de Chimie Physique; M. Voisin, member of council, Société de Chimie Industrielle; and M. Gérard, general secretary of the Société de Chimie Industrielle. **Italy:** Dr. O. Severini, director of the Società Generale per la Cianamide; Dr. G. Pirelli, representing the Società di Chimica Industriale di Milan. **United States:** Dr. F. G. Cottrell, chief metallurgist, U. S. Bureau of Mines; Dr. C. L. Parsons, chief chemist, U. S. Bureau of Mines, secretary of the AMERICAN CHEMICAL SOCIETY; Dr. E. W. Washburn, professor of Ceramic Chemistry at the University of Illinois, past chairman of the Division of Chemistry and Chemical Technology of the National Research Council. Dr. Julius Stieglitz, Dr. H. S. Washington, and Dr. Edward Bartow were unable to be present. **United Kingdom:** Sir William Pope, professor of chemistry at the University of Cambridge, chairman of the Federal Council for Pure and Applied Chemistry; Prof. H. Louis, professor of mining at Armstrong College, University of Durham, president of the Society of Chemical Industry; Prof. H. E. Armstrong, past president of the Chemical Society; Dr. E. F. Armstrong, vice chairman of the Association of British Chemical Manufacturers; Mr. A. C. Chaston Chap-

man, past president of the Society of Public Analysts; Prof. W. P. Wynne, professor of chemistry in the University of Sheffield. Dr. R. F. Ruttan, director of the department of chemistry, McGill University, Montreal, president of the Royal Society of Canada, was present by invitation and was given credentials from the AMERICAN CHEMICAL SOCIETY as a substitute for Dr. Edward Bartow.

The proceedings of the Conference were conducted in French, M. Moureu acting as chairman and M. Gérard as secretary. Almost the whole time of the Conference was taken up in framing the constitution of the new body, which is to be known as the "International Union of Pure and Applied Chemistry," (*L'Union Internationale de Chimie Pure et Appliquée*), and in discussing the desirability of its inclusion in the scheme of organization projected by the Conference of Scientific Academies. The following officers were elected for a term of three years: *President*, M. Moureu; *Vice Presidents*, M. Chavanne (Belgium), Signor L. Parodi Delfino, Dr. C. L. Parsons, and Sir William Pope; *General Secretary*, M. Jean Gérard, 49, rue des Mathurins, Paris.

In addition to the five countries represented at this meeting, it was agreed that the British Dominions and the nations signatory to the Peace Treaty should each have separate representation on making application. In this connection Canada and Poland have already signified their adhesion. It was also decided to admit neutral countries. With the exception of Belgium, each of the nations at present represented in the International Chemical Union has formed a national organization similar to the British Federal Council for Pure and Applied Chemistry; thus the United States has instituted a Chemical Division of the National Research Council; France, the Fédération Nationale des Associations de Chimie Pure et Appliquée; Italy, the Associazione Italiana di Chimica Generale ed Applicata.

The following resolutions were passed:

The International Union of Pure and Applied Chemistry, meeting in conference in London from July 14 to 18, 1919, hereby records the following opinions:

1—That the Confederation should be included in the scheme of organization contemplated by the Conference of Scientific Academies, with autonomous powers, as the Chemical Section of the International Research Council.

2—That it shall constitute "The International Committee of Chemistry."

3—That the various national delegates representing chemistry at the meeting of the International Research Council shall be appointed by the same National Federation which appoints the delegates to the Confederation.

4—That the officers of the present Confederation be, *ex officio* officers of the Chemical Section of the International Research Council.

On motion of Professor C. Marie the following resolutions were adopted:

1—It is to be understood that on the whole the critical tables will be published as planned in the United States.

There will be created an American committee of publication charged with the general organization and the carrying through of the program.

2—The collaboration of other countries will be provided for by establishing as a basic principle that the best man will be taken wherever he is found.

3—The result should be the creation in the principal countries of national subcommittees. His function would be to maintain close contact with the central American committee and to direct the work of the collaborators belonging to those countries.

4—This decision is made in the interest of the publication as being the one that would give the best result for the work.

In order to take into account the existence of the international committee on the annual tables of constants and of the considerable work which has been accomplished by this committee in the last ten years, it is to be understood that the above decision regarding critical tables is bound to require a continuation of the work on the annual tables and that every effort will be made in

the United States as well as in the other countries belonging to the international confederation, to supply the committee on annual tables the material means which would enable them to continue their work.

It was decided to hold the next meeting of the International Chemical Union in Italy during the first two weeks of June 1920.

The meeting was held conjointly with the meeting of the Society of Chemical Industry, and the delegates were the guests of that Society and were entertained royally. All members of the delegation will long remember the cordiality shown and boundless hospitality tendered them. The social functions included luncheons, which really were banquets, at the Girdler's Hall on Monday, at the Connaught Rooms as guests of the London Section on Tuesday, again at the Girdler's Hall on Wednesday, and on Thursday as guests of the Brimsdown Lead Company at the Great Eastern Hotel. On Monday a dinner was tendered by the Catalysts at the Charing Cross Hotel. On Tuesday a soirée and reception at the Imperial College of Science and Technology, South Kensington. On Wednesday the delegates were guests at the annual dinner of the Society of Chemical Industry at the Savoy Hotel, and on Thursday were taken to visit the Brimsdown Lead Company, Ltd., works at Brimsdown, and in the evening were tendered a reception at the British Scientific Products Exhibition. On Friday, again as guests of the Society of Chemical Industry, the delegates went with some two hundred others, including many ladies, on an excursion to Windsor Castle, followed by a boat trip up the Thames to above Maidenhead. At Windsor the unusual privilege was enjoyed of viewing the Albert Memorial Chapel as well as St. George's Chapel and the State Departments. Luncheon was again tendered the delegates at the White Hart Hotel. The delegates unanimously voiced their sincere appreciation of the courtesies shown them by the officers and members of the Society of Chemical Industry.

The Conference then adjourned to meet again in Brussels on July 22 in connection with the International Research Council. Unfortunately many of the English delegates were unable to be present at the Brussels meeting, but they were ably represented by Sir William Pope. The French delegates were all present except Dr. Kestner. The American delegates were joined by Dr. H. S. Washington. To the Belgian delegates were added Prof. Dony-Henault and Prof. Frederic Swarts. Prof. Albin Haller joined the French delegation and presided over the meeting, and Prof. S. Nasini represented Italy.

The meeting at Brussels was largely engaged in the discussion, modification, and final adoption of the statutes of the new International Union of Pure and Applied Chemistry. These statutes are printed below as finally adopted to conform with the statutes of the International Research Council, of which the International Union of Pure and Applied Chemistry was constituted the chemical section, in conformity with the resolutions before quoted. Also it was informally agreed that the only apparent basis for international coöperation on the abstracting of chemical literature was a simple exchange of proof sheets of abstracts between the various countries interested, although it was thought possible that the Latin countries might be able to combine to advantage in publishing an abstract journal in French. Also it was informally agreed that America should go ahead with her proposed program on Scientific and Technical Monographs, the issuance of these to be later correlated, if possible, with the English program on Compendia of Organic and Inorganic Chemistry should their plans as first proposed be extensively modified.

The election of officers as made in London was confirmed and the International Union of Pure and Applied Chemistry became officially the chemical section of the International Research Council. The statutes follow. It was voted that the French text should be official. The following is an unofficial translation into English:

STATUTES OF THE INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY

PRESENTED BY THE DELEGATION TO THE INTERALLIED CONFERENCE OF ASSOCIATIONS OF PURE AND APPLIED CHEMISTRY, LONDON, JULY 14 TO 18, 1919

ARTICLE 1

Between the national federations, national councils, or, failing such, the national associations representing chemistry in Belgium, the United States of America, France, the United Kingdom of Great Britain and Ireland, and Italy, there is established an International Union of Pure and Applied Chemistry having as a purpose:

To tighten the bonds of esteem and friendship which have been established between the various allied countries during the war.

To organize permanent coöperation between the associations of chemistry in the adhering countries.

To coördinate their resources both scientific and technical.

To contribute to the advancement of chemistry in the whole extent of its domain.

This association shall be perpetual. Its provisional headquarters will be in Paris.

ARTICLE 2

Admission of any country into the Union is governed by the conditions fixed by the statutes of the International Research Council.

A country may adhere to the Union either through its national federation, through its national council, or, failing such, through its national association representing chemistry.

ARTICLE 3

The power of the Union, as defined in the first article, will be exercised by a council, assisted by an administrative secretariat, and by a special staff to be decided upon by international agreement of the adhering countries.

ARTICLE 4

The annual assessment for each country is determined in proportion to the number of its inhabitants, according to the following table:

CLASS	Population Millions of Inhabitants	Minimum Annual Fee Francs
A.....	Less than 5	500
B.....	5 to 10	1,000
C.....	10 to 15	1,500
D.....	15 to 20	2,000
E.....	20 to 30	2,500
F.....	More than 30	3,000

The inhabitants of the colonies and protectorates of a country, who have not a separate government, are counted in the population of that country if the country concerned so decides.

The members of the Union are liable only for expenses relating to general administration.

No member shall be charged for any other expense except with its consent.

ARTICLE 5

Any member of the Union can withdraw provided all its obligations for the current year have been fulfilled. Any member may be removed by the Council for non-payment of the minimum annual allotment or for grave cause by a vote of three-fourths of the members present or represented, the interested party having been called upon beforehand to furnish an explanation.

ARTICLE 6

The Union will be administered by a council composed of delegates from each of the contracting countries, the number of delegates being fixed according to the classification in the following table:

CLASS	NUMBER OF DELEGATES
A.....	1
B.....	2
C.....	3
D.....	4
E.....	5
F.....	6

The delegates are nominated for three years by the national federation, the national council or, failing such, by the national association representing chemistry in the respective countries,

and when so elected may be reelected. One-third of the Council will be renewed each year.

ARTICLE 7

The executive power of the Council is entrusted to the staff composed of a president, four vice presidents, and one general secretary.

The Council will elect its staff from its members every three years by majority vote. The members of the staff, with the exception of the general secretary, are not eligible for reelection for consecutive terms in the same office.

The president will be chosen from among the vice presidents.

ARTICLE 8

The Council will meet at least once a year, the day preceding the general annual assembly, wherever it is to take place and also at any time that the president shall call a meeting or on the demand of three-fourths of the members.

Its functions shall be to indicate the date and place of meeting, to draw up the budget, and to make decisions as to expenditures. The decisions of this Council are to be made by majority vote. On questions relating to administration and finances the votes are expressed by countries, each country having a number of votes equal to the number of its delegates. In counting this vote, it is not necessary that delegates should all be present personally. A proxy may be designated by the delegates of one country to represent them and to take part in the voting in their name.

Voting by correspondence is admitted. Only questions in the order of the day can be voted upon. In case of equal division of votes, the president shall cast the deciding vote.

ARTICLE 9

Records of the meetings will be kept; two copies of the minutes will be made and signed by the president and the secretaries present at the meeting.

The administrative secretary will be given the custody of the archives and will be charged with the execution of the decisions made by the Council and the staff, especially with the sending out of the order of the day.

ARTICLE 10

The functions of the staff are as follows:

- 1—To see to a strict compliance with the statutes.
- 2—To fix the order of the day for the meeting of the Council.
- 3—To record and execute the program of action as established by the Council.
- 4—To carry out, in the time which elapses between two meetings of the Council, the necessary acts of administration and to submit a written account to the members of the Council.
- 5—To submit to the Council an annual budget.
- 6—To represent the Union or to choose representatives.

ARTICLE 11

There will be formed in addition to the Council an advisory committee composed of as many sections as may be necessary to insure complete representation of pure and applied chemistry in accordance with the statutes of the Union.

ARTICLE 12

The General Assembly is composed of members of the Council and delegates of the different national federations, national councils, or national associations representing chemistry.

The General Assembly will meet at least once a year in ordinary session, preferably in the city where the International Congress of Pure and Applied Chemistry is being held at the time.

The General Assembly will meet also at the call of the Council or at the demand of one-half of the members of the Union.

The General Assembly will hear the reports on the actions of the Council and on the financial situation and general condition of the Union.

It will approve the accounts for the fiscal year as presented by an auditor who is not a member of the Council and appointed by the General Assembly the preceding year.

It will vote the budget for the following fiscal year and will discuss the questions in the order of the day.

The annual report and the accounts will be sent every year to all the members at least three months before the annual meeting of the General Assembly.

The order of the day of the Assembly is fixed by the Council and will include any matter that shall have been transmitted to the Council by any members of the Union at least three months before the meeting of the General Assembly.

The staff of the Council will be also that of the General Assembly.

The votes on administrative and financial questions will be taken by countries, each country having the right to the

number of votes indicated in the classification provided for in Article 6.

The delegates of any country may designate one or more proxies to represent them and to take part in the voting in their name.

ARTICLE 13

The disbursements are ordered by the president and regulated by the administrative secretariat.

The Union will be represented in all litigation by the president who may delegate his powers to one of the members of the Council or to the administrative secretary.

ARTICLE 14

The proceedings of the Council relating to purchases, exchanges, transfer of property or title on real estate necessary to the purposes of the Union, the placing of mortgages on said real estate, leases exceeding nine years, and loans must be submitted for the approval of the General Assembly.

ARTICLE 15

No change in the statutes can be submitted to the General Assembly except on the motion of the Council of the Union or on the demand of one of the national federations, national councils, or national associations representing chemistry.

Proposed changes in the statutes will be placed on the order of the day of the General Assembly, provided they have been received by the staff of the Council at least three months in advance.

The voting will take place by countries as provided for in Article 8.

Voting by correspondence will be admitted.

The statutes can be amended only on a two-thirds majority of the votes cast.

ARTICLE 16

The General Assembly which might be called upon to dissolve the Union will be notified for this particular purpose at least three months in advance. It must be composed of at least three-fourths of the delegates of the members of the Union or their proxies.

If this proportion of members is not present at a meeting, the General Assembly will be called again within a minimum period of six months and at this meeting it can act validly, no matter what the proportion of members present may be.

Voting by correspondence is admitted.

In any case dissolution can only be voted by a two-thirds majority of the votes cast.

ARTICLE 17

In case of dissolution, the General Assembly shall designate one or several commissioners to take charge of liquidating the property of the Union.

The net funds will be turned over to some international organization.

ARTICLE 18

The present French text will be used exclusively for the interpretation to be given to any of the articles of the statutes.

FIFTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES, COLISEUM AND FIRST REGIMENT ARMY, CHICAGO, SEPTEMBER 22 TO 27, 1919

From data and information on hand the forthcoming Fifth National Exposition of Chemical Industries at the Coliseum and First Regiment Army, Chicago, during the week of September 22, promises, with its attendant society meetings, to be an affair worthy of the past accomplishments of this great Exposition. The managers of the Exposition report that there are as many exhibitors as at the last very complete Exposition, and that there are a great many who have never before been exhibitors to whose exhibits visitors may look forward with interest. Nearly all the old established exhibitors have something new in the way of products developed since the entry of our country into the war.

From the data on hand the following program has been compiled. At the time of going to press it is, of course, subject to addition and revision, but some idea of the comprehensiveness of the meetings and discussions may be gained from what is now shown.

Exposition hours are from 12 M. to 10:30 P.M.

GENERAL PROGRAM

MONDAY, SEPTEMBER 22

- 9:00 A.M.—American Institute of Mining and Metallurgical Engineers. Registration begins at Headquarters, Congress Hotel.
- 11:00 A.M.—Technical Sessions, American Institute of Mining and Metallurgical Engineers.
"Nonferrous Metallurgy and Metallurgy."
"Coal and Gas."
- 12:00 M.—OPENING OF EXPOSITION.
- 2:00 P.M.—Technical Sessions, American Institute Mining and Metallurgical Engineers, Congress Hotel.
"Coal and Gas."
"Milling."
"Geology."
"Industrial Organization."
- 8:00 P.M.—OPENING ADDRESSES:
Gov. Frank O. Lowden, of Illinois. Address of Welcome.
Charles H. Herty, *Chairman of Advisory Committee*. Response.
John W. O'Leary, President, Metal Trades Association of Chicago. "The Relation of the Chemist to the Manufacturer."
- 9:00 P.M.—MOTION PICTURES.

TUESDAY, SEPTEMBER 23

- 8:00 A.M.—Excursion of members of American Institute Mining and Metallurgical Engineers and American Electrochemical Society to steel mills at Gary, Ind. Technical sessions during the afternoon on the return trip on the boat.
"Iron and Steel."
"OH."
- 2:00 P.M.—SYMPOSIUM ON AMERICA'S CASE IN CHEMISTRY Exposition Auditorium. Ellwood Hendrick, *Chairman*.
Chairman's Address, Ellwood Hendrick.
"Dyestuffs," J. Merritt Matthews, Editor, *Color Trade Journal*.
"Glassware," E. C. Sullivan, of Corning Glass Company.
"Optical Glass," Harvey N. Ott, of Spencer Lens Company.
"Chemical Porcelain," Herman S. Coors, of Herold China and Pottery Company.
"Essential Metal Minerals," J. E. Spurr, of the War Minerals Relief Committee.
"Laboratory Supplies," C. G. Fischer, of Scientific Materials Company.
"Laboratory Supplies," J. M. Roberts, Secretary, Apparatus Makers Association of United States.
"Pharmaceuticals,"
"Fine Chemicals," H. T. Clarke, of Eastman Kodak Company.
- 8:00 P.M.—MOTION PICTURES.
- 8:00 P.M.—Joint Technical Meeting of American Institute of Mining and Metallurgical Engineers and American Electrochemical Society, Congress Hotel. Subject: "Iron and Steel."

WEDNESDAY, SEPTEMBER 24

- 10:00 A.M.—Meeting of American Electrochemical Society for reading and discussion of the following papers:
"The Effect of Amalgamation upon the Single Potential of Aluminum," Louis Kahlenberg and John A. Montgomery.
"Depreciation in Small Dry Cells with Age," A. J. Helfrecht.
"Manganin," A. Hunter and J. W. Bacon.
- 10:00 A.M.—Registration and Meeting of Technical Association of Pulp and Paper Industry in Officers' Room, First Regiment Armory
Address of Welcome.
Opening Remarks by President.
Report of Executive Committee.
Report of Secretary-Treasurer.
Reports by Standing Committees:
Abstracts of Literature. Ross Campbell, *Chairman*.
Bibliography. Henry E. Surface, *Chairman*.
Heat, Light and Power. Edward P. Gleason, *Chairman*.
Paper Testing. Frederick C. Clark, *Chairman*.
Soda Pulp. Martin L. Griffin, *Chairman*.
Standard Methods of Testing Materials Used in the Manufacturing of Paper. William H. Gesell, *Chairman*.
Sulfate Pulp. Olai Bache-Wiig, *Chairman*.
Sulfite Pulp. Herbert C. Spear, *Chairman*.
Vocational Education. George E. Williamson, *Chairman*.
- 10:00 A.M.—Meeting of American Ceramic Society.
- 10:00 A.M.—American Institute of Mining and Metallurgical Engineers. Technical Sessions.
"Local Resources."
"Sulfur in Coal."
"Iron and Steel."

- 2:00 P.M.—American Institute of Mining and Metallurgical Engineers. Technical Sessions.
"Sulfur in Coal," continued.
"Pyrometry, with Special Reference to Iron and Steel Metallurgy."
Joint Session with American Electrochemical Society on "Nonferrous Metallurgy." Chemical Exposition Auditorium.
Among the papers to be presented are:
"Radiant Resistor Furnace." A. J. Fitzgerald.
"Electric Heat in the Typewriter Industry." A. M. Clark.
"Electric Furnace for Experimental Work." A. J. Fitzgerald.
- 2:30 P.M.—Adjourned meeting of American Ceramic Society.
- 3:30 P.M.—Adjourned meeting of Technical Association of Pulp and Paper Industry.
- 6:30 P.M.—Dinner of Technical Association of Pulp and Paper Industry, Union League Club.
- Evening: American Institute of Mining and Metallurgical Engineers' Banquet, Congress Hotel.
- 8:00 P.M.—MOTION PICTURES.

- Resistance Type Furnaces for Melting Nonferrous Metals (Electric Furnace Company).
Electric Furnaces in the Heat Treatment of Essential War Materials (Electric Furnace Company).
The Detroit Rocking Electric Furnace in Operation (Detroit Electric Furnace Company).
Shawinigan Power Development and the Shawinigan Industries (Shawinigan Water and Power Company).
The American Chemical Society at the National Aniline & Chemical Company Plant, Buffalo, N. Y., April 1919 (Community Motion Picture Bureau).

THURSDAY, SEPTEMBER 25

- 9:30 A.M.—Meeting of the American Electrochemical Society. SYMPOSIUM ON CATALYSIS.
- 9:30 A.M.—General Business Meeting at Exposition of Technical Association of Pulp and Paper Industry.
- 10:00 A.M.—American Institute of Mining and Metallurgical Engineers. SYMPOSIUM ON PYROMETRY.
Excursion to De Pue, Ill., for inspection of zinc smelters, cement works, coal mines
Trip to Starved Rock and points of historical interest.
- 1:00 P.M.—Technical Association of Pulp and Paper Industry luncheon at, and as guests of Sears, Roebuck and Company, to be followed by visit to the paper mill plant.
- 2:00 P.M.—American Institute of Mining and Metallurgical Engineers. SYMPOSIUM ON PYROMETRY, continued.
- 2:30 P.M.—American Electrochemical Society Symposium on Catalysis continued, Exposition Auditorium, if not completed; if so, then
- 2:00-6:00 P.M.—Official tours of inspection of exhibits at Exposition.
- 4:00 P.M.—Committee Meetings Technical Association of Pulp and Paper Industry at Exposition.
- 8:00 P.M.—MOTION PICTURES.
Formation of Coal made Visible.
Chemistry of Gas Engines made Visible.
(Jam Handy, Vice President of Bray Studios, will make an address during the showing of these two films.)
- 8:00 P.M.—American Electrochemical Society Smoker, Congress Hotel.
- 8:30 P.M.—Technical Association of Pulp and Paper Industry Smoker, Union League Club.

FRIDAY, SEPTEMBER 26

- Morning: Technical Association of Pulp and Paper Industry will visit the Forest Products Laboratory, Madison, Wis.
- Morning: American Institute of Mining and Metallurgical Engineers. Continuation of adjourned technical sessions.
- EXCURSIONS.
North Chicago and Milwaukee.
East Chicago metallurgical plants and oil refineries at Whiting, Ind.
Local Chicago plants.
Coal trip to Franklin and Macoupin counties
- 9:30 A.M.—Joint meeting American Institute Mining and Metallurgical Engineers with American Electrochemical Society, Congress Hotel. Subject: "Pyrometry."
- 2:00 P.M.—Meeting continued, to be followed by an inspection of the pyrometry and temperature-recording instruments and devices at the Exposition.
- 2:00 P.M.—Meeting, Exposition Auditorium.
H. E. Howe, National Research Council. "The Organization and Plans of the National Research Council with Special Reference to the Industries."
Price Green, Industrial Commissioner Canadian National Railways. "Fields for Industrial Development—Canadian National Railways."

Henry B. Faber, Industrial Filtration Corporation. "Filtration."

Thomas W. Pritchard, Vice President of Fuel Products Corporation. "Destructive Distillation of Bituminous Material with Reduced Vapor Tension and Complete Temperature Control."

8:00 P.M.—MOTION PICTURES.

Address by Jam Handy, Vice President of Bray Studios on "Art Exposes the Invisible in Chemistry," while the following films are being shown:

Chemistry in Munitions.

Chemistry of Photography.

Invisible Chemistry of the Electric Battery.

Invisible Phases of Crystallization.

Address by Price Green, Industrial Commissioner of Canadian National Railways, "Natural Resources on Canadian National Railways," during showing of stereopticon and motion pictures.

SATURDAY, SEPTEMBER 27

9:30 A.M.—Technical Association of Pulp and Paper Industry, adjourned business session, Exposition Auditorium.

Afternoon: Technical Association of Pulp and Paper Industry, official visits of inspection to exhibits.

2:00 P.M.—SYMPOSIUM ON SAFETY IN PLANT AND MINE. Exposition Auditorium. M. F. Leopold, Safety Engineer, U. S. Bureau of Mines, Chairman.

8:00 P.M.—MOTION PICTURES. Depicting safety work in the plant and mine, by courtesy of U. S. Bureau of Mines.

During the week the following films not already listed will be shown:

Operation of Koppers By-Product Coke Plant (The Koppers Company).

Continuous Motion Conveying, Stacking, Elevating, Loading and Unloading by Brown Portable Handling Machines (Brown Portable Conveying Machinery Company).

The Manufacture of Zinc Oxide (New Jersey Zinc Company).

The following films will be shown through the coöperation of the Bureau of Commercial Economies. These are all recently completed films; some now being made will be completed in time for the Exposition.

The Making of Matches.

Gold Mining in Canada.

Building a Great Nitrate Industry at Muske Shoals, Ala., by the American Cyanamid Company.

Quarrying Canadian Asbestos.

Manufacturing Rubber Hose.

Making Lime.

The Silk Industry.

The Steel Industry.

The Iron Industry.

The Oil Industry.

Silver Mining in Bolivia.

The U. S. Bureau of Mines is completing a large series of films on the metal and mineral mining and manufacturing industries showing the processes from the mineral *in situ* in the earth to the finished commercial metal or article for showing at the Exposition.

The registration badges of all society members meeting at the Exposition will admit them at the doors without other tickets.

THE ASSOCIATION OF BRITISH CHEMICAL MANUFACTURERS

The Third Annual Meeting of the Association was held in the council room of the Chemical Society at Burlington House on Thursday, July 10, 1919, followed in the evening by a dinner at Princes' Hotel.

The chairman, Robert Grosvenor Perry, Esq., C.B.E., in his speech at the Annual Meeting, reported a membership of 145 firms representing a capital of about £70,000,000. In addition, 7 kindred associations are affiliated with the Association. During the year much useful work has been accomplished in consolidating the industry and strengthening the position of its various branches. The chairman pointed out that we are only on the threshold of a great dye industry in this country, and the Council of the Association had paid close attention to this question. The Association has been recognized by the Board of Trade, and Dr. A. Réé and the General Manager, Mr. Woolcock, M.P., have acted as members of the Trade and Licensing Committee. In addition, Lord Moulton, the honorary president of the Association, has accepted the chairmanship of British Dyestuffs Corporation.

The importance of the manufacture of fine chemicals as a key industry has also been impressed on the government, and the Association has been represented on the Imports and Exports Consultative Council which was set up as a temporary measure.

Close attention has been given by the Association to parliamentary legislation in so far as it affects chemical industry, and particular mention may be made of patent law and traffic problems.

A strong commission of the Association, representative of all branches of the industry, has recently returned from, and reported comprehensively upon, their visit, under government auspices, to the chemical factories in the occupied area of Germany.

It is interesting to note that during the year an *entente cordiale* has been established between the British and French chemical industries and collaboration between the two should be to their mutual advantage. After touching on many matters of domestic interest the chairman stated that he was called upon to give evidence before the recent coal commission and to give his views on the control of productive operations by public departments.

In the discussion which followed appreciation of the work done by the Council was expressed, and it is evident that the chemical industry has derived great benefit from the activities of the Association since its formation in 1916.

In the evening a distinguished and representative gathering dined at Princes' Hotel, and among the guests of the Association were: General Sir Wm. Birdwood, Sir James J. Dobbie (President, Chemical Society), the Earl of Dunmore, V.C., D.S.O., T. G. Feasey, Esq., Lord Glenconner, General Hartley, J. Fitzallan Hope, Esq., M.P., Sir Herbert Jackson (President, Institute of Chemistry), Sir Evan Jones, F. C. Kellaway, Esq., M.P., Sir Arthur Steel Maitland, M.P., Rt. Hon. Sir Alfred Mond, Rt. Hon. Lord Moulton, and R. T. Nugent, Esq.

The toast to His Majesty's Ministers was proposed by Lord Moulton and responded to by Sir Alfred Mond. Lord Moulton expressed his terror in the early days of the war at the lack of important chemical industries vitally necessary to save this country from defeat, and wondered to what extent the nation realized the importance of this industry.

In proposing the toast to the Association, Mr. F. G. Kellaway, M.P., enlarged upon the remarkable achievements of British chemists and the wonderful part played by the industry as a whole. The toast was suitably responded to by Mr. Max Muspratt.

Dr. C. Carpenter, vice president of the Association, proposed the toast "Our Guests," which was responded to by the Earl of Dunmore, V.C., D.S.O., and General Sir Wm. Birdwood, K.C.B., K.C.S.I.

The toast to the chairman was felicitously proposed by Sir William Pearce, M.P., and briefly responded to.

LONDON, ENGLAND

July 10, 1919

G. MOUNT, Secretary

CALENDAR OF MEETINGS

American Chemical Society—Fifty-eighth (Annual) Meeting, Philadelphia, Pa., September 2 to 6, 1919.

Chamber of Commerce of the United States—Atlantic City, September 30, 1919.

National Exposition of Chemical Industries (Fifth)—Coliseum, Chicago, Ill., September 22 to 27, 1919.

SOCIETIES MEETING IN CHICAGO DURING EXPOSITION WEEK

American Institute of Mining and Metallurgical Engineers—September 22 to 27, 1919.

American Ceramic Society—September 24, 1919.

American Electrochemical Society—September 24 to 27, 1919.

Technical Association of Pulp and Paper Industry—September 24 to 27, 1919.

THE CHEMICAL SOCIETIES IN NEW YORK CITY

1919-1920 SEASON—RUMFORD HALL, THE CHEMISTS' CLUB

- October 3—Société de Chimie Industrielle.
 October 10—American Chemical Society. *Joint Meeting with Société de Chimie Industrielle.*
 October 24—Society of Chemical Industry. *Joint Meeting with Société de Chimie Industrielle.*
 November 7—American Chemical Society.
 November 21—Society of Chemical Industry.
 December 5—American Chemical Society. *Joint Meeting with Society of Chemical Industry, and American Electrochemical Society.*
 January 9—American Chemical Society.
 January 16—Society of Chemical Industry. *Perkin Medal Award.*
 February 6—American Electrochemical Society. *Joint Meeting with Society of Chemical Industry, and American Chemical Society.*
 March 5—American Chemical Society. *Nichols Medal Award.*
 March 19—Society of Chemical Industry.
 April 9—Society of Chemical Industry. *Joint Meeting with American Electrochemical Society, and American Chemical Society.*
 May 7—American Chemical Society.
 May 14—Société de Chimie Industrielle.
 May 21—Society of Chemical Industry.
 June 11—American Chemical Society.

CHEMICAL WARFARE SERVICE RESEARCH DIVISION
REUNION

Former and present members of the Research Division of the Chemical Warfare Service, U. S. A., will hold a dinner at the Arcadia Cafe, Chestnut and Juniper Streets, Philadelphia, Pa., from 6 to 8 P.M., September 4, 1919.

THE FRANKLIN INSTITUTE EDWARD LONGSTRETH
MEDAL OF MERIT

The Franklin Institute, acting through its Committee on Science and the Arts, has awarded its Edward Longstreth Medal of Merit to Dr. Joshua J. Skinner, of the Laboratory of Soil Fertility of the Department of Agriculture, Washington, D. C., for his series of papers on "Soil Aldehydes," printed in the five issues of the *Journal of the Franklin Institute* from August to December 1918, inclusive. The resolution adopted by the Committee awarding the medal to Dr. Skinner contains the following statement: "These papers present the results of scientific study of a new class of deleterious soil constituents, clearly described and effectively illustrated, the whole forming a valuable contribution to the science of agricultural chemistry, and one of marked practical importance."

AMERICAN INSTITUTE OF MINING AND METAL-
LURGICAL ENGINEERS

September 22 to 26, 1919, is the time set for the Chicago meeting of the Institute, at which the progress that has been recently made in technical lines will be fully discussed. Among the subjects to receive particular attention will be the iron and steel industry, which has reached such importance in Chicago. It is planned that during the meeting the Institute shall make an excursion as a body to Gary, Indiana. Arrangements are being made to charter a steamer which will convey the members and guests across the south end of Lake Michigan directly to the steel works. A tour will be made through the various departments of the steel plant, and luncheon will be served at Gary. Technical sessions on subjects in ferrous metallurgy will be held on the boat.

The banquet has been scheduled for the evening of Wednesday, September 24, at the Congress Hotel. By putting this function in the middle of the week, it is expected that a maximum attendance can be obtained; members able to come for only a portion of the session can then be present at the banquet whether they come for the first or latter part of the week.

An elaborate program for the entertainment of the ladies is being prepared, and all members are urged to bring their wives to this meeting.

NOTES AND CORRESPONDENCE

14,000 MEMBERS
AMERICAN CHEMICAL SOCIETY

This is the Secretary's ambition for 1920. With your help it can be done. Please remember, however, that I need your help, that I will appreciate it, and that I expect you to send me an application blank with the name at the top of some chemist who has decided to join the American Chemical Society, and with your name at the bottom recommending his election. A chemist who is not a member of the American Chemical Society must feel lonesome; others realize, if he does not, that he is not doing his part toward the advancement of the profession upon which his own welfare depends.

CHARLES L. PARSONS, *Secretary*

ON WOOD CHARCOAL AS A CATALYZER AND ITS USE
AS AN ADSORBENT IN GAS MASKS

Editor of the Journal of Industrial and Engineering Chemistry:

It is noted that G. W. Jones and V. C. Allison, in their paper on "Carbon Tetrachloride, Chloroform, and Carbon Hexachloride from Natural Gas," which appeared in the July number of *THIS JOURNAL*,¹ make no reference to the process of James B. Garner and Howard D. Clayton for the manufacture of chlorina-

ted hydrocarbons,¹ developed at the Mellon Institute. Jones and Allison describe the use of certain catalyzers, such as war-gas charcoal, steamed anthracite coal, and batchite, in the chlorination of natural gas. Garner and Clayton devised the method of chlorinating natural gas by causing it to react with chlorine in the presence of charcoal. The last-mentioned investigators found during the course of their experimental work, which was carried out during 1914 and 1915 at the Mellon Institute, that "the charcoal is not altered during the reaction, its function being that of a catalyzer, which * * * causes the reactions to take place more smoothly, without explosive violence, and with great regularity and uniformity." It seems that this research of Garner and Clayton² so clearly precedes the recently conducted experiments of Jones and Allison that it was at least expected scientific courtesy that mention of that fact should have been made in their report. As indicated, the process of Garner and Clayton is protected by letters patent. Moreover, Garner has described in patents,³ as a result of this general investigation, a method of activating wood charcoal

¹ U. S. Patent 1,262,769 of April 16, 1918; application filed June 23, 1915.

² The investigation cited is discussed in *Proc. Nat. Gas Assoc.*, **10** (1918), 136; *Nat. Gas and Gasol. J.*, **12** (1918), 319; and *Gas Age*, **41** (1918), 555.

³ U. S. Patent 1,262,770 of Apr. 16, 1918; application filed June 30, 1915.

for use as a catalyzer in effecting chlorination reactions and as an adsorbent for such gases as sulfur dioxide, chlorine, etc.¹

Jones and Allison are, therefore, clearly incorrect in stating that "nothing of practical value" had been accomplished along the line of natural gas chlorination up to the time of the initiation of their research.

It is of interest to mention here that from the processes of Garner and Clayton were developed what is believed to be one of the first charcoal-containing gas masks. During the latter part of April 1915 it was realized at the Mellon Institute that charcoal, on account of its high adsorbent qualities, might be efficient in the adsorption of poisonous gases from the atmosphere and that there were great possibilities in the use of charcoal in this connection, were it possible to design a suitable, non-cumbersome fighting mask. The first gas mask based upon the use of charcoal was designed by Mrs. J. B. Garner, and practical tests demonstrated its utility against war gases. Accordingly, twelve masks of this type were made and transmitted (in June 1915) to the British government through their U. S. Agents, Messrs. J. P. Morgan & Company, of New York. Upon the declaration of war by the United States, full details of the experimental work and all apparatus used therein were

¹ U. S. Patents 1,173,566 of Feb. 29, 1916, and 1,220,411 of Mar. 27, 1917.

communicated to the Pittsburgh Station of the Bureau of Mines. Notwithstanding this fact, no credit has been given to the Industrial Fellows of the Mellon Institute nor has any mention been made of the fundamental work of the research staff of that institution in the numerous publications which have emanated from the Bureau of Mines and American University on the subject of wood charcoal and its use in defensive gas warfare.

This letter has been prompted by my established practice of securing for all incumbents of Industrial Fellowships complete recognition of their research accomplishments.

RAYMOND F. BACON, *Director*

MELLON INSTITUTE OF INDUSTRIAL RESEARCH
PITTSBURGH, PA.
July 25, 1919

INTERALLIED ORGANIZATIONS FOR CHEMICAL WARFARE—CORRECTION

In the article of the above title [THIS JOURNAL, 11 (1919), 721], the following correction should be made:

Page 722, 1st column, 6th line from top, "against the" should read "against and the."

August 15, 1919

J. E. ZANETTI

WORKS AND LABORATORY ACCIDENTS

A NOVEL METHOD OF REMOVING METAL FROM AN EYE

Editor of the Journal of Industrial and Engineering Chemistry:

Having heard that a friend since boyhood had been injured while at work in the laboratory of the Dayton Metal Products Company I sought further information and obtained a story which is certainly worth telling, particularly to chemists. The blowing out of the safety diaphragm of a hydrogen tank with defective valve, which tank contained the gas at 2000 lbs. pressure, resulted in numerous fine particles of metal becoming embedded in the cornea of the right eye of my friend, whom I shall call Mr. M., as he has asked that I "mention no names." The metal was not analyzed but was known to be a low-melting alloy such as would be used for a safety diaphragm of a tank containing combustible gas, and it was thought to consist of bismuth, tin, and lead. A few of the pieces of metal were large enough to be picked out but it was estimated that after their removal some forty or fifty smaller particles remained. The doctor believed that to remove them mechanically would require so much digging around as to destroy the sight. He tried treatments to soften the cornea with the thought that the particles might drop out by gravity, but they failed to do so. In the meantime the irritation was not only putting the injured eye in worse and worse condition but the left eye was beginning to cause trouble of a sympathetic sort, so that at the end of three weeks after the accident had occurred Mr. M. was feeling very uncomfortable, to say the least.

Then he decided to take things into his own hands. He conceived the idea of removing the metal by amalgamation. He purified some mercury by treating it in the usual way with dilute nitric acid and redistilling and applied it to his eye by means of an eye-cup. Almost immediately the irritation to the eyelid which fine projecting points of metal had caused was relieved, these points disappearing like magic. By repeating the applications, using fresh mercury each time, every piece of metal was removed inside of two weeks and the eye was restored to normal condition. Can you point to an experience either in fiction or in real life which shows more ingenuity in a pinch?

E. J. CRANE

OHIO STATE UNIVERSITY
COLUMBUS, OHIO

FIRE HAZARDS IN DYESTUFF STORAGE AND MIXING

Editor of the Journal of Industrial and Engineering Chemistry:

A fire which recently occurred in a dyestuff warehouse in Boston, furnishes an illustration of the hazards connected with a certain class of dyestuff. The building was located in a built-up city block. It was occupied mainly for the storage and mixing of colors for the textile and leather trades. On the top floor, however, were 2 barrel-shaped mills in which dyes were occasionally pulverized, preparatory to the mixing and packing processes. At the time of the fire a substance known as meta-chrome brown or pala-chrome brown in the dry state was being pulverized in one of these mills. A sudden burst of flame, amounting in effect to a mild explosion, occurred in this mill. The action was so violent that flame was projected out of the building some 20 ft. across an open airway, scorching windows some distance from the mill itself. The flame also ignited considerable material inside the building and it was only by the prompt use of the extinguishing facilities present that a severe loss was avoided.

Upon investigation it was found that this color was made from picramic acid, a material very likely to explode from friction, shock, or ignition. It is supposed that the explosive action noted in the color itself was due to an excess of free picramic acid. Since this fire it has been learned that several fires have occurred in mills where alizarol browns and yellows were being ground and that the risk of grinding these materials in a dry state is almost prohibitive. In the case of this plant, it is apparent that the material had been ground in the dry state several times previously without any resulting fire or explosion. It is evident that the material should be handled and ground in paste form only, if at all, and that all materials of this sort, derived from picramic acid, should be regarded with suspicion and handled with caution.

BOSTON, MASS.
June 13, 1919

W. D. MILNE

Editor of the Journal of Industrial and Engineering Chemistry:

A fire recently occurred in a wholesale dyestuff plant in Boston, Mass., which illustrates the hazards which may be present in properties where dyes are handled but where no strictly manufacturing processes are carried on.

The contents of 4 bbls. of sulfur black dye which were considered to be not of uniform composition had been mixed together and returned to the barrels. About 24 hours later smoke was observed in the room where these barrels stood and upon investigation it was found that the barrels were smoking, one being partially burned through. Fire was extinguished by the use of hand chemicals and did but slight damage. About 2000 lbs. of the dyestuff were involved.

There appears to be little doubt that the fire was caused by spontaneous heating of the dye. It appears that this ignition may have been due to an excess of sulfur being present, since sodium polysulfide is used in the preparation. This dye is one of the simplest to manufacture, and for this reason it may be produced by plants where little precaution is taken to secure high-grade products. Under these conditions, all sulfur black dyes should be regarded with suspicion and handled with caution. They should not be stored in such a manner that fire in them will be easily communicated to combustible material or to large areas.

BOSTON, MASS.
June 16, 1919

W. D. MILNE

EXPLOSIONS WITH AMMONIACAL SILVER OXIDE SOLUTIONS

Editor of the Journal of Industrial and Engineering Chemistry:

Considering the frequency with which the solubility of silver oxide and silver chloride in ammonium hydroxide is utilized in the chemical laboratory, especially in undergraduate courses, the fact that silver fulminate is readily obtained by the treatment of silver oxide with ammonium hydroxide is not sufficiently well known. It is the purpose of this note to warn of the danger incurred when concentrated ammonium hydroxide reacts with silver oxide and to urge that a warning be placed in all procedures in which ammoniacal silver oxide solutions are used.

My own experiences on the formation of explosive silver fulminate occurred some years ago while studying the oxidation of some organic compounds with silver oxide. In order to determine the amount of oxygen consumed the undissolved residue ($\text{Ag} + \text{Ag}_2\text{O}$) was treated with ammonium hydroxide to dissolve the unchanged silver oxide. The silver residue was then dried and weighed. On one occasion such a precipitate mysteriously disappeared overnight from a hot plate (on which it had been left to dry) along with much glass apparatus. Later, evidence was obtained to show that the apparatus was fragmented and cleanly swept away by the explosion of the precipitate.

On another occasion a flash of flame and a charring of the filter paper was observed when something gently exploded while washing a precipitate with concentrated ammonium hydroxide.

On the last occasion the contents of a small beaker containing ammoniacal silver oxide exploded just after stirring the precipitate with a small, glass rod. It was noticed that gas bubbles were evolved just a moment before the liquid exploded. About 200 minute fragments of glass were driven into my forearm and the strongly alkaline liquid was thrown into my eyes. I was fortunately only temporarily inconvenienced. That the power of this explosion was terrific is indicated by the fact that some of the small glass fragments (less than 1 mm. in diameter) were driven through the walls of flasks and condensers as much as 10 ft. away. These holes were so small that some of them were not detected for months afterwards.

Raschig¹ who fully investigated silver fulminate obtained in this way states that the violence of the explosion is much overestimated. He, however, was careful to handle his product in very small portions. Larger amounts would have impressed him more.

Matignon¹ observed an explosion of an ammoniacal silver oxide solution that stood overnight, which suggests that such solutions should not be kept without proper precautions.

Raschig states that explosive derivatives are never formed with dilute ammonia and silver oxide. My own experience confirms this.

For further details the two papers referred to should be consulted.

OTHO S. A. SPRAGUE MEMORIAL INSTITUTE
CHICAGO, ILLINOIS
March 25, 1919

E. J. WITZEMANN

REPORTS FROM THE CHEMICAL LABORATORY OF THE MASSACHUSETTS DISTRICT POLICE

BURNING TEST ON MOTION PICTURE FILMS, MARCH 20, 1919

I took the usual accumulation of censored motion picture films from the State House this morning to the vacant lot near Albany and Dover Streets, Boston, and destroyed them by fire.

At the request of the Boston Fire Department several different makes of fire extinguishers were tried to see which one was best adapted to put out fires occurring in motion picture film exchanges.

FIRST TEST—About 20 pounds of films in reels were placed on the ground and ignited. Extinguishers of the carbon tetrachloride type were tried but after four were emptied the fire burned with increasing force. They seemed to have no effect whatever on the flames.

SECOND TEST—About 40 pounds of the films were placed in a wooden box and ignited. After they were well ablaze, streams from four, full-size soda and acid extinguishers of the usual type were played on the fire. They seemed to have no effect whatever and the extinguishers were exhausted, leaving the films to burn themselves out.

THIRD TEST—About 50 pounds of the films were placed in a wire cage and ignited. They burned furiously when a hydrant stream from Engine 3 was turned on them for about five minutes. The fire still burned and then flameless combustion ensued, generating dense volumes of gas which, when combined with the oxygen of the air and confined, resulted in disastrous explosions at Pittsburgh, Pa.

FOURTH TEST—About 10 pounds of the films were placed in a wooden box with kindling wood and a pail of gasoline poured over them, and ignited. The stream from a fire foam extinguisher was played on the fire and thoroughly extinguished all fire in the gasoline, but the films kept right on burning until they were all burned out.

District Police regulations permit a maximum of 1250 pounds of film in a fireproof vault while the regulations of the Fire Prevention Commissioner allow 2500 pounds. I had about 120 pounds of film in the above tests divided into four parts and we found nothing in extinguishers or apparatus that would put out the fire.

The tests were witnessed by the Chief, Deputy and District Chiefs of the Boston Fire Department, as well as by many chiefs from nearby cities and towns, also by Mr. Frank Lewis, Fire Prevention Commissioner, representatives from the Underwriter's Bureaus, motion picture operators, and reporters.

EXPLOSION OF A NAPHTHA SETTLING TANK AT LAWRENCE, MASS., JUNE 17, 1919

This is a case where a man bought a second-hand tank in a junk yard and attempted to solder a faucet in it for use on a kerosene oil wagon. Unbeknown to him the tank had formerly been used as a naphtha settling tank in a dry cleaning establishment and was partly filled with settlings consisting of dirt from naphtha-washed clothing. He was badly injured.

¹ Bull. Soc. Chim., [4] 3 (1908); Chem.-Zig., 32, 607; Chem. Zentr., [II] 1908, 136.

Any receptacle which has once been used for a volatile inflammable liquid should be kept away from lights and fires until it has been filled with water to expel the inflammable vapor and thoroughly washed out.

If this cannot be done at once, to avoid trouble it is best to turn the drum or barrel bung-hole downward and open to the air, then the heavy vapor will gradually pass out of the vessel, its place being taken by air.

FIRE IN THE PLANT OF G. W. RICHARDSON COMPANY, NEWBURYPORT, MASS., MANUFACTURERS OF CELLULOID HAIR ORNAMENTS

About 8:25 A.M., July 16, 1919, fire occurred in the above plant destroying the main building, two celluloid storehouses, and one dwelling house. Loss estimated at \$100,000.

The main building was about 40 x 117 ft., basement and three stories in height. Basement had brick walls, superstructure was of wood. The building was sprinklered.

The fire originated in a basement room about 50 x 75 ft., and in this room were located eleven steam heating tables for the purpose of softening the celluloid stock in the process of forming it into ornaments by means of dies. There was also in this basement room an oven heated by steam pipes and constructed of wood about 24 ft. in length. Through this oven there was a slow moving belt. Hair pins were dipped in a polishing solution consisting of acetone, alcohol, and amyl acetate, hung on the moving belt and passed through the hot oven or dryer. When they arrived at the other end they were dry, the liquid having been evaporated by the heat. Underneath this belt there was a wire screen to prevent any celluloid falling on the hot steam pipes beneath.

Between 9:00 and 10:00 A.M., July 15, this belt either broke or slipped off the pulleys at which time it was thought to have disarranged the wire screen in some way to allow some of the celluloid to drop on the hot steam pipes. The belt was repaired and during the afternoon of the 15th the dryer was said to be working as usual.

A man who was working in the room says that he saw the fire start on one of the steam tables near the oven or dryer.

A woman says that she was working near the dryer and that the fire started at the end of the dryer near the belt.

The foreman of the room says that they usually carried 90 lbs. steam pressure on their boiler and that it was absolutely necessary to maintain this pressure so as to give them at least 300° F. on their steam tables so they could work their celluloid.

Samples of the celluloid, such as they used, were taken from the ruins of the plant to this laboratory for ignition tests which gave the following results:

Hair pin stock, dark, mottled. Ignition point 281° F. (average of four tests)
Hair ornament stock, yellow. Ignition point 274° F. (average of four tests)

A sample of the polishing solution in which the hair pins were dipped before they were passed through the hot dryer was also taken. The flash point of this solution was found to be 17° F.

Vapor of this solution was mixed with air and placed in the laboratory exploding machine where it was found to be highly explosive at a temperature of 79° F.

Regardless of the conflicting testimony of the above-mentioned witnesses, it is quite evident that the fire was caused by excessive heating of the celluloid.

The engineer of the plant says that he usually carried 90 lbs. pressure on his boiler.

His license allows a maximum pressure of 125 lbs. which he claims is regulated by a Julian D'Este Company damper regulator set at 90 lbs.

The temperature of steam at 90 lbs. pressure is 320° F. and it is therefore reasonable to assume that on the steam tables and dryer pipes the temperature would be in excess of 300° F., as they are only a short distance from the boiler, and the latter

temperature is claimed by the foreman to be necessary for their processes.

As previously stated, laboratory tests of the same celluloid they were using show conclusively that it ignites at 274° F. and 281° F. when exposed suspended in air heated to those points.

Paper is claimed to be sometimes laid on the steam tables to prevent excessive heating. It is also claimed that the liability of ignition increases in direct ratio to the length of time of exposure.

If it is necessary, in the process of manufacture, to expose celluloid to a temperature ranging from 19° to 26° above its usual point of ignition, then it must be admitted that such process is of too hazardous a nature to be conducted in a wooden building containing more than one hundred employees, mostly women, in the heart of a city, and near to two storehouses where \$25,000 worth of crude celluloid stock were stored.

Some of the witnesses claim that there was an explosion which is highly probable from the fact that the oven or dryer must have contained a dangerous mixture of air and vapor from the polishing liquid which is found to have an extremely low flash point and to be highly explosive when mixed with air.

Greater isolation of similarly dangerous processes under fireproof construction would seem to be the lesson taught by this fire.

FIRE IN A BARREL OF SAWDUST IMPREGNATED WITH NITRIC ACID

About 2:30 P.M., Thursday, July 31, 1919, I received an emergency call requesting my presence at an acid fire in the corridor on the fifth floor of the building of the Tuttle Silver Company, Boston.

I arrived a few minutes later finding the fire department there in charge of District Chief Caulfield.

The cause of the fire was as follows:

The company is engaged in silver-plating and polishing, and during the latter operation quantities of silver scale or silver oxide are obtained which represent considerable commercial value.

The silver scale is dissolved in nitric acid; the resulting solution contains silver nitrate and free nitric acid. This is sent away for the purpose of reclaiming the silver.

Heretofore the company have precipitated the silver from this solution in the form of silver chloride by adding a solution of common salt, sending the chloride to the refiners.

But in this instance, and this is the first time they have tried this method, they poured the solution of silver nitrate and free nitric acid into a wooden barrel nearly filled with wood sawdust, heading it up ready for shipment and placing it in the corridor.

The weather was very warm and soon attention was attracted to the barrel by a loud hissing noise, large volumes of gas being given off.

The fire department was called and they proceeded to ventilate the barrel, with small holes at first, afterwards removing the head and when fire appeared they poured in water.

On my arrival the corridor was filled with people and the dense red fumes of nitrogen dioxide were being given off from the barrel. Realizing the danger, I ordered out all those having no business there, after which we obtained large earthenware crocks in which the contents of the barrel were diluted with water until the generation of gas ceased.

I was informed that the barrel contained \$500 worth of silver and adopted this method as being the quickest and best to save it for the company if possible.

All firemen and members of the insurance protective brigade present, including myself, were more or less affected by the fumes, the symptoms being slight dizziness, extreme dryness and burning of the throat.

As soon as possible thereafter I obtained a supply of fresh ammonium carbonate cubes advising the chief to have his men

breathe the ammonia fumes to neutralize the effect of the acid. Draughts of water and milk were also recommended.

No serious results followed although District Chief Caulfield, who was exposed to the fumes more than others, experienced considerable discomfort early the next morning.

Throughout this country many firemen and industrial workers have lost their lives by breathing these fumes, the effects of which are insidious at first. The gas is said to change to nitric acid on coming in contact with the moist tissue of the lungs, and death follows from oedema in from 24 to 48 hrs. after exposure.

The practice of absorbing a solution of free nitric acid and nitrate of silver with wood sawdust is said to be recommended by certain firms engaged in silver reclaiming.

As it is a well-known fact that organic matter and nitric acid are spontaneously inflammable, to say nothing of the danger to life from the fumes, such practice should receive emphatic condemnation.

Attached hereto is a very interesting letter which I have received from Dr. Eugene J. McCarthy, of the State Board of Labor and Industries, explaining the effect of these fumes from a medical viewpoint.

BOSTON, MASS.

WALTER L. WEDGER,
Chemist, Explosives and Inflammables

Concerning preventive measures to safeguard the lives of firemen in fighting fires where acid fumes are present, such as in plating works or chemical or dye factories, I would suggest to you the use of the world-war gas mask, either American or French, the latter being lighter and called the Tissot mask. However, the American mask stood the supreme test and saved thousands of American soldiers' lives.

As you know, the gases used in warfare were practically all of acid reaction, so that alkalis were used in the mask as neutralizers. These masks are good for about 55 hours' continuous

or intermittent use before needing refilling, a card being attached to check off how long used.

The American Government has millions of these masks now on hand, of which a reasonable number could be purchased for a nominal sum. The firemen could be given exercises with the masks on so that they would become accustomed to them. Soldiers were trained to run up hill with them on and experienced no inconvenience, in fact the careful soldier would not be without his gas mask, so much confidence had he in it.

Breathing in the fumes of cubes of ammonium carbonate will offset the acid fumes if too great a concentration of fumes has not been breathed and if given immediately after the attack. However, why consider too deeply after-treatment when prevention is possible, especially when acid fumes act insidiously and cause nitrogen dioxide poisoning. Death may result in 10 to 48 hours after exposure to acid fumes in spite of every available means and methods known to doctors, including oxygen tanks, lung motors, pulmotors, etc.

Often large quantities of nitrous gases (acid fumes) are borne well for 6 to 8 hours without discomfort, when suddenly, after a long interval, up to 24 hours without disturbance, ominous symptoms develop. Symptoms of irritation in the air passages appear as a feeling of constriction of the larynx, spasmodic cough, oppression in the chest, labored respiration, anxiety, cold perspiration on the face, protrusion of the eyes, gasping speech, paroxysms of coughing, bluish discoloration of the countenance, and coldness of the extremities. Consciousness is at first unimpaired, but with increasing difficulty of breathing it becomes dimmed; injury to the teeth. The urine is scanty, brown in color, containing hemoglobin and albumen. Death results from oedema of the lungs. Methemoglobin is present.

This is not painting the symptoms too black as to the possibilities, as you know we have had a number of nitrogen dioxide poisoning deaths in certain industrial plants in Massachusetts and furthermore have autopsical findings on file of some of these cases, thus making possible positive diagnoses of nitrogen dioxide poisoning.

EUGENE J. MCCARTHY, M.D.

STATE BOARD OF LABOR AND INDUSTRIES
BOSTON, MASS., August 7, 1919

WASHINGTON LETTER

By PAUL WOOTON, Union Trust Building, Washington, D. C.

While the focal point of interest has changed during the past month from tariff matters to the cost of living problem, enough has been done with the tariff to indicate clearly what may be expected in that connection from the present extra session of Congress. The bill providing duties for laboratory glass- and porcelain-ware passed the House without a roll call. The discussion of the bill took on unusual significance from the fact that it brought out for the first time the real intentions of the leaders of each party in regard to tariff legislation. It is a foregone conclusion that the bills providing duties on magnesite, tungsten, and zinc will be passed just as reported out by the Committee. In addition to the Republican majority, a number of Democrats are voting with the Republicans on the emergency tariff bills. Dyestuffs and potash fall in a different category, as there is considerable difference of opinion, even among the Republicans, as to the safeguarding of those industries.

Speaking generally, the Democrats prefer a licensing system at this time, as preferable to a duty. The Republicans do not regard the licensing system with much favor and are working along customary lines in drafting tariff schedules. The Democratic point of view was summed up very precisely by Representative Kitchin, of North Carolina, the ranking Democrat of the Ways and Means Committee. During the discussion of the chemical glassware bill, Mr. Kitchin made the following declaration of the Democratic position:

Nobody knows at this time how to write intelligently or scientifically a tariff bill on the Republican theory or on the Democratic theory, because we have got to know, in considering and writing a tariff according to the Republican theory, what the difference is between the cost of production abroad and here; and in considering a tariff according to the Democratic theory we ought to have a reasonable knowledge as to the difference in the cost. It is admitted by everybody that this is not known at this time, and cannot be known what it will be a week or a month or a year hence, because of the rapidly varying conditions. Here is the Democratic position: We realize the wisdom and necessity of maintaining the chemical and dyestuff industry and a few other industries essential in the production of materials for direct munitions of war, which industries were established here during and by the necessities of the war, but which are valuable in the production of necessary articles of everyday use. In the present and ever

changing conditions, having no data or facts upon which to intelligently base a tariff rate, the Democrats propose for a period of two years—a reasonable transition period from abnormal to normal conditions—a license system for importation of chemicals and dyestuffs and the few war-essential materials referred to by me a moment ago; that the Tariff Board shall constitute the license board; that no license to import such articles shall be granted within the two years—the transition period from abnormal to normal—unless it be shown that they cannot be obtained in the United States at a reasonable price; if such be shown, license to import shall be granted. This will with certainty protect these newly established war-essential industries and at the same time prevent the manufacturers here from demanding exorbitant prices. By the expiration of the two years we can hope that conditions of production and values here and elsewhere throughout the world will become normal. By then the Tariff Commission and others can give Congress proper data as to the cost of production at home and abroad. We can then, if it ever could be done, ascertain the difference in the cost of production at home and abroad. Both the Republicans and Democrats will then be in an intelligent position to write a tariff and fix rates according to their respective theories. Why is not this the intelligent, reasonable, and patriotic position for all of us to take?

In defending the chemical glassware bill, Representative Fordney, of Michigan, the chairman of the Ways and Means Committee, made the following explanation:

We have combined in this bill chemical glassware, optical glassware, and surgical instruments of all kinds. Before the war these articles were not made in this country. We could not compete with Germany. Germany used every unfair method to destroy industries of this kind the minute we started them in this country. No one has ever more clearly explained that than the Attorney General, Mr. Palmer, in his annual report as Alien Property Custodian, made last January, in which he goes on to show that there were five institutions in this country making chemicals. Three of those institutions were finally forced to go out of business for the reason the chemicals they were making, say, oxalic acid, which was then selling for 6 cents, was reduced to 4.6, and finally to 2.2 a pound, and immediately upon closing their doors the Attorney General said the price went up to 7 cents, higher than ever before, and when the war broke out and we took part in that war we discovered that those two institutions that remained in business were German-owned and he, as custodian of alien property, took them over. Therefore, the two institutions that remained in business were

German institutions, and the "yellow-dog" fund in Germany was used against our own industries to drive them out of business. The war has operated as the high protective wall. Our industries have sprung up in aid of the Government in its effort to defeat the enemy. Do we need now any greater lesson than the one we have just received? Do we want another war to drive it into our heads that it is necessary for the American Congress to protect American labor and American capital? I think not.

The line of Mr. Kitchin's argument against the chemical glassware bill may be judged from the following brief extract from his speech:

The American Chemical Society, through Dr. Parsons, let it be known that they did not object to 60 per cent; that they knew nothing about tariff rates; but that was what the manufacturers wanted, and they were willing to stand by what the manufacturers wanted in order to build up the industry. How did these chemists know anything about the cost of production here or the cost of production abroad? They wanted the industry here. They did not manufacture. They did not care what the rates were; how high they were made. The only fellows who were interested in the rates were the manufacturers who are going to make money out of this exorbitant 60 per cent. And neither this chemical society nor the members of it are going to have to pay a cent of this tariff tax. The big corporations, in whose employ they are, like the Steel Corporation, the sugar and oil refineries, and so forth, that use much chemical glass in their testing laboratories, and the educational institutions, of whose faculty they may be members, and the students of such institutions will have to bear the burden of the tax.

In answering Mr. Kitchin's claim that the principal result of the duty would be to add \$14.33 to the expense of each student in the chemical and scientific departments of our universities and colleges, Representative Longworth, of Ohio, made the following statement:

For years a paragraph has been carried in all tariff laws enabling educational institutions to import these articles free of duty, and under that for many years more than half of all our importations of these various kinds of chemical apparatus have been coming into this country. The situation, however, has always been entirely different from what it is at present. In the old days and up to this very moment the educational institutions were asking that their apparatus be brought in free, because they did not believe that it could be made in America, and so we leaned upon Germany entirely for every single piece of apparatus that we have in our chemical laboratories. But to-day the situation is different. Shut off from Germany by the war, American citizens showed that they were capable of making just as good chemical apparatus as the Germans were capable of making, and now we do not want any more chemical apparatus made in Germany. And to-day these very educational institutions themselves, about whom the gentleman from North Carolina betrays such earnest solicitude, are asking that this free-trade paragraph be eliminated from this bill.

If there is anything in the Democratic theory of free trade, or, if you please so to call it, a tariff for revenue, it is in the interest of the consumer. But when the consumer comes to you and tells you that he no longer wants free trade in these articles, if you regard only the interest of the consumer, is it not fair to take him at his word?

That is precisely the case here. Our educational institutions know now that Americans can make just as good chemical apparatus and surgical instruments as the Germans ever could, and they have learned the folly of relying upon any other nation for their supply of those articles which America herself can produce just as well. They learned a bitter lesson when this war came on, because they were for a time cut off entirely from the supply of those articles absolutely necessary to conduct the laboratory, educational, scientific, and industrial experiments and investigations in this country, and they now realize that the worst thing that could happen to the colleges and the educational institutions here would be again to be dependent upon the mercy of Germany for the supply of all these articles. Hence they are asking this House that this industry be made self-sustaining. So all the argument of the gentleman from North Carolina to the effect that we must look after the interests of the consumer and we must protect him against this great monopoly falls absolutely to the ground when the consumers themselves come and ask us to do just exactly what this bill does.

It had been expected to proceed rapidly with the emergency tariff bills, but plans for a vacation recess of the House interfered first, and then the cost of living activities took the center of the stage. At this writing, however, the tungsten bill has been taken up and it is expected that the others will come up in rapid succession once the parliamentary situation is such as to permit their uninterrupted consideration.

Much importance was attached to the testimony of Hoyt S. Gale when he appeared before the Committee on Ways and Means to sum up the results of his observations as to potash in Germany, Alsace, and Spain. Mr. Gale's assurances that no large amount of potash is available for shipment from Germany and that the price laid down in Hamburg hardly will be less than \$1.50 a unit are understood to have relieved the Committee of the urgency for reporting the potash bill. Among the statements made to the Committee by Mr. Gale is the following:

Herr Schüddekopf, general director of the kali or potash syndicate, assured me at the time of my visits, which were shortly after the first of July, that he believed the German mines would be able to supply as much potash as the United States will need, but that for the present this would consist of the lower grades of potash fertilizer salts, provided boats for the transportation of this material from Germany could be secured. He was positively unwilling to state from what properties the principal production was then being made. He spoke of the uncertainties due to the general disorganization, lack of fuel and railway transportation facilities, and the men available, he said, were not as efficient as formerly. The men returning from the war will not at first be in condition for the work and will not be as many as are needed, and they will have to be paid higher wages than formerly; the mines and refineries are now badly run down and in need of repairs. That is particularly true of equipment for making the higher grades of refined salts, which will require considerable time for replacements before the former efficiency will be regained. There is also uncertainty as to what the national policy toward the potash industry will be. The potash industry will undoubtedly be subject to heavy taxes which will be needed to raise revenue and those burdens will be put as largely as possible on the export prices of potash.

Therefore, I do not look during the next year for much lower prices than are now offered on German potash.

In connection with the investigation of expenditures in the War Department, General Sibert, the head of the Chemical Warfare Service, was called to explain expenditures in that Service. Apparently his explanation was regarded as satisfactory by the committee. General Sibert took advantage of his appearance to express his views as to the effectiveness of gas in warfare and to point out that it has humanitarian advantages over bullets and high explosives.

The General Staff bill for the reorganization of the Army makes no mention of the Chemical Warfare Service, but a letter accompanying the bill explains that such work as would be necessary in chemical warfare would be conducted under the direction of the Engineer Corps. This meets with determined opposition on the part of the chemists who are interested in this branch of the service, as they fear that it cannot develop properly under the Engineer Corps. The reorganization bill abolishes the Chemical Warfare Service.

The War Trade Board section of the Department of State announced, August 7, that Paragraph 1 of the limitations upon the General Enemy Trade License (W. T. B. R. 802, issued July 14, 1919) has been amended, effective August 7, 1919, so as to delete from the paragraph the item "potash," and accordingly the General License as now amended authorizes the importation into the United States of potash produced or manufactured in Germany.

INDUSTRIAL NOTES

Paper will be manufactured from cotton stalks, linters, and other fibers by the Southern Fiber Co., Dallas, Tex., which has been organized with a capitalization of \$250,000 and the following officers: *President*, Z. E. Marvin; *Vice President*, A. C. Ebiep; *Secretary*, E. P. Angus; *Treasurer*, E. W. Ross. Four miles from Dallas the company has purchased a site upon which it intends to build a \$200,000 mill, equipping it with machinery for the production of paper from fibers by a process of which L. D. Jones, of Dallas, is the inventor.

Rosin, turpentine and pine oil will be manufactured at Calvert, Ala., by the National Reduction Company, of New York. The buildings for this company's plant will be of steel-concrete fireproof construction and will cost \$300,000. Arthur D. Little, Inc., Cambridge, Mass., is the engineer in charge of designing the plant, constructing the buildings, and installing the necessary machinery. Frank W. Boykin, of St. Joseph, Mo., is the president, and Francis A. Reilly, of New York, is the secretary-treasurer of the company.

Lord Moulton, the chairman of the British Dyestuffs Corporation, Ltd., announced recently that since the company took power to create new shares a few weeks ago the government had become shareholders to the extent of £850,000 preference shares and £850,000 preferred ordinary shares. There is planned the issue of further preference shares of such an amount as the directors may determine, but not exceeding, together with the preference shares already issued to the shareholders of British Dyes, Ltd., and Levenstein, Ltd., a total nominal amount of £4,500,000. The government shares would stand exactly on the same footing as other shares in the same class.

The Imperial Institute of Great Britain finds that 90 per cent of the world's supply of cinchona bark is obtained from Java, and the recent agreement between the planters of cinchona in Java and the Dutch manufacturers of quinine, by which the manufacturers withdrew objections to the planters entering the manufacturing field so as to be able to ship the crude quinine instead of the bark, gives Holland and her Dutch East Indian possessions a monopoly in quinine.

Pratt and Lambert, varnish makers, have purchased a tract of land in Long Island City, N. Y. Plans for a two-story building have been prepared. The company recently sold the plant it was operating at Long Island City to the American Drug Syndicate.

The Board of United States General Appraisers holds that anhydrous refined wool grease (*adeeps lanæ*, anhydrous) is dutiable at one-half cent per pound under Paragraph 44, Act of 1913. The case is the protest of S. L. Jones & Company against the assessment of duty by the collector at San Francisco, who classified the goods at one cent per pound as lanolin under Paragraph 44, and the importer claimed a refund on the ground that the goods should have been classified as "wool grease refined" at one-half cent per pound under the same paragraph. Merck's case, decided August 4, 1916, and confirmed by the Court of Customs Appeals, was cited to show that Congress intended to leave *adeeps lanæ*, anhydrous, to be classified as wool grease. The protest was sustained.

The Union Dye and Chemical Company, which took over the assets and plant of the Federal Dyestuff and Chemical Company, Kingsport, Tenn., when the Federal Company went into receivers' hands, has closed the plant so far as production is concerned, but is still selling its surplus products and making deliveries on previous orders. The plant, while under control of the Federal Company, made a wide range of intermediates, including dinitrophenol, dinitrobenzol, nitroretol, dinitrochlorbenzol, betanaphthol, monochlorbenzol, caustic soda, and muriatic acid. The new company continued the manufacture of most of these products. Large contracts were obtained from the Government, which required heavy expenditures, and the company is slowing up during the reconstruction period to await payments and dispose of stock on hand. The Union Dye and Chemical Company took possession of the Kingsport plant in September last, with A. A. Matheson, formerly of the du Pont Chemical Works, in charge. The company was organized with Everly M. Davis, *president*; Samuel Armstrong, *treasurer*; and H. Starr Giddings, of Sullivan & Cromwell, *secretary*.

Fertilizer manufacture on an extensive scale is the purpose of the United States Guano Company, which has been incorporated with a capitalization of \$500,000. The plant will be located on the Curtis Bay waterfront. Marshall Jones, William E. Vallant, and Charles H. Robertson, of Baltimore, are the new company's incorporators.

The board of directors of Midvale Steel and Ordnance Company recently authorized an extensive reconstruction program, for which approximately \$8,000,000 will be required. A large part of this amount will be expended at the blast furnaces and open-hearth department of the Franklin plant of Cambria Steel Co., Johnstown, Pa., in replacing worn-out equipment and modernizing the plant.

The officials of the American Cellulose Chemical Manufacturing Company, Ltd., have decided to erect a large plant in Cumberland, Md., at a cost of not less than \$2,000,000, and have closed a contract with the film company of Pathé Freres, Inc., to manufacture all films used by the motion picture enterprise. Plans for the plant are now being drawn by the engineers. About 1,000 men and women will be employed in the establishment.

The Chamber of Commerce of the United States will hold a meeting at Atlantic City on September 26, at which meeting will be present foreign missions from England, Belgium, France, and Italy. International questions will be taken up and it is planned to arrange a nation-wide trip for the visitors.

The American Zinc, Lead and Smelting Company has taken over the entire zinc oxide production of the American Steel and Wire Company's plant at Donora, Pa., for a term of years, according to an announcement made by L. E. Wemple, manager of the zinc oxide department of the American Zinc, Lead and Smelting Company.

While the decision of the United States Supreme Court in the final chapter of the long litigation over the patents of the flotation process of the Minerals Separation Company for recovering metals did not sustain all its claims, the fact that it holds as infringement the use of any oil in quantity under 20 lbs. to the ton of material treated, is of tremendous importance to it and to the whole mining industry. It confirms the major contentions of the Separation Company and places the mining companies which have infringed under liability for heavy damages.

The du Pont de Nemours Company has decided to sell five complete towns, among them Hopewell, the powder city which grew up overnight in Virginia, Carney's Point, N. J., Haskell, N. J., and two smaller communities, all set up during the war and engaged in the manufacture of munitions.

Texas, Missouri, and South American investors will build a quinine factory at Houston, the daily capacity to be 8,000 ounces. The Colombia Alkaloid Company has been organized to operate the plant, and its officers are: *President* and *General Manager*, R. T. Gibbs, of Houston; *Vice President* and *Assistant Manager*, R. S. Clower, of St. Louis; *Second Vice President*, Manuel M. Angel, of Bogota, Colombia, S. A. The company will establish a plant in Colombia to extract crude alkaloïds from the cinchona bark and ship them to Houston. Its Houston factory building will be a first unit, two-story concrete structure.

Delaware and Pennsylvania capitalists plan the development of West Virginia coal properties and have incorporated the Jones By-Products Coal Company, of Palmer, W. Va., with a capitalization of \$1,000,000. They are: H. Chester Johnson, John E. Bassett, Randall F. Collins, of Philadelphia; Robert H. Jones, of Wilmington; and John M. L. Black, of Villa Nova, Pa.

The Electrolabs Co., New York, announces that the Paschall Oxygen Co., Philadelphia, will increase the capacity of its plant 25 per cent, making a total of 1000 Levin cells in operation.

The Alkali Export Association, Inc., New York, is composed of five companies: Pennsylvania Salt Manufacturing Co., Philadelphia; Solvay Process Co., Syracuse, N. Y.; Michigan Alkali Co., New York; Columbia Chemical Co., Cincinnati; Hooker Electrochemical Co., Niagara Falls, N. Y.

Manufacture of carbon black and the extraction of gasoline from gas has developed into a large industry in the Monroe, La., gas field. Six carbon plants have been constructed and are now in operation. Two of these factories have installed machinery for the extraction of gasoline from the gas prior to the use of the gas for making carbon, and the other four will follow the same course as soon as the equipment can be secured. The six plants in this district are the Southern Carbon Company, at Spyker and Fairbanks, Oscar Nelson, Inc., at Lamkin, Imperial Carbon Company, at Guthrie, Peerless Carbon Company, at Sterlington, and the Beacon Carbon Company, at Wardville.

A new plant for the grinding of talc and soapstone has recently been completed at Henry, Franklin County, Virginia. The mine and mill are owned and operated by the Franklin Soapstone Products Corporation, of Roanoke, Virginia. The mill has a reported capacity of 200 tons of finely pulverized material per day. It is equipped with a No. 2 Sturtevant rotary crusher, a Fuller-Lehigh rotary dryer, and two 42-in. Fuller-Lehigh pulverizer mills. The crusher, dryer, and several elevators and conveyors are driven by a 50-h. p. Vim engine while the pulverizers are driven by a 150-h. p. Corliss-type engine. The material now being ground is a soapstone, and its principal markets will be found in the paint filler, foundry facing, composition roofing, and rubber trades.

The prohibition bill which has passed the House of Representatives and is now in the Judiciary Committee of the Senate defines industrial alcohol to include ethyl alcohol, hydrated oxide of ethyl, or spirit wine from whatever source or process produced. Persons engaged in the production of alcohol are required within 30 days following the enactment of the bill, to secure a permit from the Collector of Internal Revenue to manufacture this product, to be registered, and to file a bond. Denaturing plants might also be established on the premises of plants making industrial alcohol and the denatured product sold tax-free for domestic use or export.

A new dyewood is to be put on the market in the near future by Natural Dyewoods, Ltd. It is stated that experiments with the wood, which is a native of southern United States, have shown that it can be used to produce several shades of brown, and it is expected that with the use of mordants other colors can be developed as well. Tests show that the material is suitable for use on wool, cotton, silk, and leather.

After an exhaustive study conducted by the United States Bureau of Mines for the purpose of informing the petroleum industry regarding recent progress in development and application of the absorption process for recovering gasoline from natural gas, an official publication on this subject has been sent to press which deals with the various units of absorption plants from the viewpoint of an operator or designer. It shows the development of the industry of natural gas gasoline from its beginning and includes the rapid advance of the absorption production in comparison with the compression production during the last year or two, which indicates that the absorption method of extracting gasoline from natural gas is becoming more and more important, especially so as this process will treat economically gases of any gasoline content and practically at any pressure.

Fire which is attributed to spontaneous combustion destroyed three of the five buildings of the plant of the Armour Fertilizer Works, at Baltimore, with damage of \$1,000,000.

The production, stocks on hand, and total shipments of turpentine and rosins by concerns engaged in the production of wood turpentine, both destructive and steam-distilled, and of solvent-extracted wood rosin and rosin reclaimed from batting dross (the cotton batting used for straining rosin and completely saturated with the latter) are shown in the following table:

STATES	No. Stills	TOTAL PRODUCTION SEASON OF 1918		ON HAND AT STILLS MARCH 1, 1918		TOTAL SHIPMENT APRIL 1, 1918 TO MARCH 1, 1919	
		50 gal. Casks	500 lb. Bbls.	50 gal. Casks	500 lb. Bbls.	50 gal. Casks	500 lb. Bbls.
Alabama....	174	41,579	136,180	4,992	14,494	39,335	129,939
Florida....	453	125,678	414,150	5,630	30,362	125,889	413,226
Georgia....	478	65,468	215,550	1,453	1,740	67,027	225,891
Louisiana.	34	52,845	165,301	10,369	62,723	45,937	107,743
Mississippi	53	31,924	109,123	12,775	38,952	24,811	88,749
No. Caro- lina.....	14	876	2,919	17	201	893	2,972
So. Caro- lina.....	22	690	2,344	0	34	690	2,565
Texas.....	17	21,220	68,599	5,145	26,412	18,151	51,059
TOTAL.....	1,245	340,280	1,114,166	40,401	174,918	322,733	1,022,144
Wood Turps., Wood Rosin, and Batting- Reclaimed							
Rosin.....	32,419	123,352	1,965	12,304	28,024	122,424	

GRAND TOTAL PRODUCTION OF NAVAL STORES.....	372,699	1,237,518	42,366	187,222	350,757	1,144,568	
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Ground was broken this week for the construction of the \$10,000,000 coke and by-product manufacturing plant of the St. Louis Coke and Chemical Company, near Granite City, Ill. A new feature of the plant will be the installation of a dyestuff manufacturing department, according to announcement made by the vice president of the company.

The Director of Sales of the War Department announces that plans are being made for marketing the Army's surplus stock of phenol through the Barrett Co., New York, and the Monsanto Chemical Works, St. Louis.

Incorporation of the St. Louis Trading and Navigation Company, with capital of \$25,000,000, is planned by the St. Louis Chamber of Commerce, for the development of foreign trade. The company will operate its own steamships. A bank of discount with \$10,000,000 capital is contemplated in order to handle the business in exports and imports. It is understood that John F. Queeny, president of the Monsanto Chemical Company, and other leading manufacturers, and some of the largest banks in St. Louis, are interested in the project. The trading company will be organized under the Webb law. There will be a board of directors of fifteen members, of whom three will be bankers.

The Wiley Fertilizer Company, Troy, Ala., is considering plans for the reconstruction of its fertilizer plant, recently destroyed by fire with loss estimated at about \$60,000.

The Atlantic Dyestuff Company has rebuilt its plant at Burrage, Mass., which was destroyed by fire last February. The reconstruction of the works has now reached such a point that the company is once more able to put sulfur black on the market. The company will also be equipped in their new buildings to manufacture a number of other dyestuffs and chemicals.

The Louisiana-Texas Quicksilver Company has just closed a deal for the purchase of 8960 acres of land in the heart of the Terlingua quicksilver district. It is stated that there are many rich outcroppings of cinnabar ore upon the tract, and that the purchasing company will begin development operations on an extensive scale in the near future. The known ore deposits and other localities will be thoroughly tested by means of diamond drill borings. The company plans to build a 100-ton quicksilver furnace as soon as the ore output is sufficient to warrant the plant. The buildings adjoin the quicksilver mines of the Chisos Mining Company, the Big Bend Mining Company, and the Colquitt-Tinger Quicksilver Mining Company.

An increase of capital from \$200,000 to \$700,000 has been announced by the O. B. Andrews Company, Chattanooga, Tenn., this \$500,000 to provide plants for manufacturing paper and fiber boxes. A \$100,000 plant will be built for the production of the fiber boxes and other containers, to be followed later by a \$225,000 mill to manufacture the paper for the fiber. The daily capacity of the paper mill will be 65,000 lbs., and the mill buildings will be of steel and reinforced concrete.

At a recent meeting of the Board of Directors of the National Aniline and Chemical Company, Inc., the resignation of Mr. William J. Matheson, as chairman of the board and president of the company, was accepted with deep regret and high appreciation of his signal service to the company during the critical period following organization. Mr. Matheson was induced to undertake the executive leadership of the company in 1917 only as a patriotic duty for the period of the war, and his present resignation was tendered accordingly. Mr. Orlando F. Weber, a member of the Board of Directors since the organization of the company, and who has been acting as president of the company in the absence of Mr. Matheson, was elected chairman of the board and president to succeed Mr. Matheson.

At the annual meeting of the German Rubber Manufacturers' Association, held recently, the subject of synthetic rubber was discussed and statements made which are highly significant. Synthetic rubber, it was said, was a friend indeed during the war, and its use would have to be continued until the resumption of imports of raw rubber, but no longer. The cost of synthetic rubber is too high to allow of its continued use, and it cannot be worked up without old rubber. It was hoped that within a short time natural rubber would be at the disposal of the manufacturers, enabling them to dispense with the synthetic product.

In connection with the Potash Bill (H. R. 4870), Professor Gale, of the Bureau of Mines, presented a report to the Ways and Means Committee recently on wages and cost of production in the potash mines of Germany. He showed that costs had more than doubled from pre-war scales. Opponents of the bill are still confident of being able to prevent a report coming from the Committee. Senator Smith, of South Carolina, said that the unfavorable cotton report issued by the Department of Agriculture on that day was an argument for importation of free potash. The Department's report showed the cotton crop as 67.1 per cent of normal and forecast a production of 11,016,000 bales. Senator Smith said that this unfavorable showing was largely due to the lack of potash during the last several years.

The contract has just been signed for an addition to the laboratory of the department of chemistry of the Rensselaer Polytechnic Institute to cost \$175,000. The new wing will be devoted to laboratories for quantitative analysis, organic chemistry, and physical chemistry. The new construction is necessary because of the growth in the number of students taking the courses in chemical engineering and general science.

The Krupp Works of Essen, Germany, are reported to be planning the erection of a gigantic plant at Apeldoorn, Holland. The plant will be connected with the iron of the Ruhr district and coal of Westphalia.

Exports of soap during the month of April reached a total of \$1,272,360, composed of toilet soap to the value of \$346,007, and 10,023,608 lbs. of other soaps, valued at \$926,553. American soap is now being used by more than 75 foreign countries. The Dutch East Indies are the heaviest consumers of our toilet soaps, having used \$38,269 worth during April, while Mexico is the heaviest purchaser of other soaps, importing 3,303,842 lbs., valued at \$315,221 during the month.

The export of dyes and dyestuffs from the United States to European Russia varied greatly in value in the calendar years 1915, 1916, 1917, and 1918. In the year 1915, the amount was \$13,194; in 1916 more than thirty-nine times this amount, or \$524,603, was exported. In 1917 the value fell off to \$187,014, and in 1918 the amount was only \$12,825. The value of the exports of dyes and dyestuffs is a very small proportion of the value of the total amount of trade between the United States and European and Asiatic Russia. This fell from \$438,000,000 in 1917 to \$28,000,000 in 1918. The export trade in all articles in 1918 amounted to only \$9,000,000 to European Russia, and \$8,500,000 to Asiatic Russia, a decline of 97 per cent and 93 per cent, respectively, over the preceding year.

Great Britain intends to hold, or at least attempt to hold, the scientific optical trade which the war brought back to England. Such was the announcement made by Sir Alfred Keough, rector of the Imperial College of Science and Technology at South Kensington, London, England. It is recognized that this can be brought about only through research and through the training of high-grade men. Already the Imperial College has equipped laboratories and perfected plans whereby they are confident that they can compete successfully with anything in the optical line.

The interesting and possibly important discovery has been made that platinum occurs in encouraging quantities in Eby township in Northern Ontario. Samples taken from a large sulfite deposit on a group of claims in Eby have been found to contain a very high percentage of sulfur, as well as very encouraging quantities of gold and of silver, the latter sometimes occurring in commercial quantities. Up until quite recently no test for platinum had been made. As a result of the first and only test so far made, the ore has been found to contain about \$2 per ton in platinum.

The American Zinc Institute held its second annual convention at St. Louis and commissioned George C. Stone, metallurgist of the New Jersey Zinc Company and chairman of the Committee on Development of the Zinc Industry, to go to Europe in July to study means and opportunities for increasing the use of zinc products. Mr. Stone read a paper on "New Uses for Zinc." It was suggested by George S. Harney, of the American Zinc Products Company, that the nomenclature of the industry be revised to include the word zinc in the name of products made from that material. William A. Ogg, president of the American Zinc, Lead and Smelting Company, read a paper on "Some Causes of the Unsound Economic Position of the Zinc Industry." Officers were elected as follows: *President*, Charles T. Orr, of the Athletic Mining and Smelting Co.; *First Vice President*, Edgar Palmer, New Jersey Zinc Company; *Treasurer*, Howard I. Young; *Secretary*, Stephen S. Tuthill. The next convention will be held at Chicago.

With the largely increased demands and high prices for glassware in the Philippines, the problem of the manufacture of glass locally is being studied by the Philippine Bureau of Science. Conditions seem to be favorable in that raw materials of good quality occur in abundance. A very good grade of white silica sand and vein quartz occur in large quantities in the island of Lubang, near Mindoro. Limestone is found in large quantities in Binangonan, Montalban, and other localities. Sodium carbonate at present is imported, but might be produced locally if modern methods of salt manufacture were to replace the native methods now in use. Manganese dioxide is now being produced at Ilocos Norte. The problems would seem to be those of transportation of raw material, training of workmen, and importation of glass-making machinery and refractories.

According to recent reports, the glass industries of Germany will not be able to seek export trade, or compete in the world's markets for some time to come. First, the heavy war demands for glass, together with the curtailment of production, have made impossible the building up of stocks of glass. Second, large domestic needs must be supplied. Third, the shortage of coal in Germany is so acute that most of the glass plants have been compelled to shut down, or run with a very restricted output. Fourth, costs of production and, therefore, prices have increased so greatly that it is doubtful if German glass could compete with American-made glass. These fundamental reasons, together with the natural prejudice against all German-made goods, makes the much feared dumping of German glass very improbable.

An important deposit of high-grade silica sand has recently been discovered near Munroe, La. This deposit is estimated to contain about 18,000,000 yards of sand and gravel, underlain by large beds of glass sand. It is located near a railway, and convenient to water and gas.

The plant of the American Zinc Company, at Mascot, Tenn., which employs more than 900 men, is to be run by a "House of Representatives," composed of employees, and a "Senate," made up of department heads.

Thermalene, an intimate mixture of acetylene and vaporized oils, is claimed to have great advantage over other gases for producing high temperatures. It is somewhat heavier than air, has a specific heat a little over one-eighth that of acetylene, and possesses a soft, sweet, not unpleasant odor. In welding, it can be used at relatively low pressure; it produces no corrosive or poisonous effects, and is not liable to cause explosion.

Contract has been awarded for the erection of four additional buildings to the plant of Powers-Weightman-Rosengarten Co., Philadelphia. These consist of five-story brick buildings, 35 x 80, 35 x 72, 35 x 58, 25 x 31, at a cost of about \$45,000.

According to the U. S. Bureau of Chemistry there are approximately 500,000,000 lbs. of unscoured wool used in this country annually. This contains about 75,000,000 lbs. of wool grease, worth normally \$2,250,000 (at the present time, \$10,000,000), and 25,000,000 lbs. of potassium carbonate, worth normally \$750,000 (at present, \$15,000,000). Practically all the potassium carbonate and the greater part of the wool grease are allowed to waste. The former is urgently needed in glass and soap manufacture, while experiments of the Bureau of Chemistry have shown that wool grease is one of the most effective materials for waterproofing shoe leather. The Bureau has been working on plans for recovering these valuable materials, heretofore almost entirely wasted. An additional object of this undertaking is to prevent the pollution of streams now occasioned by running the scouring wastes into the rivers.

Sixty thousand horsepower will be developed on the Nipigon River, about sixty miles northeast of Port Arthur, by the Hydro Electric Commission of Ontario, and it is expected that by June of next year two 12,000 h. p. units will be in operation, and three more will be installed at a later date. Single runner vertical water turbines will be direct-connected to 3-phase, 60-cycle, 12,000-volt, internal revolving field generators, each 10,600 k. v. a. (80 per cent factor, maximum rating). The generators will be arranged for parallel operation and will supply light, heat, and industrial power on the Commission's "Nipigon System." This development is farther west than any other yet undertaken by the Commission.

A laboratory method for the determination of graphitic carbon in the presence of amorphous carbon has been standardized at the Pittsburgh station of the Bureau of Mines and is now being checked on a large number of natural graphites and amorphous carbon in the form of coal. The method gives promise of being suitable for the direct quantitative determination of graphitic carbon, which up to the present time has always been an uncertain indirect determination. A laboratory method for the determination of the various forms of sulfur in coal has been tried on a number of typical samples of Eastern coal with very satisfactory results.

Plans have been started for the erection of a large sulfuric acid and acid phosphate producing plant by the Henryetta Spelter Company, of Tulsa, Okla. The company will expend a total of \$750,000 on the plant, which will be located on a site covering 26 acres in West Tulsa. The plant will be equipped with complete research laboratories and offices, together with an electric power plant generating its own electricity. The kilns of the plant will be equipped to burn gas, fuel oil, or coal.

At an approximate cost of \$2,000,000, the United States Food Products Corporation, formerly the Distillers' Securities Corporation, has acquired four sugar companies and a tank steamship line. As a result of the purchase it is figured that the corporation will become one of the largest producers of industrial alcohol in the country. The following companies were acquired: Sugar Producing Company, Pure Cane Molasses Company of the United States, Pure Cane Molasses Company of Canada, British Molasses Company of Great Britain, and the Tres Company, Ltd., of Great Britain.

The Monsanto Chemical Company of St. Louis, Mo., has completed the transformation of the plant in which phenol was manufactured during the war and is now turning out approximately 500,000 lbs. a month of chlorosulfonic acid. A large part of the output of the plant is taken by the Monsanto Company itself to use in the manufacture of saccharin and vanillin. Another commodity that the Monsanto Company has turned to recently is chrome alum, which is being turned out now at the rate of 2 tons a day. A large new series of buildings belonging to the Monsanto Company, and to be used for the manufacture of caustic soda and liquid chlorine, is almost completed in East St. Louis, Ill. The cost of this new plant will be \$500,000.

PERSONAL NOTES

Clarence W. Hathaway, metallurgist for the last eight years for the Granite City Steel Works Branch of the National Enameling & Stamping Company, met his death by drowning while swimming with a party of friends in the Mississippi River on July 19 at Granite City, Illinois. He was born in Columbus, Ohio, in 1886, and was educated in the schools of that place and at the Ohio State University, Columbus, Ohio. He had previously been employed with the U. S. Steel Corporation, at Gary, Indiana, before accepting his last position. He was a man of exceptional ability, a keen investigator, and a tireless worker. He leaves a wife, father and mother, one brother and four sisters. He was a member of the Masons and Elks, and of the American Chemical Society, the Metallurgical Society of America, and the American Ceramic Society.

Major General Wm. L. Sibert, Director, Chemical Warfare Service, U. S. A., was made a Commander of the French Legion of Honor on July 14, 1919 (Bastille Day). The presentation was made by the French Ambassador, M. Jusserand.

Brigadier General Amos A. Fries, C. W. S., U. S. A., has been awarded the Distinguished Service Medal for exceptionally meritorious and distinguished services set forth as follows: As Chief of the Chemical Warfare Service, he was charged with the important task of training and equipping our troops for a form of warfare in which the American Army had had no experience prior to the present war. Both in securing proper defensive measures against gas and in developing new methods for its use as an offensive agency, he performed his arduous duties with marked success, thereby rendering valuable services to the American Expeditionary Forces.

Miss Grace MacLeod, assistant editor of *THIS JOURNAL*, has resigned in order to accept the position of instructor in the department of nutrition and food economics in Teachers' College, Columbia University. In behalf of all the members of the American Chemical Society who have had the constant evidence of her loyal and efficient service, we extend to Miss MacLeod the best of good wishes in her new work.—[EDITOR.]

Dr. J. P. Street, chemist in charge of the analytical laboratory of the Connecticut Agricultural Experiment Station and recently Major in the Sanitary Corps of the United States Army, has been assigned by the National Canners' Association as chief inspector for the State of Indiana and will have his office and laboratory in Indianapolis.

Dr. Joel H. Hildebrand and Dr. Edmond O'Neill, of the University of California, are recovering from wounds received when they were shot by a graduate of the University who alleged that they had prevented him from obtaining a position.

Prof. H. L. Coles, who had charge of industrial chemistry at the College of the City of New York, during the absence of Professor Moody, has resigned from the chemistry department of the college and has accepted a position with the Niles Tool Works Company, New York, as metallurgical expert.

Mr. Alexander Lehrman has secured his discharge from the U. S. Navy and returns to the College of the City of New York as Fellow in chemistry.

The Chemical Warfare Service Post of the American Legion has been organized. Maj. Gen. William L. Sibert, director of the Service, sent a letter to the Post's luncheon expressing his appreciation. The officers elected were: Richmond Levering, *President*; Owen M. Voight, George A. Burrell, and O. D. Burton, *Vice Presidents*; J. C. Roth, *Secretary*; C. H. Hock, *Treasurer*; Blair Frazier, *Chaplain*; and H. E. Bruce, *Member of the Executive Committee*.

Dr. Wilder D. Bancroft, chief of the Research Division of the Chemical Warfare Service, received the honorary degree of doctor of science from Lafayette College, Easton, Pa.

Mr. C. H. Wildridge, formerly with R. W. Hunt & Co., Montreal, has accepted a position as metallurgist with the Manitoba Steel Foundries at Selkirk, Manitoba.

Mr. H. E. Haring, for the last two years in the inspection division of the Ordnance Department, is now connected with the Bureau of Standards where he will be engaged in electrochemical research.

Dr. Theodore W. Richards, professor of chemistry at Harvard University, has been elected president of the American Academy of Arts and Sciences.

Dr. G. W. Gray, who was a member of the United States Fuel Administration in the oil division, is now located in Chicago with the Sinclair Oil and Refining Company.

Mr. Thomas J. Dee, who has been with the Davison Chemical Corporation for the last four years and who was formerly their purchasing agent, was recently elected treasurer and has already entered upon his new duties.

The Rumford Committee of the American Academy of Arts and Sciences has voted the following appropriations: To Prof. P. W. Bridgman, of Harvard University, to aid his research on the effect of temperature and pressure on the physical properties of materials, particularly their thermal conductivity (additional to previous appropriation), \$400; to Prof. Horace L. Howes, of the New Hampshire College, to aid his research on the experimental study of the effect of temperature on the luminescence and selective radiation of the rare earths, \$500.

Mr. F. J. Bartholomew, formerly assistant chief chemist of the Air Nitrates Corporation, Muscle Shoals, Ala., is now chief chemist of the Charlotte Chemical Laboratories, Inc., Charlotte, N. C.

Mr. Herbert J. Krase, formerly chemical engineer for the Special Chemicals Co., Inc., of Highland Park, Ill., is now employed in the Fixed Nitrogen Research Laboratory at the American University, Washington, D. C., as assistant chemical engineer.

Mr. B. B. Wroth, who for the past year has been acting head of the department of chemistry at Earlham College, Richmond, Ind., during the leave of absence of Dr. Lloyd Van Doren, will return to his former position as assistant professor of chemistry at the Georgia School of Technology, Atlanta, Ga.

Mr. Thorne L. Wheeler and Mr. John C. Woodruff, each of whom served in the gas defense division of the Chemical Warfare Service with the rank of Major, have formed a partnership for the general practice of chemical engineering under the firm name of Wheeler and Woodruff. Offices: 280 Madison Avenue, New York.

Mr. Prevost Hibbard recently resigned from his position with the U. S. Bureau of Public Roads, and has accepted the position of chemical engineer with the Asphalt Association, New York.

Mr. William T. Miller has resigned as secretary of the National Aniline and Chemical Company, Inc., and is now a member of the firm of Wm. T. Miller Aniline and Chemical Co., Inc.

Mr. L. E. Warren has resigned as chief research chemist for Wm. R. Warner and Co., New York City, and has accepted a position as associate chemist in the laboratory of the American Medical Association in Chicago.

Mr. N. A. Gilbert, who for the past several years has been engaged as chemist and engineer in the graphite fields of Alabama and earlier was engaged as chemical engineer in the sugar and sirup industry in Louisiana and South America, is now engaged in the construction of a modern sirup plant and the development of a sugar cane plantation. Mr. Gilbert intends to devote his future efforts to the development of the sugar and sirup business of Florida through the application of scientific methods, the lack of which, Mr. Gilbert says, has retarded the growth of this business in that state.

Dr. A. L. Metz, formerly of Tulane University, has been forced to give up all work of any nature whatsoever for a time and to retire from active university work because of his health. Dr. Metz has been placed on a retiring allowance with an annuity from the Carnegie Foundation.

Mr. A. D. Greenlee, formerly assistant chemist with the food research laboratory, U. S. Bureau of Chemistry, and, during the period of the war, specialist in poultry handling for the same bureau, with office at the Field Station, Indianapolis, Ind., has resigned from this position to become president of the newly organized Greenlee Products Company, located in St. Louis, for the handling of eggs and utilization of the by-products of the egg industry.

Mr. Henry S. Sparkman, formerly Lieutenant Colonel in the U. S. A., from which he was just recently honorably discharged, has resumed his professional activities as president of the Henry S. Sparkman Engineering Company, Philadelphia, Pa.

Lt. Col. Elmer K. Hiles, formerly of the Engineers, A. E. F., has joined the Pittsburgh Testing Laboratory as manager of laboratories.

Mr. Lester M. Whitmore, formerly in charge of the chemical work on leather for the Bureau of Standards, Washington, D. C., is going to Salem, Va., where he will be in the process department of Leas & McVitty, Inc., sole leather tanners.

Mr. Paul D. V. Manning, formerly chemist with the nitrate division of the Ordnance Department, his last assignment being at the Fixed Nitrogen Research Laboratory, American University, Washington, D. C., has accepted a position as electrometallurgist with the Chile Exploration Company, New York City.

Mr. Harry S. Mork has resigned as vice president of Arthur D. Little, Inc., Cambridge, Mass., and has been elected to the vice presidency of the Lustron Company of Boston, manufacturers of artificial silk. Mr. Mork will also act as consultant to the Industrial Company of Boston.

Mr. R. C. Sherwood, formerly assistant chemist in the Agricultural Experiment Station, South Dakota State College, Brookings, S. D., has accepted a position as analyst in the food and drug department, Montana State Board of Health, Bozeman, Mont.

Mr. C. J. Bower, formerly with E. J. Lavino and Company, of Philadelphia, where he was in charge of the laboratory at the Marietta plant, and later in the chemical sales department, is now with the American Manganese Bronze Company, Holmsburg, Philadelphia, acting as assistant to Mr. T. H. Addie, manager of sales.

Major M. G. Donk, previously associated with and in charge of government work at Midland, Mich., has joined the staff of the Hercules Engineering Corporation. Major Donk's special work is the installation of equipment.

Dr. J. T. Brewster, who has acted in a consulting capacity with the Hercules Engineering Corporation for the last three years, has succeeded Mr. A. H. Alberger as head of the technical and engineering departments of that corporation. Previous to Dr. Brewster's association with the Hercules Corporation, he was connected with the du Pont organization.

Mr. Everett W. Fuller has received his discharge from the Chemical Warfare Service and is now employed as research associate in the research laboratory of applied chemistry at the Massachusetts Institute of Technology, Cambridge, Mass.

Mr. Clifford L. Snyder, who has just recently been discharged from the Army, has joined the technical staff of the Detroit Testing Laboratory as sales engineer.

Mr. Roy C. Charron, formerly with Arthur D. Little, Inc., Cambridge, Mass., and now connected with the Crunden Martin Manufacturing Company, has been made superintendent of the enamel ware plant of the Crunden Company, at St. Louis, as a result of his work in the standardization and perfection of the processes of that company for the manufacture of enameled iron ware.

Mr. Louis N. Markovitz, formerly in the Chemical Warfare Service stationed at Nela Park, Cleveland, Ohio, has returned to his former position in the Insecticide Laboratory of the Bureau of Chemistry, Washington, D. C.

Mr. E. A. Banning has resigned his position as chemist with the Jaques Manufacturing Company of Chicago, and has accepted a position as chemist with the Hart-Parr Company, Charles City, Iowa.

Mr. W. R. Sadler, formerly in the Chemical Warfare Service, Philadelphia, Pa., is now in charge of the chemical research laboratory of the experimental station of the U. S. Bureau of Fisheries, San Pedro, Cal.

Mr. C. M. Salls, who for the past two and one-half years has been employed by the Canadian Explosives, Ltd., has now taken the position as chemist with the Canada Starch Company, at Cardinal, Ontario, Canada, which is the Canadian branch of the Corn Products Refining Company.

Prof. W. M. Cobleigh, professor of chemistry in the State College of Agriculture and Mechanic Arts, of the University of Montana, has been appointed state chemist under provisions made in an oil inspection law passed by the Montana legislature.

Mr. William Kremers has left the Holland-St. Louis Sugar Company at Decatur, Indiana, and has become associated with the firm of Wright and Kremers, Inc., Niagara Falls, N. Y., of which firm he will act as treasurer and general manager.

Mr. Milton H. Fischer, for the past four years associated with the Barrett Company in Frankford, Pa., has joined the sales force of the Sherwin-Williams Company, New York City, as specialty dry-color man.

Mr. E. A. Wildman has resigned his position as director of chemical research for Eli Lilly and Company and accepted the position of professor of chemistry and director of the chemical department of Earlham College, Richmond, Ind.

Dr. Austin M. Patterson, who has been engaged in editorial work for the Chemical Warfare Service for the last fourteen months at the American University, Washington, D. C., has returned to his home at Xenia, Ohio.

Mr. Edwin A. Mattson, of Branford, Conn., is now located with the Henry T. Doherty Company, Toledo, Ohio, in one of their junior engineers' training schools.

Mr. M. A. Norris, formerly in the U. S. Navy where he was attached to the chemical laboratories of the U. S. Naval Medical School, Washington, D. C., is now in the employ of the Electric Storage Battery Company at their Chicago Exide Depot.

Dr. Neil E. Gordon has resigned his position as assistant professor of chemistry at Coucher College, Baltimore, Md., and has accepted a position as professor of physical chemistry in the Maryland State College of Agriculture, College Park, Md.

Mr. Elton B. Punnett, formerly in the research laboratory of the Eastman Kodak Company and later Lieutenant in the research division, Chemical Warfare Service, is at present in the organic division of E. I. du Pont de Nemours and Company, Experimental Station, Wilmington, Del.

Mr. Bernard H. Smith has left the Baker Extract Company of Springfield, Mass., where he has been for a number of years chemist and superintendent, and has accepted a similar place with Garrett and Company, of Brooklyn, N. Y.

Mr. Leroy S. Palmer has resigned his position as assistant professor of dairy chemistry in the University of Missouri to accept the position of associate professor of agricultural biochemistry in the University of Minnesota and dairy chemist to the Minnesota Agricultural Experiment Station, St. Paul, Minn.

Mr. N. Howell Furman has resigned his instructorship in chemistry at Leland Stanford, Jr. University, at University, Cal., and has accepted an assistant professorship in analytical chemistry at Princeton University.

Mr. Elmer B. Vliet is now connected with the U. S. Fixed Nitrogen Research Laboratory recently organized at the American University Experiment Station, Washington, D. C.

Capt. O. L. Barnebey and Lt. M. B. Cheney, formerly superintendent and assistant superintendent of the defense section of the development division of the Chemical Warfare Service located at Nela Park, Cleveland, Ohio, have formed an engineering company known as the Barnebey-Cheney Engineering Company to be located at Columbus, Ohio.

Capt. Esbon Y. Titus, formerly chief chemist for Nitrate Plant No. 1, Sheffield, Ala., has been appointed assistant professor of chemistry at the University of Wisconsin.

Lt. Col. C. G. Storm, Ordnance Department, U. S. A., chief of the Research Section, Ammunition Division, has been honorably discharged from the service and is now engaged in research work with the Pennsylvania Trojan Powder Company, Allentown, Pa.

Mr. W. F. Gidley, who has been for the past year assistant chief of the scientific department of E. R. Squibb & Sons, New York, returned to his former position of professor of materia medica, Purdue University, Lafayette, Ind.

Mr. James H. Ranson, formerly of the chemistry department at Purdue and last year head of the chemistry department in Vanderbilt University, resigned his position in May to accept the office of research chemist with the Michigan Smelting and Refining Company, of Detroit.

Mr. Raymond J. L. Fish, who was formerly an inspector of powder and explosives with the British War Mission to this country, has been released from his duties as chief army inspector, U. S. Ordnance Department, stationed at the Western Cartridge Company, Springfield, Ill., and is about to sail for England where he will enter the glass manufacturing industry with a large English concern. His address will be Rhyl, North Wales, Great Britain.

Mr. Julius B. Kohn, formerly employed by the U. S. Public Health Service as organic chemist doing research work under the direction of Dr. Julius Stieglitz on arspenamine and neo-arsphenamine at Kent Chemical Laboratory of the University of Chicago, is now connected with the Mallinckrodt Chemical Works as research chemist in their organic department, at St. Louis, Mo.

Mr. Jack J. Hinman, Jr., formerly Captain in the Sanitary Corps of the American Expeditionary Forces, where he was engaged in water supply work, is now returning to his pre-war duties as water bacteriologist and chemist to the Iowa State Board of Health and assistant professor of epidemiology in the State University of Iowa.

Mr. W. A. Deeds, who has been superintendent of the β -naphthol and acetanilide plants for the Sherwin-Williams Company, and later field superintendent of chemical plant installations with Lewis Colwell, is now chief chemist of the Ohio Sugar Company, at Ottawa, Ohio.

GOVERNMENT PUBLICATIONS

By R. S. McBRIDE, Bureau of Standards, Washington

NOTICE—Publications for which price is indicated can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. Other publications can usually be supplied from the Bureau or Department from which they originate. Commerce Reports are received by all large libraries and may be consulted there, or single numbers can be secured by application to the Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington. The regular subscription rate for these Commerce Reports mailed daily is \$2.50 per year, payable in advance, to the Superintendent of Documents.

NATIONAL MUSEUM

Energy Resources of United States, Field for Reconstruction. C. G. GILBERT AND J. E. POGUE. Bulletin 102, Vol. 1. 165 pp. Paper, 35 cents. This bulletin was previously issued in 7 parts which are now to be collected into volumes. Volume 1 includes the material presented in Parts 4-6, under the titles Coal, the Resource and Its Full Utilization; Power, Its Significance and Needs; Petroleum, a Resource Interpretation.

GEOLOGICAL SURVEY

Cadmium. C. E. SIEBENTHAL. Separate from Mineral Resources of the United States, 1916, Part I. 3 pp. Issued June 9, 1919.

The price of stick cadmium through the first quarter of 1916 was listed as \$1.50 a pound in retail lots. During the second quarter the price was \$1.25 to \$1.50 a pound, and through the remainder of the year the quotations remained practically stationary at \$1.30 to \$1.50 a pound. The average price for 1916 as calculated from sales was \$1.56 a pound, compared with an average of \$1.19 a pound in 1915.

The average selling price of cadmium sulfide in the United States in 1916 was \$1.26 a pound, compared with \$1.13 a pound in 1915.

The value of the cadmium produced in the United States in 1916, calculated at the average selling price, was \$210,931, compared with \$108,443 in 1915, and the value of the cadmium sulfide produced was \$27,942, as against \$12,057 in 1915.

Sand-Lime Brick in 1918. J. MIDDLETON. Separate from Mineral Resources of the United States, 1918, Part II. 2 pp. Issued June 10, 1919.

The sand-lime brick industry in common with other building material industries experienced a severe setback in 1918 by reason of the general conditions prevailing in that year. The decrease in output compared with 1917 was 89,147,000 brick, or nearly 48 per cent. The value decreased \$536,401, or nearly 38 per cent. The principal causes of the decrease were the scarcity and high cost of materials and labor, congestion of transportation, and government restrictions on the use of fuel and on general building. The production in 1918 was the smallest recorded since 1905, and was 128,945,000 brick, or nearly 57 per cent less than the output of 1916, the year of maximum production, and \$590,144, or 40 per cent less than the value for that year.

Salt Resources of the United States. W. C. PHALEN. Bulletin 669. 284 pp. Paper, 35 cents. In the search for deposits of soluble potash salts carried on by the Geological Survey under specific authority of Congress a great deal of important information on the salt resources of the United States has been collected. The bulletin containing this information as first prepared was divided into five parts, as follows: (1) Geology of the salt deposits of the United States; (2) theories (origin and formation) of saline deposition; (3) chemical composition of saline materials; (4) statistics of the production of salt in the United States; and (5) technology of the manufacture of salt. The part re-

lating to the technology of the manufacture of salt is omitted from the Geological Survey publication as more properly connected with the work of the Bureau of Mines. That part, which complements the present bulletin, has therefore been prepared for publication as Bulletin 146 of the Bureau of Mines, to which bureau application should be made for it.

Gems and Precious Stones in 1918. W. T. SCHALLER. Separate from Mineral Resources of the United States, 1918, Part II. 8 pp. Issued July 16, 1919.

The production of gems and precious stones in the United States in 1918 was smaller than in any previous year since 1881, except in 1896. The value of the output in 1918 was only \$106,523. The enlistment of many gem miners in the military service, the general scarcity of labor, and the poor market all had their effect in reducing the quantity and value of the precious stones produced.

VALUE OF PRECIOUS STONES PRODUCED IN THE UNITED STATES, 1917 AND 1918

	1917	1918
Beryl	\$2,178	\$1,906
Copper ore gems	2,857	2,399
Corundum	54,204	42,414
Diamond	4,175	1,910
Feldspar	(a)	(a)
Garnet	624	1,277
Hematite	(a)	138
Jade		
Opal	805	6,304
Peridot	(a)	1,018
Pyrite	(a)	(a)
Quartz	28,273	15,211
Rhodonite	(a)	515
Smithsonite	(a)	
Spodumene	(a)	281
Thomsonite	(a)	(a)
Topaz	230	907
Tourmaline	12,452	6,206
Turquoise	14,171	20,667
Variscite	2,350	753
Vesuvianite	2,765	320
Miscellaneous gems	5,928(b)	4,397(c)
	1131,012	106,523

(a) Small production included under "miscellaneous gems."

(b) Includes andalusite, chlorastrolite, datolite, epidote, feldspar, fossil coral, hematite, Iceland spar, lapis lazuli, obsidian, peridot, phenacite, pyrite, rhodonite, rutile, sepiolite, smithsonite, spodumene, staurolite, thomsonite, willemite, and zoisite.

(c) Includes andalusite, calamine, chlorastrolite, datolite, epidote, feldspar, fluorsite, Iceland spar, lapis lazuli, mariposite, meerschaum, obsidian, phenacite, pyrite, satin spar (gypsum), staurolite, thomsonite, willemite, and zoisite.

The Farnham Anticline, Carbon County, Utah. F. R. CLARK. Bulletin 711-A. Contributions to Economic Geology, 1919, Part II. 13 pp. Issued July 3, 1919.

Water-Power Investigations and Mining Developments in Southeastern Alaska. G. H. CANFIELD, THEODORE CHAPIN AND R. M. OVERBECK. Bulletin 692-B. Separate from Mineral Resources of Alaska, 1917-B. 93 pp.

Mineral Production of the United States in 1916. H. D. McCASKEY AND MARTHA B. CLARK. Separate from Mineral Resources of the United States, 1916, Part I. 70 pp. Issued June 28, 1919. The report of the United States Geological Survey on the mineral resources of the United States for 1916 marks the thirty-fifth year for which such reports have been published. The present summary sets forth the essential statistics embodied in the separate chapters of the report for 1916. Owing to the lateness of publication resulting from the delay caused by urgent war work, the summary is presented in the briefest possible form, the elaboration of its many interesting features being left for reports for subsequent years. The reader who is interested in any particular mineral industry should consult the chapters on that industry for 1916 and preceding years. The statistics and the current data for all the minerals considered are given each year, but special features are discussed more fully in some years than in others, and therefore only a complete report, such as it has been planned to publish at intervals for each subject, will contain a treatment in detail.

Stone in 1917. G. F. LOUGHLIN AND A. T. COONS. Separate from Mineral Resources of the United States, 1917, Part II. 68 pp. Issued June 20, 1919.

The total value of stone sold in the United States in 1917 was \$82,215,671, an increase of 4 per cent over the value of that sold in 1916. This increase followed an increase of 6 per cent in 1916 and a decrease of 4 per cent in 1915. The quantity of stone sold in 1917 was approximately 83,562,000 short tons, a decrease of about 9 per cent from that sold in 1916. The increase in value in 1917 was due entirely to the greater value of limestone sold, as the total value of all other varieties of stone sold was less, the decrease ranging from 1 to 11 per cent. An increase of 12 per cent in the value of limestone was due to a large increase in the output of stone quarried for use as furnace flux—from 23,623,508 long tons, valued at \$13,946,882, in 1916, to 25,574,146 long tons, valued at \$18,679,213, in 1917. The production of limestone sold to industrial works, such as paper mills, sugar factories, glass works, and alkali works, also showed an increase in both quantity and value. The output of limestone for agricultural use, however, decreased 3 per cent in quantity, although it increased 22 per cent in value.

BUREAU OF STANDARDS

Effect of Solar Radiation upon Balloons. J. D. EDWARDS AND M. B. LONG. Technologic Paper 128. 29 pp. Issued June 13, 1919. Paper, 5 cents. The action of sunlight upon a balloon affects both the temperature and the life of the fabric of which the balloon envelope is constructed, and the resulting temperature changes affect both the operation of the balloon and its gas permeability. It is a matter of interest as well as importance, therefore, to understand the character and magnitude of these effects so that they may be intelligently controlled. Sunlight affects the operation of the balloon because changes in its character and amount cause fluctuations in the temperature of the balloon envelope and consequently in the temperature and lifting power of the gas contained in it. The reduction of such changes to a minimum makes for stability and efficiency in the operation of the balloon. The other effect of the sunlight, that of its photochemical action upon the fabric, results in decreasing the strength of the fabric and causing deterioration of the rubber. This eventually results in increasing the porosity of the fabric to an inadmissible extent. The increase in temperature of the fabric caused by the radiation absorbed also increases its permeability.

A Simplification of the Inverse-Rate Method for Thermal Analysis. P. D. MERICA. Scientific Paper No. 336. 4 pp. Issued June 11, 1919. Paper, 5 cents.

Specifications for and Methods of Testing Soaps. Circular No. 62. 2nd Edition. 32 pp. Issued June 17, 1919. Paper, 5 cents. This circular has been prepared by the Bureau of Standards with the cooperation of representatives of other branches of the government service in the hope that it may lead to more uniform specifications and methods of testing soaps. It is not intended to discuss the manufacturing operations in soap making, but to consider only those matters which are of importance to purchasers and chemists examining purchases of soaps.

Recommended Specification for Linseed Oil, Raw, Refined, and Boiled. Prepared and recommended by the United States Interdepartmental Committee on Paint Specification Standardization, April 16, 1919. Circular No. 82. Issued June 14, 1919. This committee was appointed at the suggestion of the Secretary of Commerce, and consisted of representatives of the War, Navy, Agriculture, Interior, Post Office, Treasury, and Commerce Departments, the Railroad Administration, the Panama Canal, and the war service committee of the Paint Manufacturers' Association of the United States. The committee submitted a preliminary draft of this specification to more

than 300 representatives of the paint and varnish industry, including all of the large manufacturers of linseed oil, and gave careful consideration to the large number of replies received in time. The three following specifications are supplemented by instructions for sampling and laboratory examination, including reagents for testing.

Linseed oil, raw, refined, or boiled; as specified in contract, shall be pure and shall conform to the following requirements:

RAW LINSEED OIL

	Maximum	Minimum
Loss on heating at 105° to 110° C., per cent.....	0.2	...
Foots by volume, per cent.....	2.0	...
Specific gravity 15.5/15.5° C.....	0.936	0.932
Acid number.....	6.0	...
Saponification number.....	195.0	189.0
Unsaponifiable matter, per cent.....	1.5	...
Iodine number (Hanus) ¹.....	...	170.0
Color.....	Not darker than a freshly prepared solution of 1.0 g. potassium bichromate in 100 cc. pure strong (1.84 sp. gr.) sulfuric acid.	

¹ When raw linseed oil from North American seed is specified by the purchaser, the iodine number must be not less than 180 and the oil shall conform to all the other requirements as above.

REFINED LINSEED OIL

Contract shall state whether acid refined or alkali refined is desired.

	Maximum	Minimum
Loss on heating at 105° to 110° C., percent.....	0.2	...
Foots by volume, per cent.....	0.2	...
Specific gravity at 15.5/15.5° C.....	0.936	0.932
Acid number (acid-refined oil).....	9.0	3.0
Acid number (alkali-refined oil).....	3.0	...
Saponification number.....	195.0	189.0
Unsaponifiable matter, per cent.....	1.5	...
Iodine number (Hanus) ¹.....	...	170.0
Color.....	Not darker than a freshly prepared solution of 0.1 g. potassium bichromate in 100 cc. pure, strong (1.84 sp. gr.) sulfuric acid	

¹ When refined linseed oil from North American seed is specified by the purchaser, the iodine number must be not less than 178, and the oil shall conform to all the other requirements as above.

BOILED LINSEED OIL

Boiled oil shall be pure, well-settled linseed oil that has been boiled with oxides of manganese and lead. It shall conform to the following requirements:

	Maximum	Minimum
Loss on heating at 105° to 110° C., per cent.....	0.2	...
Specific gravity at 15.5/15.5° C.....	0.945	0.937
Acid number.....	8.0	...
Saponification number.....	195.0	189.0
Unsaponifiable matter, per cent.....	1.50	...
Iodine number (Hanus) ¹.....	...	168.0
Ash, per cent.....	0.7	0.2
Manganese, per cent.....	...	0.03
Lead, per cent.....	...	0.1
Time of drying on glass, hours.....	20.0	...

¹ When boiled linseed oil from North American seed is specified by the purchaser, the iodine number must be not less than 178 and the oil shall conform to all the other requirements as above.

The Ultraviolet and Visible Transmission of Eye-Protective Glasses. K. S. GIBSON AND H. J. McNICHOLAS. Technologic Paper No. 119. 47 pp. Issued June 7, 1919. Paper, 10 cents. Eighty-two samples of eye-protective glass have been studied in regard to their transmission of ultraviolet and visible radiant energy. For each specimen is given: (1) the trade name under which it is marketed, (2) the company from which it may be obtained, (3) the approximate color, (4) the thickness, the samples being from 1.42 to 3.20 mm. thick, that ordinarily used in spectacle lenses, (5) the per cent transmission curve from 230 m. to 710 m., in each figure being given for comparison the transmission curve of a sample of colorless crown glass and the visibility curve for the average human eye, (6) the total transmission factor for light of equal energy at all wave

lengths. Four different methods were used to obtain the data, part of the work being done in the physical laboratory of Cornell University and part of this bureau. Sample transmission curves are given with all values plotted, illustrating the kind of agreements and disagreements obtained on the different instruments. A brief summary is given of the good or bad qualities of the various kinds of glass in comparison with colorless glass as regards protection against ultraviolet radiant energy. A brief elementary discussion is given, explaining the meaning of terms used in spectrophotometry and illustrating how to compute the transmission for thicknesses other than that measured.

Effect of Rate of Temperature Change on the Transformations in an Alloy Steel. HOWARD SCOTT. Scientific Paper 335. 10 pp. Paper, 5 cents. Issued July 10, 1919.

New Forms of Instruments for Showing the Presence and Amount of Combustible Gas in the Air. E. R. WEAVER AND E. E. WEIBEL. Scientific Paper 334. 44 pp. Paper, 15 cents. Issued June 23, 1919. All of the new devices described in this paper depend upon the combustion at the surface of an electrically heated platinum wire of the gas contained in the surrounding atmosphere. This surface combustion takes place at a temperature much below the normal ignition temperature of the gas in air or at the surface of another material which does not exert a catalytic effect. The resulting rise in temperature of the wire depends upon the quantity of the combustible gas which is present. The measurement of temperature rise is made in various ways, each of which is better suited to certain particular purposes than is any of the others. For some purposes an indicator is required, *i. e.*, an instrument which will indicate, either continuously or when desired, the amount of the combustible gas present. For other purposes only a detector is required, *i. e.*, an instrument which sounds an alarm or otherwise shows the presence of a dangerous amount of the combustible gas.

Notes on the Graphitization of White Cast Iron upon Annealing. P. D. MERCIA AND L. J. GUREVICH. Technologic Paper 129. 12 pp. Paper, 5 cents. Issued July 12, 1919.

Constitution and Microstructure of Silica Brick and Changes Involved through Repeated Burnings at High Temperatures. H. INSLEY AND A. A. KLEIN. Technologic Paper 124. 31 pp. Paper, 10 cents. Issued July 11, 1919. This paper deals only with the effects on the microstructure of silica brick during the burning. For the effect of different procedures in grinding and burning and the procedure to be followed, considering commercial limitations, to obtain best results, the reader is referred to a companion paper on silica refractories, by Mr. D. W. Ross, Bureau of Standards' Technologic Paper 116.

Physical and Chemical Tests on the Commercial Marbles of the United States. D. W. KESSLER. Technologic Paper 123. 54 pp. Paper, 15 cents. Issued July 15, 1919. This investigation includes the following: Compression tests, transverse strength tests, tensile tests, effect of freezing and thawing, effect of soaking in water, effect of repeated temperature changes, absorption tests, apparent specific gravity, true specific gravity, porosity, staining tests, permeability tests, chemical analysis, volume-resistivity tests, carbonic-acid tests, thermal expansion of marble, and warping of marble.

DEPARTMENT OF AGRICULTURE

Chemical Analyses of Logan Blackberry Juices. R. S. HOLINGSHEAD. Department Bulletin 773. 12 pp. Issued May 29, 1919. Paper, 5 cents. A table of analyses that will aid in detecting dilutions common in commercial products made from the Logan blackberry.

Digestibility of Some By-Products Oils. A. D. HOLMES. Department Bulletin 781. 16 pp. Issued May 31, 1919.

Paper, 5 cents. This bulletin records studies of the digestibility of apricot-kernel oil, cherry-kernel oil, melon-seed oil, pumpkin-seed oil, and tomato-seed oil. It is primarily of interest to students and investigators of food problems.

Moisture in Wheat and Mill Products. J. H. SHOLLENBERGER. Department Bulletin 788. 12 pp. Issued May 15, 1919. Paper, 5 cents. This is of special interest to millers and persons in charge of grain elevators.

Field Operation of the Bureau of Soils. M. WHITNEY. 2850 pp. Cloth, \$8.25. For distribution also by Senators, Representatives, and delegates in Congress.

Cotton Gin Fires, Caused by Static Electricity. Department Circular 28. 8 pp.

A Report on the Retail Prices of Nitrate of Soda and Acid Phosphate, as of May 1, 1919. Department Circular 39. 15 pp.

Articles from the Journal of Agricultural Research

Meat Extracts, Their Composition and Identification. J. A. EMERY AND R. R. HENLEY. 17, 1-17 (April 15).

Quantity and Composition of Ewes' Milk: Its Relation to the Growth of Lambs. R. E. NEIDIG AND E. J. IDINGS. 17 19-32 (April 15).

Seed Disinfection by Formaldehyde Vapor. C. C. THOMAS. 17, 33-39 (April 15).

DEPARTMENT OF COMMERCE

List of Publications of the Department of Commerce Available for Distribution. 17th Edition. 78 pp. Issued May 1, 1919.

BUREAU OF FOREIGN AND DOMESTIC COMMERCE

International Trade in Cement. E. WHITNEY. Miscellaneous Series 79. 76 pp. Paper, 10 cents. This gives the import statistics for countries whose imports exceeded \$200,000 in value and export statistics for countries whose exports exceeded \$1,000,000 in value, 1908, 1913, and latest available year.

Chemicals and Allied Products Used in United States. E. R. PICKRELL. Miscellaneous Series 82. 194 pp. Paper, 25 cents. This gives the imports by quantities, values, and countries of origin during fiscal year 1913-14 and statistics of domestic production. Prepared in collaboration with the AMERICAN CHEMICAL SOCIETY.

Industrial Standards Series. Text as adopted by American Society for Testing Materials. Spanish-English editions prepared under supervision of Bureau of Standards. Series covers industrial standards for materials, which includes standards prepared by Government, technical societies and other organizations.

18—Standard specifications for lap-welded and seamless steel boiler tubes for locomotives. Revised 1918. 19 pp., 4 text figs. 5 cents.

19—Standard specifications for lap-welded and seamless steel and wrought-iron boiler tubes for stationary service. Revised 1918. 19 pp., 4 text figs. 5 cents.

20—Standard specifications for welded steel pipe. Revised 1918. 15 pp. 5 cents.

23—Standard specifications for lap-welded charcoal-iron boiler tubes for locomotives. Revised 1918. 15 pp., 2 text figs. 5 cents.

27—Standard specifications for wrought-iron plates. Revised 1918. 13 pp. 5 cents.

28—Standard specifications for cast-iron pipe and special castings. Adopted 1904. 27 pp., 2 text figs. 5 cents.

31—Standard specifications for quenched high-carbon steel splice bars. Adopted 1915. 15 pp., 2 text figs. 5 cents.

32—Standard specifications for quenched carbon steel track bolts. Revised 1916. 15 pp., 2 text figs. 5 cents.

33—Standard specifications for quenched alloy-steel track bolts. Revised 1916. 15 pp., 2 text figs. 5 cents.

39—Standard specifications for rail-steel, concrete-reinforcement bars. Revised 1914. 13 pp. 5 cents.

40—Standard specifications for cold-rolled steel axles. Revised 1916. 15 pp., 2 text figs. 5 cents.

41—Standard specifications for wrought solid carbon-steel wheels for electric railway service. Revised 1916. 21 pp., 2 text figs. 5 cents.

42—Standard specifications for automobile carbon and alloy steels. Revised 1918. 23 pp., 4 text figs. 5 cents.

43—Standard specifications for cold-drawn Bessemer steel automatic screw stock. Adopted 1914. 11 pp. 5 cents.

44—Standard specifications for cold-drawn, open-hearth automatic screw stock. Adopted 1915. 11 pp. 5 cents.

45—Standard specifications for foundry pig iron. Revised 1909. 13 pp. 5 cents.

46—Standard specifications for gray-iron castings. Revised 1918. 15 pp., 4 text figs. 5 cents.

47—Standard specifications for hard-drawn copper wire. Revised 1915. 25 pp., 14 text figs. 5 cents.

48—Standard specifications for soft or annealed copper wire. Revised 1915. 15 pp. 5 cents.

49—Standard specifications for Lake-copper wire bars, cakes, slabs, billets, ingots, and ingot bars. Revised 1913. 15 pp. 5 cents.

50—Standard specifications for electrolytic copper wire bars, cakes, slabs, billets, ingots and ingot bars. Revised 1913. 13 pp. 5 cents.

51—Standard specifications for spelter. Revised 1918. 21 pp. 5 cents.

52—Standard specifications for manganese-bronze ingots for sand castings. Revised 1914. 13 pp., 2 text figs. 5 cents.

53—Standard specifications for purity of raw linseed oil from North American seed. Revised 1915. 11 pp. 5 cents.

54—Standard specifications for purity of boiled linseed oil from North American seed. Adopted 1915. 11 pp. 5 cents.

55—Standard specifications for turpentine. Adopted 1915. 13 pp. 5 cents.

56—Standard specifications for carbon-steel and alloy-steel blooms, billets, and slabs for forgings. Revised 1918. 19 pp. 5 cents.

57—Standard specifications for welded wrought-iron pipe. Adopted 1918. 15 pp. 5 cents.

58—Standard specifications for quenched and tempered alloy-steel axles, shafts, and other forgings for locomotives and cars. Revised 1918. 25 pp., 2 text figs. 5 cents.

COMMERCE REPORTS—JUNE 1919

Recent borings in the Trinidad Lake asphalt beds show that the material is uniform to a depth of at least 150 ft.; no greater depth has ever been reached, as the movement of the asphalt bends all pipes and drills. The material as removed contains approximately 30 per cent moisture, 30 per cent mineral matter, and 40 per cent of asphalt. The mineral matter is largely colloidal and is very intimately mixed with the asphalt, so that holes, etc., are soon filled up. Gas containing hydrogen sulfide is emitted from certain parts of the lake. (Pp. 154-6)

The British tin-plate industry is facing serious difficulties owing to the great increase in the production of tin plate in America and its export to foreign countries, including England. The high price of steel bars in England also hinders the revival of the tin-plate industry there. (Pp. 1157-9)

Through the cooperation of Sheffield University, the manufacture of laboratory glassware in England has made substantial progress. In order to conduct further research and to reduce the present high cost of production, the government has been asked to contribute about \$365,000 over a period of five years, to be augmented by about \$121,000 from the manufacturers. (Pp. 1193 and 1368)

Owing to the threatened future shortage of camphor in Tainan from natural grown trees, groves of camphor trees are being planted. Some fear is expressed, however, as to whether they will furnish adequate supplies before the exhaustion of the native trees. (P. 1198)

Through the demand for charcoal from cohune nuts for use in gas masks, attention has been called to the value of the oil for cooking purposes. Large supplies of these nuts are available in Honduras. (P. 1230)

In a consideration of Canada's fuel problem, it is pointed out that most of the Canadian coal deposits are low-grade lignitic or sub-bituminous. Among the suggestions made for the use of

this material are the manufacture of briquettes from coke produced by carbonization of the lignite, and the use in locomotives and industrial plants of powdered coal. In one method for the first purpose, briquettes of "carbo-coal" are produced which are denser than coke and approach anthracite in properties. (P. 1242)

The use of X-rays in detecting flaws in steel and for distinguishing between plain and alloy steels is being investigated in England. (P. 1261)

Strong efforts are being made to revive the British glass industry, especially the manufacture of bulbs, etc. (P. 1274)

In a special report upon the dyestuff situation in Europe, the licensing system adopted in England, and being considered in France and Italy, has proven satisfactory. The British committee includes representatives of dye producers and consumers and the Board of Trade. (P. 1286)

Consideration of the paper-textile industries of Denmark, Sweden, and Germany, indicates that the future use of paper textiles will be confined to materials not to be used for clothing or to be washed. They cannot compete with other textiles for ordinary clothing. (Pp. 1288-9)

In a discussion of the hours of labor in British chemical industries, it is pointed out that any decrease in the working hours of "shift workers" would result in a corresponding increase in the cost of production, since it is not possible to speed chemical processes to yield as much in six as in eight hours. (P. 1329)

In the effort to aid the British paper industry, it is proposed to restrict imports of paper, but not to adopt any system of rationing of supplies. Imports from other parts of the Empire are not to be restricted. (Pp. 1346-8)

Importation of scientific books from Germany into the United States is now permitted on condition that the purchase price be applied to the purchase of foodstuffs for Germany. (P. 1361)

Among the key industries of Australia are linseed oil, coal tar, tungsten ore, zinc concentrates, and manganese ore. (P. 1420)

The zinc industry of Japan is facing a serious situation owing to the decline in foreign markets, and the greatly increased capacity of the smelters erected during the war. (P. 1454)

The glass industry of Japan was formerly confined to small articles, but during the war the manufacture of window glass has reached large proportions which it is expected to retain. (Pp. 1513-15)

The new "Federation of British Industries" comprises 172 associations and 956 individual firms, or in all, about 17,000 British manufacturing establishments. Among its functions are matters relating to foreign trade, education, industrial organization, commercial organization, transportation, taxes and duties, housing, patent law, trade-marks, etc. It includes practically all trades, among them numerous chemical and metallurgical industries. (Pp. 1606-11)

Germany now has a capacity for producing annually 500,000 metric tons of combined nitrogen, for which the domestic consumption is only 225,000 tons. Three hundred thousand tons are produced by the Badische Anilin und Soda Fabrik, using the Haber process. About 100,000 tons are produced by the cyanamide process, and 100,000 from coke ovens and gas plants. (Pp. 1628-9)

SPECIAL SUPPLEMENTS ISSUED IN JUNE

BRAZIL—40c
BRITISH INDIA—50b

CHINA—52a
FRENCH EAST AFRICA—70a

STATISTICS OF EXPORTS TO THE UNITED STATES

BRAZIL—Sup. 40c
Castor seed
Gum jatoba
Hides
Rubber
Manganese ore
Chrome ore
Castor oil
Diamonds
Ipecac
Carnauba wax

CHINA—Sup. 52a
Albumen
Ammonium sulfate
Soy beans
Castor oil
Peanut oil
Castor seed
Linseed

BOOK REVIEWS

An Introduction to the Physics and Chemistry of Colloids. By EML HATSCHEK. 3rd Ed. 116 pp. 17 illustrations. P. Blakiston's Son & Co., Philadelphia, 1919. Price, \$1.50, net.

The second edition of this book was reviewed in *THIS JOURNAL*, 8 (1916), 1181. In the third edition "A number of small corrections and additions have again been made so as to include such recent advances as fall within the purview of a brief introduction to this branch of science." The usefulness of this book as an introduction to the subject of colloids remains as great as before. At present, a knowledge of the fundamental facts and methods as developed here is of special importance, since the study of the colloidal properties of matter is tending toward explanations of a more quantitative chemical and physical character with a consequent simplification of the relationships involved.

K. GEORGE FALK

Boiler Chemistry and Feed Water Supplies. By J. H. PAUL. 242 pp. Longmans, Green & Co., London and New York. Price, \$4.50, net.

American readers of this English book must remember that the very numerous analytical results which are stated in "grains per gallon" have to do with the British Imperial gallon and not with the United States gallon. The former is a larger unit of measure than that commonly used in this country and it contains 70,000 grains of water.

Moreover, hardness is expressed in the old form of degrees, a degree representing hardening material equivalent to 1 grain of calcium carbonate per Imperial gallon of water.

The first chapter opens with analyses of sundry atmospheric waters, rain, hail, and snow, attention being called to the acid character of such of these as fall over city areas. Fourteen diagrams follow, giving in graphic form the amounts of fixed and free carbonic acid found in London water; and the chapter closes with many detailed mineral analyses of soft waters, chalk waters, magnesian waters, and waters from rivers, canals, collieries, wells, and seas. Under soft waters the author does well to point out that such may be found even in chalk deposits in the absence of carbonic acid.

Chapter 3 has to do with the more common constituents of natural waters, and tables are given showing their solubilities at different temperatures. Those familiar with waters from the Far West would add sodium carbonate to the list.

In Chapter 4 are given detailed analyses of many varieties of boiler scales and sludges.

In the chapter on softening, the author reminds the reader that simply bringing water to the boiling temperature is not sufficient for the entire removal of free carbonic acid but that actual boiling for ten minutes is required.

In the same chapter are to be found tables for use when testing lime water and soda ash, together with factors suitable for calculating the quantities of softening materials required to remove the various forms of hardness.

The author is pronounced in his view that for boiler use all hardness should be removed for the reason that partial softening may allow corrosive salts to remain even after the "scale-formers" have been extracted, thus making the last state of the water worse than the first.

The statement (page 107) that the natural zeolites are hardly sufficient in softening power to permit of their competing with the artificial is scarcely true, as several of these latter are already on the market.

Emphasis is placed upon the necessity of keeping the con-

centration of boiler water within such limits that soluble salts shall not exceed 1000 grains per Imperial gallon (about 14,000 p. p. m.), otherwise sodium chloride and sodium sulfate will deposit.

The likelihood of corrosion following the use either of "peaty" water or of that containing salts of magnesium, especially the chloride, is naturally touched upon; and much discussion, with illustrations, will be found bearing upon the general subjects of corrosion, scale formation, and methods of combating these evils.

Under "priming," exception is well taken to the widely conceived notion that alkalinity *per se* will cause foaming, and illustrations are given to show the fallacy of this belief.

The many analytical tables in the last chapter cover waters from nearly all parts of the world except continental North America. This omission makes the book less useful to American readers than it would otherwise have been; nevertheless, those interested in boiler waters will find in it much that is valuable and instructive.

W. P. MASON

Crude Rubber and Compounding Ingredients. By HENRY C. PEARSON. The India Rubber World, 1918. Price, \$10.00.

This, the third edition of this book, aims to bring up to date information regarding crude rubber and compounding ingredients. It is not, as it makes no pretense to be, a treatise on India rubber. It is rather a dictionary of materials used in the art with the description of their method of preparation, properties, and use in connection with rubber manufacture. In comparison with previous editions, more space has been given in the present volume to the description of plantation rubber, its preparation, uses, etc., and to recent developments in connection with the same; in this edition also will be found special chapters devoted to such subjects as accelerators, synthetic rubber, the reclamation of rubber, and the vulcanization of rubber without sulfur.

Perhaps the most striking fact to be learned from a review of this book is the enormous number of materials which have been recorded in the literature in connection with the manufacture of India rubber. The work of bringing together under one head and appropriate title all such materials in itself speaks for the value of the present volume as an encyclopedia of rubber and its compounding ingredients. Not all the materials or processes, however, described in this volume can be successfully used; many of them are obsolete or of no practical value whatsoever. Perhaps the weakest point in connection with the volume lies in the fact that little or no effort has been made to distinguish between materials of proven, practical value and those of merely scientific or historical interest. Thus, for example, in the chapter dealing with accelerators, one page will be found devoted to quinoline and its derivatives, all more or less useless materials for practical purposes, while some of the best of everyday accelerators receive but scant mention. Similarly in the chapter devoted to resins, gums, etc., no mention at all is made of the millions of pounds of glue annually consumed in compounding with India rubber for tires and other purposes.

On the whole, however, the volume should commend itself to the practical man as a work to which he can refer. The chapters dealing with crude rubber and pseudo-rubbers and their preparation are particularly valuable and interesting. In another edition it would seem that some mention should be made of the subject of fabrics used now so extensively in the rubber industry.

D. SPENCE

NEW PUBLICATIONS

By CLARA M. GUPPY, Librarian Mellon Institute of Industrial Research, Pittsburgh

- Wheels; Their Nature, Manufacture, and Use.** 337 pp. Price, \$3.00. N. W. Henley Publishing Co.
- Aluminum: Manufacture of Aluminum.** J. T. PATTISON. 104 pp. Price, 75c. Spon and Chamberlain, New York.
- Beverages: On Uncle Sam's Water Wagon; 500 Recipes for Delicious Drinks which Can be Made at Home.** H. W. MOORE. 12mo. 222 pp. Price, \$1.50. G. P. Putnam's Sons, New York.
- Coal-Tar Dyes: The Chemistry of Coal-Tar Dyes.** I. W. FAY. 2nd Ed. Revised and Enlarged. 8vo. 500 pp. Price, \$4.00. D. Van Nostrand Co., New York.
- Coal-Tar Dyes and Intermediates.** E. DE BARRY BARNETT. 8vo. 213 pp. Price, \$3.50. D. Van Nostrand Co., New York.
- Electrometallurgy: Industrial Electrometallurgy Including Electrolytic and Electrothermal Processes.** E. K. RIDEAL. 8vo. 247 pp. Price, \$3.00. D. Van Nostrand Co., New York.
- Gas and Gas Making.** W. H. Y. WEBBER. 12mo. 130 pp. Price, \$1.00. Sir Isaac Pitman and Sons, New York.
- Graphical Charts: Construction of Graphical Charts.** J. B. PEDDIE. New Ed. 8vo. 158 pp. Price, \$2.00. McGraw-Hill Book Co., New York.
- Hydrogen: Chemistry and Manufacture of Hydrogen.** P. L. TREED. 8vo. 152 pp. Price, \$2.40. Longmans, Green & Co., New York.
- Liquid Fuels for Internal Combustion Engines; A Practical Treatise for Engineers and Chemists.** HAROLD MOORE. 8vo. 200 pp. Price, \$5.00. D. Van Nostrand Co., New York.
- Machine Design: A Manual of Practical Instruction in Designing Machinery for Specific Purposes.** E. L. WALLACE. 8vo. 157 pp. Price, \$1.75. American Technical Society, Chicago.
- Metal Workers' Handy-Book of Receipts and Processes; being a Collection of Chemical Formulas and Practical Manipulations.** W. T. BRANNT. New, Enlarged Ed. 12mo. 582 pp. Price, \$3.00. H. C. Baird & Co., New York.
- Mining: Standardization of Mining Methods.** C. A. MITKES. 112 pp. Price, \$1.50. McGraw-Hill Book Co., New York.
- Petroleum.** ALBERT LIDGERT. 12mo. 130 pp. Price, \$1.00. Sir Isaac Pitman & Sons, New York.
- Rare Earths: Metals of the Rare Earths.** J. F. SPENCER. 8vo. 279 pp. Price, \$4.50. Longmans, Green & Co., New York.
- Fats: How the World Famine in Fats is being Met; the Role of Hydrogen in Revolutionizing the Use of Liquid Fats.** CARLTON ELLIS. *Chemical Age*, Vol. 1 (1919), No. 1, pp. 38-43.
- Fertilizer: The World's Supply of Nitrogenous Fertilizers.** G. W. ANDERSON. *Chemical News*, Vol. 119 (1919), No. 3090, pp. 6-7.
- Flotation: Notes on Flotation.** J. P. RUTH. *Engineering and Mining Journal*, Vol. 107 (1919), No. 26, pp. 1149-1152.
- Flotation: An Outline for Flotation Test Work.** H. L. HAZEN. *Engineering and Mining Journal*, Vol. 107 (1919), No. 26, pp. 1160-1161.
- Fuels: Problems in the Utilization of Fuels.** R. F. BACON AND W. A. HAMOR. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 12, pp. 1614-1681.
- Fusion Welding Applied to Drop Forgings; Oxy-Acetylene and Electric Welds and Their Applicability to Defective Forgings.** S. W. MILLER. *The Iron Age*, Vol. 104 (1919), No. 5, pp. 287-293.
- Glass: Procedures in the Manufacture of Optical Glass.** W. S. WILLIAMS AND C. C. RAND. *Journal of the American Ceramic Society*, Vol. 2 (1919), No. 6, pp. 422-442.
- Gun Metal: How Impurities Affect Gun Metal.** F. JOHNSON. *The Iron Trade Review*, Vol. 65 (1919), No. 2, pp. 95-96.
- Impact Tester for Fiber Board.** E. O. REED AND F. P. VEITCH. *Paper*, Vol. 24 (1919), No. 21, pp. 24-27.
- Kaolin for Tannin Analyses.** R. W. FREY. *Journal of the American Leather Chemists Association*, Vol. 14 (1919), No. 7, pp. 393-401.
- Leather Work of the Bureau of Standards.** L. M. WHITMORE. *Journal of the American Leather Chemists Association*, Vol. 14 (1919), No. 7, pp. 401-404.
- Metallurgical Visit to Shasta, California.** HERBERT LANG. *Mining and Scientific Press*, Vol. 119 (1919), No. 2, pp. 47-52.
- Nelson Electrolytic Chlorine Cell; Development and Description of the Cell.** C. F. CARRIER. *Chemical and Metallurgical Engineering*, Vol. 21 (1919), No. 3, pp. 133-138.
- Paper-Making: Cooking and Washing of Rags.** E. ARNOULD. *Paper*, Vol. 24 (1919), No. 19, pp. 15-17.
- Paper-Making: Waste Paper for Paper-Making; Researches on Printing Ink in Relation to Its Destructibility.** H. A. BROMLEY. *Paper*, Vol. 24 (1919), No. 18, pp. 18-21.
- Platinum Situation: Shortage in Platinum and Platinum Group of Metals Attributable to Disturbances of Normal Production Created by the War. Uses of Platinum and Possibilities for Maintaining Supplies.** J. M. HILL. *Engineering and Mining Journal*, Vol. 108 (1919), No. 4, pp. 131-137.
- Sheeting Material: Exposure Tests of Sheeting Material.** S. L. HOYT. *Chemical and Metallurgical Engineering*, Vol. 21 (1919), No. 3, pp. 142-144.
- Soaps: Colloid Chemical Studies of Soaps.** M. H. FISCHER. *The Chemical Engineer*, Vol. 27 (1919), No. 7, pp. 155-162.
- Steel: Flakes in Alloy Steel; A Recapitulation and Discussion of Recently Published Matter on the Subject.** E. E. TRUM. *Chemical and Metallurgical Engineering*, Vol. 21 (1919), No. 3, pp. 145-146.
- Steel: Improvements in Case-Hardening Process in Which the Authors Have Devised Certain Modifications in the Case-Hardening Process.** D. HANSON AND J. E. HURST. *The American Drop Forger*, Vol. 5 (1919), No. 7, pp. 338-345.
- Sulfite Liquor: Utilization of Waste Sulfite Liquor.** BJARNE JOHNSEN AND R. W. HOVEY. *Pulp and Paper Magazine*, Vol. 17 (1919), No. 30, pp. 596-600.
- Synthetic Alcohol: Notes on the Production of Synthetic Alcohol.** E. K. RIDEAL. *The Chemical Age (London)*, Vol. 1 (1919), No. 1, pp. 9-11.
- Tannery By-Products.** V. A. WALLIN. *Journal of the American Leather Chemists Association*, Vol. 14 (1919), No. 7, pp. 373-381.
- Tannin: Waste Pulp Mill Bark as a Source of Tannin.** V. P. EDWARDS. *Journal of the American Leather Chemists Association*, Vol. 14 (1919), No. 7, pp. 381-390.
- Tobacco: Mustiness in Tobacco.** L. J. RILEY. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 12, pp. 1714-1721.
- Zinc: New Uses for Zinc. Publicity is Necessary to Inform Public of the Desirable Qualities and Varied Industrial Applications of the Metal.** G. S. HARNEY. *Engineering and Mining Journal*, Vol. 108 (1919), No. 3, pp. 100-101.
- Zinc Industry of Missouri, Arkansas, Kansas, and Oklahoma.** ORTO RUM. *Engineering and Mining Journal*, Vol. 107 (1919), No. 26, pp. 1170-1171.
- Zinc Plating: The Art of Zinc Plating; Some Information Regarding Various Solutions and Methods.** T. C. EICHSTAEDT. *The Metal Industry*, Vol. 17 (1919), No. 7, pp. 325-326.

RECENT JOURNAL ARTICLES

- Acetone: Production of Acetone and Butyl Alcohol by a Bacteriological Process.** H. B. SPEARMAN. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 12, pp. 1551-1611.
- Alcohol as a Necessity to Industrial Progress.** B. K. TUNISON. *Chemical Age*, Vol. 1 (1919), No. 1, pp. 20-24.
- Beltting: Scientific Methods to Prolong Life of Beltting versus Careless Methods that Destroy.** E. E. MARBAKER. *Beltting*, Vol. 15 (1919), No. 2, pp. 17-20.
- Benzene: Chlorination of Benzene, Analysis of Mixtures of Benzene, Chlorobenzene and Dichlorobenzene.** P. F. FRANKLAND, S. R. CARTER, AND DOROTHY WEBSTER. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 12, pp. 1531-1551.
- Bleaching Powder; Descriptive Summary; Its Invention, History, Uses, Domestic and Foreign Manufacturing Conditions.** UNITED STATES TARIFF COMMISSION. *Chemical Age*, Vol. 1 (1919), No. 1, pp. 28-32.
- Carbide Conversion Calculations.** I. E. KNAFF. *Chemical and Metallurgical Engineering*, Vol. 21 (1919), No. 3, pp. 139-140.
- Chrome-Nickel Steel: Heat Treatment of Chrome-Nickel Steel.** H. C. LOUDENBECK. *The American Drop Forger*, Vol. 5 (1919), No. 7, pp. 348-352.
- Clay Bricks: Radioactive Bricks.** H. J. KNOLLMAN. *Journal of the American Ceramic Society*, Vol. 2 (1919), No. 6, pp. 451-460.
- Column Apparatus in Chemical Industry.** S. J. TUNGAY. *The Chemical Age (London)*, Vol. 1 (1919), No. 1, pp. 11-14.
- Denaturation of Spent Acids; a Practical Discussion of the Recovery of Nitric Acid from Spent Acids.** ARTHUR HOUGH AND J. R. PITMAN. *Chemical Age*, Vol. 1 (1919), No. 1, pp. 44-47.
- Die Casting: Modern Developments in Die Casting; A Description of the Plant of the Doehler Die-Casting Company.** ADOLPH BREGMAN. *The Metal Industry*, Vol. 17 (1919), No. 7, pp. 327-330.
- Diesel Engines: Use of Oil in Diesel Engines.** L. H. MORRISON. *Engineering and Mining Journal*, Vol. 108 (1919), No. 4, pp. 138-141.
- Dyes: Vat Dyes and Processes of Dyeing.** R. W. SMITH. *Color Trade Journal*, Vol. 5 (1919), No. 2, pp. 29-31.
- Electrolytic Bleach; Technical Details of Reactions in the Operation of Electrolytic Bleach Plants.** A. G. BETTS. *Paper*, Vol. 24 (1919), No. 18, pp. 15-16.

MARKET REPORT—AUGUST, 1919

WHOLESALE PRICES PREVAILING IN THE NEW YORK MARKET ON AUGUST 15, 1919

INORGANIC CHEMICALS

Acetate of Lime, Basis 80%.....	100 Lbs.	2.00	@	2.05
Alum, ammonia, lump, U. S. P.....	100 Lbs.	4.25	@	4.50
Aluminum Sulfate, (iron free).....	Lb.	2 1/2	@	3
Ammonium Carbonate, domestic.....	Lb.	13	@	13 1/4
Ammonium Chloride, white.....	Lb.	19	@	20
Aqua Ammonia, 26°, drums.....	Lb.	6 1/4	@	7
Arsenic, white.....	Lb.	10 1/4	@	11
Barium Chloride.....	Ton	65.00	@	85.00
Barium Nitrate.....	Lb.	12	@	14
Barytes, prime white.....	Ton	30.00	@	35.00
Bleaching Powder, 35 per cent, Works.....	100 Lbs.	2.00	@	2.20
Blue Vitriol.....	Lb.	9	@	9 1/4
Borax, crystals, in bags.....	Lb.	7 1/4	@	10 1/4
Boric Acid, powdered crystals.....	Lb.	13 1/4	@	14
Brimstone, crude, domestic.....	Long Ton	28.00	@	35.00
Bromine, technical, bulk.....	Lb.	75	@	
Calcium Chloride, lump, 70 to 75% fused.....	Ton	18.00	@	22.00
Caustic Soda, 76 per cent.....	100 Lbs.	3.32	@	3.50
Chalk, light precipitated.....	Lb.	4 1/4	@	5
China Clay, imported.....	Ton	20.00	@	30.00
Feldspar.....	Ton	8.00	@	15.00
Fuller's Earth, foreign, powdered.....	Ton	nominal		
Glauber's Salt, domestic.....	Ton	20.00	@	30.00
Glauber's Salt, in bbls.....	100 Lbs.	1.25	@	1.50
Green Vitriol, bulk.....	100 Lbs.	2.00	@	2.25
Hydrochloric Acid, commercial, C. P.....	Lb.	11	@	8 1/4
Iodine, resublimed.....	Lb.	4.25	@	4.30
Lead Acetate, white crystals.....	Lb.	14	@	15
Lead Nitrate, C. P.....	Lb.	85	@	
Litharge, American.....	Lb.	9 1/4	@	10
Lithium Carbonate.....	Lb.	1.50	@	
Magnesium Carbonate, U. S. P.....	Lb.	21	@	22
Magnetite, "Calcined".....	Ton	60.00	@	65.00
Nitric Acid, 40°.....	Lb.	6.75	@	7.25
Nitric Acid, 42°.....	Lb.	7.00	@	7.50
Nitric Acid, 48/50%.....	Lb.	25	@	28
Phosphorus, yellow.....	Lb.	35	@	40
Phosphorus, white.....	100 Lbs.	2.00	@	2.50
Plaster of Paris.....	Lb.	26	@	27
Potassium Bromide, granular.....	Lb.	1.25	@	1.30
Potassium Carbonate, calcined, 80 @ 85%.....	Lb.	16	@	18
Potassium Chlorate, crystals, spot.....	Lb.	23	@	25
Potassium Cyanide, bulk, 98-99 per cent.....	Lb.	nominal		
Potassium Hydroxide, 88 @ 92%.....	Lb.	60	@	70
Potassium Iodide, bulk.....	Lb.	3.30	@	3.50
Potassium Nitrate.....	Lb.	13	@	17
Potassium Permanganate, bulk, U. S. P.....	Lb.	60	@	65
Quicksilver, flask.....	75 Lbs.	109.00	@	
Red Lead, American, dry.....	100 Lbs.	10.25	@	10.75
Salt Cake glass makers'.....	Oz.	65	@	15
Silver Nitrate.....	Oz.	65	@	67
Soapstone, in bags.....	Ton	10.00	@	12.50
Soda Ash, 58%, in bags.....	100 Lbs.	2.00	@	2.05
Sodium Acetate, broken lump.....	Lb.	6 1/2	@	7
Sodium Bicarbonate, domestic.....	100 Lbs.	2.35	@	2.65
Sodium Bichromate.....	Lb.	14 1/4	@	15
Sodium Chlorate.....	Lb.	14	@	15
Sodium Cyanide.....	Lb.	29	@	30
Sodium Fluoride, commercial.....	Lb.	14	@	15
Sodium Hyposulfite.....	100 Lbs.	2.60	@	3.60
Sodium Nitrate, 95 per cent, spot.....	100 Lbs.	3.05	@	
Sodium Silicate, liquid, 40° Bé.....	Lb.	2	@	2 1/4
Sodium Sulfide, 60%, fused in bbls.....	Lb.	3	@	3 1/4
Sodium Bisulfate, powdered.....	Lb.	5	@	7
Strontium Nitrate.....	Lb.	25	@	30
Sulfur.....	100 Lbs.	2.25	@	4.60
Sulfuric Acid, chamber 66° Bé.....	Ton	16.50	@	18.50
Sulfuric Acid, oleum (fuming).....	Ton	24.00	@	
Talc, American, white.....	Ton	18.00	@	22.00
Terra Alba, American, No. 1.....	100 Lbs.	1.25	@	
Tin Bichloride, 50°.....	Lb.	22 1/2	@	25
Tin Oxide.....	Lb.	60	@	63
White Lead, American, dry.....	Lb.	9	@	9 1/4
Zinc Carbonate.....	Lb.	18	@	20
Zinc Chloride, commercial.....	Lb.	8	@	10

ORGANIC CHEMICALS

Acetanilid, C. P., in bbls.....	Lb.	36	@	38
Acetic Acid, 56 per cent, in bbls.....	100 Lbs.	5.75	@	6.00
Acetic Acid, glacial, 99 1/4%.....	100 Lbs.	12.00	@	14.00
Acetone, drums.....	Lb.	13 1/4	@	16
Alcohol, denatured, 180 proof.....	Gal.	50	@	55

Alcohol, Ethyl, non-beverage, 190 proof.....	Gal.	4.70	@	4.95
Alcohol, wood, 95 per cent, refined.....	Gal.	1.30	@	1.33
Amyl Acetate.....	Gal.	3.75	@	3.85
Aniline Oil, drums extra.....	Lb.	25	@	26
Benzoic Acid, ex-toluol.....	Lb.	90	@	1.00
Benzene, pure.....	Gal.	24	@	28
Camphor, refined in bulk, bbls.....	Lb.	1.24 1/4	@	1.25
Carbolic Acid, U. S. P., crystals, drums.....	Lb.	15	@	16
Carbon Bisulfide.....	Lb.	9	@	10
Carbon Tetrachloride, drums, 100 gals.....	Lb.	13 1/4	@	14
Chloroform, U. S. P.....	Lb.	30	@	32
Citric Acid, domestic, crystals.....	Lb.	1.15	@	1.16
Cresote, Beechwood.....	Lb.	2.00	@	2.10
Cresol, U. S. P.....	Lb.	14 1/4	@	15 1/2
Dextrine, corn (carlodes, bags).....	Lb.	7	@	8
Dextrine, imported potato.....	Lb.	nominal		
Ether, U. S. P. 1900.....	Lb.	23	@	24
Formaldehyde, 40 per cent.....	Lb.	20	@	21
Glycerin, dynamite, drums extra.....	Lb.	20 1/4	@	21
Oxalic Acid, in casks.....	Lb.	25	@	28
Pyrogallol Acid, resublimed, bulk.....	Lb.	2.60	@	2.75
Salicylic Acid, U. S. P.....	Lb.	42	@	45
Starch, corn (carlodes, bags) pearl.....	100 Lbs.	6.07	@	6.25
Starch, potato, Japanese.....	Lb.	9	@	9 1/4
Starch, rice.....	Lb.	24	@	
Starch, sago flour.....	Lb.	7	@	8
Starch, wheat.....	Lb.	10	@	10 1/4
Tannic Acid, commercial.....	Lb.	65	@	80
Tartaric Acid, crystals.....	Lb.	86 1/4	@	87

OILS, WAXES, ETC.

Beeswax, pure, white.....	Lb.	64	@	68
Black Mineral Oil, 29 gravity.....	Gal.	24	@	25
Castor Oil, No. 3.....	Lb.	18	@	
Ceresin, yellow.....	Lb.	16	@	17
Corn Oil, crude.....	100 Lbs.	22 1/4	@	
Cottonseed Oil, crude, f. o. b. mill.....	Lb.	24 1/4	@	
Cottonseed Oil, p. s. y. Oct. option.....	100 Lbs.	24.00	@	24.50
Menhaden Oil, crude (southern).....	Gal.	1.11	@	1.12
Neat's-foot Oil, 20°.....	Gal.	2.20	@	2.30
Paraffin, crude, 118 to 120 m. p.....	Lb.	7	@	8
Paraffin Oil, high viscosity.....	Gal.	40	@	41
Rosin, "F" Grade, 280 lbs.....	Bbl.	19.50	@	
Rosin Oil, first run.....	Lb.	82	@	83
Shellac, T. N.....	Lb.	nominal		
Spermaceti, cake.....	Lb.	31	@	33
Sperm Oil, bleached winter, 38°.....	Gal.	1.95	@	1.97
Spindle Oil, No. 200.....	Gal.	38	@	40
Stearic Acid, double-pressed.....	Lb.	18 1/4	@	19
Tallow, acidless.....	Gal.	1.65	@	
Tar Oil, distilled.....	Gal.	40	@	42
Turpentine, spirits of.....	Gal.	1.12 1/4	@	

METALS

Aluminum, No. 1, ingots.....	Lb.	33	@	
Antimony, ordinary.....	100 Lbs.	9.00	@	
Bismuth, N. Y.....	Lb.	nominal		
Copper, electrolytic.....	Lb.	21 1/4	@	22 1/4
Copper, lake.....	Lb.	24	@	
Lead, N. Y.....	Lb.	5.60	@	
Nickel, electrolytic.....	Lb.	55	@	56
Platinum, refined, soft.....	Oz.	105.00	@	
Silver.....	Oz.	1.12 1/4	@	
Tin.....	Lb.	70	@	
Tungsten (Wol).....	Per Unit	10.00	@	
Zinc, N. Y.....	100 Lbs.	9.40	@	9.60

FERTILIZER MATERIALS

Ammonium Sulfate.....	100 Lbs.	4.75	@	
Blood, dried, f. o. b. New York.....	Unit	6.25	@	
Bone, 3 and 50, ground, raw.....	Ton	38.00	@	39.00
Calcium Cyanamide.....	Unit of Ammonia	5.15	@	10.00
Calcium Nitrate, Norwegian.....	100 Lbs.	—	@	
Castor Meal.....	Unit	—	@	
Fish Scrap, domestic, dried, f. o. b. works.....	Unit	7.00	@	10.00
Phosphate, acid, 16 per cent.....	Unit	17.00	@	17.50
Phosphate Rock, f. o. b. mine.....	Ton	nominal		
Florida land pebble, 68 per cent.....	Ton	7.50	@	8.00
Tennessee, 78-80 per cent.....	Ton	nominal		
Potassium "muriate," basis 80 per cent.....	Ton	nominal		
Pyrites, furnace size, imported.....	Unit	18 1/2	@	
Tankage, high-grade, f. o. b. Chicago.....	Unit	6.25	@	10.00

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ANNUAL MEETING AMERICAN CHEMICAL SOCIETY

COUNCIL MEETING

President William H. Nichols called the Council of the SOCIETY to order at 4 P.M. on Monday, September 2, 1919, in the ballroom of the Bellevue-Stratford Hotel, Philadelphia. In a few well chosen words he outlined the high points of the SOCIETY's work, touching especially upon the mutual benefit which he felt had resulted from his visit to the local sections on the Pacific Coast.

The first order of business was the election of officers. Dr. A. B. Lamb was reelected editor of the *Journal of the American Chemical Society*; Dr. E. J. Crane is to continue as editor of *Chemical Abstracts*; and Dr. Chas. H. Herty will edit THIS JOURNAL during the coming year. The secretary, Dr. Charles L. Parsons, was retained in office, and Dr. B. C. Hesse, retiring member of the Advisory Committee on National Policy, was designated to succeed himself in that office. The present board of associate editors of the *Journal of the American Chemical Society* was reelected, and power was delegated to the editor to fill any vacancies caused by declination of present members to serve longer. It was further voted that a committee composed of Dr. W. A. Noyes, *chairman*, the present editor, and the associate editors of that Journal examine the present procedure regarding the appointment of associate editors, with a view to improvement on the method, and report at the Spring Meeting in 1920.

On motion of Mr. H. E. Howe, secretary of the Division, the name of the Division of Industrial Chemists and Chemical Engineers was changed to Division of Industrial and Engineering Chemistry. It was pointed out that this new title was consistent with the names of other Divisions of the Society, and furthermore, brought the name into conformity with the title of THIS JOURNAL.

Choice of a meeting place for the spring of 1920 fell to St. Louis, the exact date to be agreed upon later. An invitation was also received from the Washington, D. C., Section, and the determining factor was the recollection of the gracious manner in which the St. Louis Section had accepted the decision to cancel the Spring Meeting of 1917, plans for which were already well under way.

It was voted to hold the Annual Meeting for 1920 in Chicago. Invitations had been received from the Chicago, Detroit, Rochester, and Washington Sections, and were accompanied by urgent invitations from the chambers of commerce and local organizations of the cities mentioned. The decision as to whether this meeting shall be held as usual during September, or shall be postponed until the meeting of the American Association for the Advancement of Science in December, was left until the next meeting of the Council.

The Report of the Committee on the Preparation of a List of Recommended Chemical Texts for Libraries was accepted and placed on file.

A committee consisting of Drs. Charles Baskerville, F. P. Venable, Julius Stieglitz, W. D. Bancroft and M. T. Bogert was appointed to draft appropriate resolutions on the death of Lord Rayleigh, an Honorary Member of the SOCIETY.

The presentation of the following by-law covering associate membership in divisions of the SOCIETY brought out considerable discussion, but the by-law was unanimously adopted.

No person shall become a member of any Division who is not a member of the AMERICAN CHEMICAL SOCIETY; but Divisions may have associate members not members of the AMERICAN CHEMICAL SOCIETY who shall be entitled to all the privileges of the Division, save that of voting for officers; provided that such associate members shall not be entitled to any of the other privileges of the AMERICAN CHEMICAL SOCIETY, and shall pay such dues, of not less than two dollars (\$2.00) per annum, as the Division may require.

Dr. E. W. Washburn presented the report of the American delegates to the Interallied Chemical Conference in London and Brussels. The substance of his report was printed in the September issue of THIS JOURNAL, page 886.

Dr. Francis C. Phillips spoke briefly of the progress of the plans of the Priestley Memorial Committee, and stated that in the near future the active work of collecting funds would be resumed.

President Nichols announced that representatives of the Army and Navy Departments had enthusiastically endorsed the proposal that the AMERICAN CHEMICAL SOCIETY furnish lecturers on certain chemical subjects closely allied with war problems, at the West Point and Annapolis Academies, and warned the members that some of their number would shortly be called upon for this purpose.

The plans of the Committee on Nomenclature, Spelling and Pronunciation were elaborated by Dr. E. J. Crane, editor of *Chemical Abstracts*, who expressed the hope that a degree of coordination might be obtained among all the scientific societies using the English language. It was moved and passed:

That the President of the AMERICAN CHEMICAL SOCIETY invite on behalf of the Council of the SOCIETY the governing bodies of the Chemical Society (London) and the Society of Chemical Industry to appoint a committee, or committees, on Nomenclature, Spelling and Pronunciation, to cooperate with the corresponding committee of the American society in order to secure as large a measure of agreement in these fields as is practical.

The support of the SOCIETY was asked, through a letter read by one of the councilors, of the plan of one of the popular scientific journals to conduct a section devoted to the correct abstracting of scientific articles in popular language. There was extended discussion of the possible results of such a course, and the following motion was finally made a special order for the spring meeting:

That as a general policy the SOCIETY do not lend its name to any private undertaking for profit. This will not preclude contracts with private concerns to carry out undertakings of the SOCIETY.

Later the subject was reopened, and the motion passed:

That a committee of three be appointed to study the question of possible relation between the AMERICAN CHEMICAL SOCIETY and certain scientific publications, and report to the next meeting of the Council.

The chairman appointed Dr. Allen Rogers, Mr. H. E. Howe and Dr. Charles Baskerville.

The Council expressed its disapproval of the suggestion that the SOCIETY circularize its membership in support of the Conference of National Public Works to be held by the Association of Engineers, Architects and Contractors, feeling that there was little of interest to the chemical profession in the movement.

At this stage in the proceedings a message to the chairman resulted in his declaring a recess, that the ninety-seven councilors present—we believe latecomers made an even hundred—might accept the dinner invitation extended by the Philadelphia Section. Dr. Harry F. Keller, *chairman*, and his committee proved delightful hosts.

The attention of the Council was called to features of the Army Reorganization Bill (S. 2715) now before the Senate Committee on Military Affairs, of the utmost importance to chemists (see THIS JOURNAL, September 1919, pages 814-816*h*). The Secretary pointed out that the SOCIETY was already on record as against the abolition of the Chemical Warfare Service as a separate unit of the Army, as proposed by the Secretary of War (see THIS JOURNAL, August 1919, p. 789). The importance of individual effort by the councilors in bringing to the attention of their own senators and representatives the grave danger confronting the country if the bill containing these features was allowed to pass, was brought out very strongly. A committee was appointed to draft resolutions to be presented to the President of the United States and the Congress, urging that technically trained men be given the same privileges as line officers in the organization of the War Department, which is not the case in the present bill, and reported resolutions as follows, which were unanimously adopted:

The AMERICAN CHEMICAL SOCIETY of a membership of over 13,500 American chemists to-day by its authorized representatives unanimously adopted the following:

WHEREAS, The recent war has clearly demonstrated that the advancement of science through competently directed research in military problems is indispensable to the security of the nation, and

WHEREAS, The bill recently introduced into Congress (Senate 2715) by the General Staff of the Army providing for universal military service and the reorganization of the Army is of such scope and effect as to inevitably impede the development of all technical and scientific work of the Army by placing it under the absolute control and direction of purely military officers who do not have the requisite scientific knowledge and

WHEREAS, An organization so constituted could not function efficiently and in time of stress would prove to be an element of fatal weakness and could never hope to attract to itself those scientific and technical experts without whose aid modern warfare cannot be successfully conducted,

Now, therefore, be it resolved, That the AMERICAN CHEMICAL SOCIETY emphatically protests against this or any other bill which does not provide for commissioning staff officers in the corps and departments in which they are to serve and which does not accord to the technical man the same recognition and opportunity throughout every grade and department of the Army as are accorded to the man trained for a military career only.

The following resolutions were introduced, and adopted by the Council:

WHEREAS, The AMERICAN CHEMICAL SOCIETY is convinced that

the compensation of the chemist in the national and states service, like that of the university investigator in chemistry, is far below that received in the chemical industries, and

WHEREAS, The Government cannot maintain an efficient chemical service unless it offers adequate compensation to its chemists, and

WHEREAS, Various agencies are now at work toward remedying this situation, and

WHEREAS, The Congressional Commission on Reclassification of Federal Employees is one of these agencies,

Be it therefore resolved, That the AMERICAN CHEMICAL SOCIETY hereby pledges its cooperation with Congress and with the Commission of Reclassification of Federal Employees with all other agencies with like endeavor and urges upon them the vital necessity to the welfare of this country of remedying the present situation, and

Be it further resolved, That copies of this resolution be sent to the Commission of Reclassification of Employees, the press, and be published in the *Journal of Industrial and Engineering Chemistry*.

In this connection it was voted

That the President appoint a committee of three with power, directing them to cooperate with the Commission of Reclassification of Federal Employees, and to furnish them with any available data and to take such action with the Commission and other agencies as shall be thought wise in furthering the ends set forth in the resolution.

The President appointed Drs. W. D. Bancroft, W. D. Bigelow and C. L. Parsons.

The Report of the Omnibus Committee was called, it having been a special order for this meeting, but no councilor had any instructions from his local section regarding its provisions. The work of the committee was, therefore, considered as finished.

On motion, the Council adjourned.

GENERAL MEETING

When the members and guests who filled the halls and completely obscured the registration desk in the lobby of the first floor of the Bellevue-Stratford Hotel had assembled in the spacious ballroom at the call of music, scarcely a seat was vacant, and many had chosen points of vantage in the galleries. Following the singing of the Star Spangled Banner, Dr. Harlan S. Miner, senior vice president, formally opened the Fifty-eighth Meeting of the AMERICAN CHEMICAL SOCIETY, and introduced Hon. Joseph S. McLaughlin, Director of Supplies of the City of Philadelphia, who won his audience with a fund of witty stories, and in gracious words welcomed the SOCIETY to Philadelphia, the city of Priestley and Hare, and from that day to this a center of the American chemical industry.

In responding, President Nichols expressed appreciation of the hospitable welcome the SOCIETY had received, and promised that its members would reciprocate with contributions of real scientific value to the community. He took occasion also to express his appreciation of the intelligent publicity which the newspapers were giving to the chemist and the chemical profession.

Earnest and serious attention was given to the addresses by Secretary of War Baker, and Admiral Earle, Chief of the Bureau of Ordnance, Navy Department. The Secretary was loud in his praise of the chemists' part in the war, and eloquent when it came to future plans of the great department he represented. Admiral Earle gave concrete illustra-

tions of the problems the chemist had solved for his department. (Their addresses are printed in full in this issue.)

A motion was passed expressing the thanks of the SOCIETY to its distinguished guests, and the hope was expressed that there might be no interruption of the cordial coöperation now existing between the Army and the Navy and the SOCIETY. A hearty demonstration was accorded the motion that a vote of thanks be extended to the local committees whose arrangements for the welfare of the visiting members had been so painstaking and so thorough.

The SOCIETY in general session instructed the Secretary to send telegraphic regrets to Past President T. J. Parker and Treasurer E. G. Love, both of whom were detained by illness. (It is with sincere regret that we record that Dr. Love passed away on September 11.)

At the afternoon session of the General Meeting, five papers of general scientific and technical interest were read. Two of these by Dr. Phelps and Dr. Fischelis are printed in full in this issue. Those by Dr. Bovie and Dr. Harkins will appear in the *Journal of the American Chemical Society*, while Dr. Wheeler's address will be printed in a later issue of THIS JOURNAL.

The presidential address by Dr. Nichols, most appropriately delivered in the beautiful auditorium of the Museum of the University of Pennsylvania, on Thursday evening, was received with serious attention, and Dr. Nichols' hearers felt that his offer of coöperation with the Federation of Labor in the advancement of the progress of research was epoch-making, bearing enormous possibilities for the furtherance of the economic welfare of this nation. Seated with President Nichols and Dr. Miner, the chairman of the meeting, were past presidents of the SOCIETY, Dr. Edgar F. Smith, beloved provost of the University in which we were meeting and historian of the early progress of chemistry in this country, Drs. Harvey W. Wiley, M. T. Bogert, and W. D. Bancroft.

DIVISIONAL MEETINGS

On Thursday morning the smaller rooms, all adjoining the main corridor of the first floor of the hotel, became the centers for the gatherings of the various divisions, for the reading of papers lying more strictly within the field of their particular branches of chemical science. The full program of these divisional meetings is printed on page 985 of this issue. Interest ran high in what the various readers had to offer, and until late on Friday afternoon the gatherings were well attended. The Dye Section, newly formed at the Buffalo Meeting, was obliged to post in its assigned room "Small quarters for this infant section outgrown," and moved to a decidedly larger room on the floor below, where interesting papers and lively discussions ensued. The attention of President Nichols was drawn to the report in one of the newspapers of an undercurrent of sentiment at the meeting opposing the licensing commission feature of the Longworth bill, and Dr. Nichols issued a strong statement refuting the charge, as follows:

The assertion made in New York newspapers that there is an undercurrent of opposition to the license system is entirely without foundation. The chemists of the United States are solidly aligned in favor of the importation of foreign dyes through special license until such time as the dye manufacturers of the United States will be in a position to supply all the special dyes, such as the so-called vat dyes, which may be required.

The American dye manufacturers will undoubtedly be able to meet this demand within 6 months. Meanwhile the manufacturing chemists offer no objection to the importation of such dyes as cannot immediately be furnished to the textile and other industries. It is significant that this report of any opposition to the dye licensing plan should be circulated immediately after the Council of the AMERICAN CHEMICAL SOCIETY had concluded its proceedings and there is no time until 6 months from now for it to officially adopt resolutions refuting this report. This looks very much like the workings of German propaganda, which, all though the war is over, is still as active as ever, and as insidious.

During the course of its sessions the Dye Section unanimously passed the following resolutions:

WHEREAS, The manufacture of dyes from coal tar distillates involves the same general processes and materials used in the manufacture of explosive and poison gases for military use,

Resolved, That the question of the importation of dyes and of intermediates from which they may be made is a military question,

Resolved, That the importation of such dyes, the bases from which dyes are made or the intermediate products produced in the manufacture of such dyes is a menace to the possible future defense of our country, for the reason that such importations foster and support in foreign countries industries which would furnish an enemy with essential munitions of war,

Resolved, That insofar as dyes or intermediates or coal tar distillates are allowed to be imported in time of peace, such importations prevent or discourage the establishment, development and maintenance of an industry that is essential to national defense in time of war,

Resolved, That a copy of these resolutions be submitted at once to the Advisory Committee of the AMERICAN CHEMICAL SOCIETY for such action as in its judgment the circumstances merit, with the suggestion that copies be sent to the President of the United States and the chairmen of appropriate committees of the Congress.

WHEREAS, The American armies were factors in the victorious completion of the Great War vs. Germany, and

WHEREAS, The allied governments are placing corps of skilled chemists to oversee operations in the dyestuff plants in the occupied areas of Germany, and

WHEREAS, The American dyestuff industry is very much in need of any information that can be obtained to assist the development of this industry,

Now, therefore, be it resolved, That it should be brought to the attention of the President of the United States and an urgent request made that we have our share in the operating control of these factories and that we should have qualified representatives stationed there, the information gained to be used for the benefit of American industry.

Be it further resolved, That this tentative resolution be submitted at once to the Committee on National Policy of the AMERICAN CHEMICAL SOCIETY for such action as they think the circumstances merit.

WHEREAS, We find at the head of the laundry list of the Bellevue-Stratford Hotel the following notice: "Owing to dyes now being used, we will not assume any responsibility in the laundering of guests' apparel," and

WHEREAS, We find the similar lack of confidence in American dyes expressed by the department stores,

Now, therefore, be it resolved, That the Dye Section views with great disapproval the expression of any such misleading statements as to the quality of American dyes,

Resolved, That this tentative resolution be submitted at once to the Committee on National Policy of the AMERICAN CHEMICAL SOCIETY for final but prompt action.

The Rubber Division, but recently raised to the status of a division of the SOCIETY, presented a series of papers of a high order of merit.

In the Industrial Division, in addition to a program of more than twenty-five papers, two symposiums were conducted. Dr. A. V. Bleining led the Re-



PRESIDENT AND DIVISIONAL CHAIRMEN OF THE SOCIETY

Seated, Left to Right: W. E. Henderson, L. W. Jones, Wm. H. Nichols, F. B. Carpenter, F. O. Taylor. Standing, Left to Right: H. S. Miner, J. B. Tuttle, R. S. Weston, Chas. L. Reese, W. D. Richardson, I. K. Phelps

fractories Symposium, and the papers presented will appear in a later issue of *THIS JOURNAL*.

The symposium on the proposal that an annual system of patent renewal fees be adopted in the United States brought out some widely differing views, and we have tried to present the discussion as fully as possible on pages 930 to 938.

The Division of Industrial and Engineering Chemistry, the Pharmaceutical Division and the Dye Section, in joint session, unanimously passed the following tentative resolution for final action by the Advisory Committee:

WHEREAS, The National Research Council through its Committee on Patents has made an exhaustive report on present conditions of the United States Patent Office and Patent System and has suggested remedies for present obvious defects and wise provisions for future developments, and

WHEREAS, Such report was adopted by the AMERICAN CHEMICAL SOCIETY as its own, and

WHEREAS, Bills have been introduced into Congress for the purpose of carrying those suggestions into practical effect, *Now, therefore, be it resolved*, That the Division of Industrial and Engineering Chemistry, the Pharmaceutical Division and the Dye Section of the AMERICAN CHEMICAL SOCIETY do hereby unqualifiedly endorse House of Representatives Bill 5011, 66th Congress, 1st Session, being a bill "To establish a Patent and Trade-mark Office independent of any other department and to provide for compensation and infringements of patents in the form of general damages, and for other purposes," and House of Representatives Bill 7010, 66th Congress, 1st

Session, as amended being a bill to increase the force and salaries of the Patent Office, and fully endorses the principle of a single United States Court of Patent Appeals permanently domiciled at Washington, D. C., as embodied in House of Representatives Bill 5012, 66th Congress, 1st Session, being a bill "To establish a United States Court of Patent Appeals and for other purposes," but without expressed opinion as to the best mode of constituting and continuing such a Court. And it is further

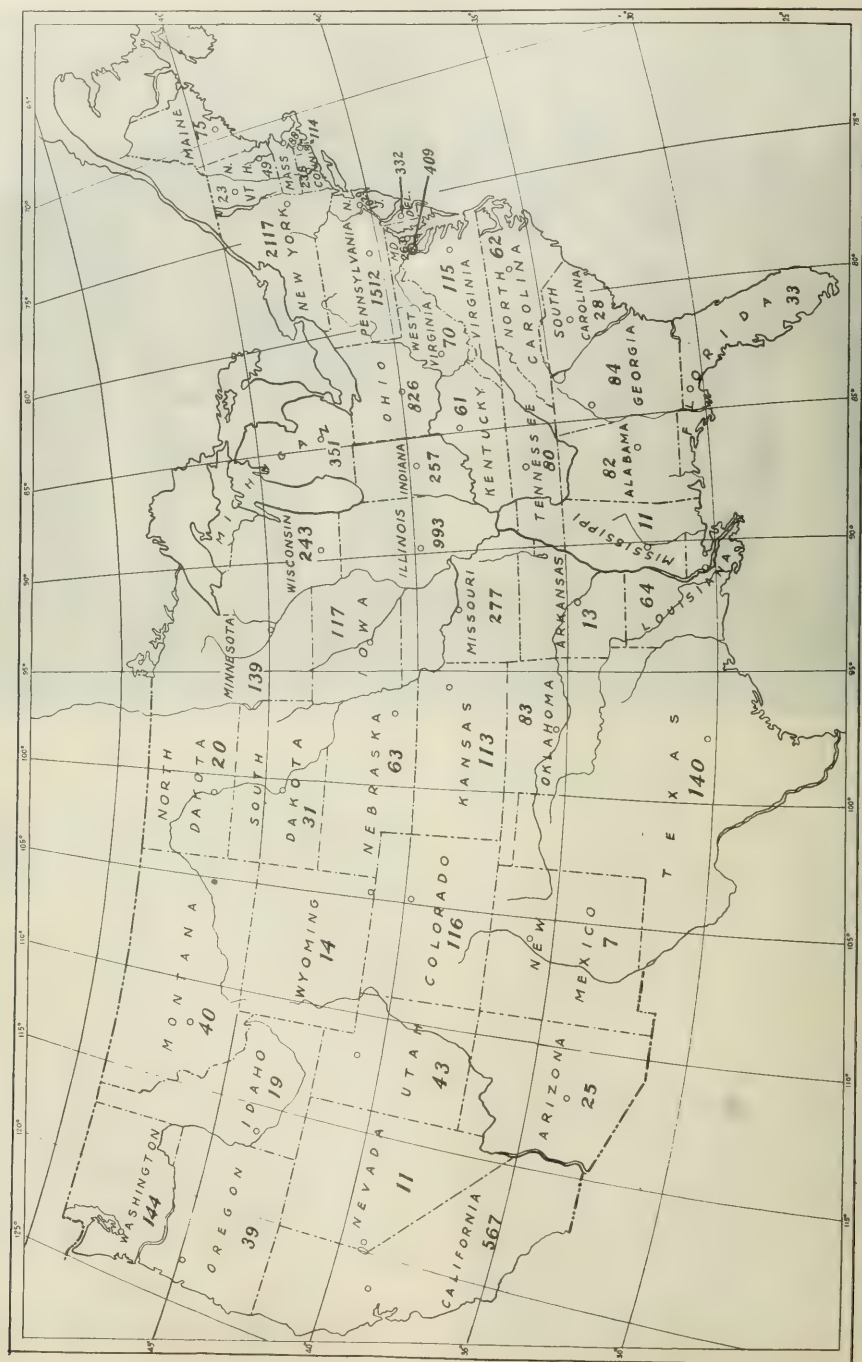
Resolved, That this resolution be submitted at once to the Advisory Committee of the AMERICAN CHEMICAL SOCIETY for such action as in its judgment circumstances merit.

Plans were inaugurated for a new section of the SOCIETY, namely, a Sugar Section. Dr. C. A. Browne was nominated temporary chairman, and Dr. F. J. Bates, secretary. A program of real merit from this section is looked for at the St. Louis Meeting.

Undoubtedly the most discussed paper of the meeting was No. 16 on the program of the Biological Division, by W. D. Bancroft, entitled "Blue Eyes." We suspect, however, that the air of mystery with which this was surrounded had more to do with it than any deep-seated scientific interest in his discussion of the physical and chemical causes of color in one's eyes.

FEATURES OF THE MEETING

On Thursday afternoon, the divisional meetings took a recess in order that their members might join



DISTRIBUTION BY STATES OF MEMBERS OF THE AMERICAN CHEMICAL SOCIETY, SEPTEMBER 1, 1919
RESIDENT IN UNITED STATES: 12,330, FOREIGN MEMBERS: 1286



SOME OF THE MEMBERS OF THE LOCAL COMMITTEE, PHILADELPHIA MEETING

Seated, Left to Right: Wm. C. Carnell, Sydney Davis, Geo. D. Resengarten, *Chairman*, J. H. Graham, A. M. Comey. Standing, Left to Right: W. T. Taggart, Abraham Henwood, Geo. E. Barton, E. F. Hicks, O. L. Shinn, H. S. Miner, Chas. L. Reese, C. C. Tutwiler, Leon Hoffman, Jas. A. Branegan.

the industrial excursions to some of the many factories in or near Philadelphia, where opportunity was afforded to see familiar chemical processes in large-scale operation, with the most modern of machinery and equipment.

The total registered attendance was slightly over 1700, and this number included only 170 residents of Philadelphia and vicinity. It is known that large delegations from local plants came to attend certain meetings, and it is unfortunate that in several cases these groups did not register their attendance. Such being the case, we feel safe in stating that the total attendance neared the two thousand mark.

A new and extremely useful feature, filling a real need, it seems, was the daily publication of *The Catalyst*, the official organ of the Philadelphia and Delaware Sections. This up-to-the-minute news sheet carried notices of any changes in the program of the meeting, a complete registration list from day to day, and bits of information of the sort that are often most elusive at convention gatherings.

It was pleasant to see a large banner of blue and gold, with the SOCIETY'S emblem in the center, floating from a balcony of the hotel, and we suspect that Dr. Rosengarten was responsible for this innovation. On Saturday this same banner flew above the excursion boat which carried our party down the river. It has

been deposited with the Secretary to be loaned for any appropriate occasion.

One of the busiest rooms was the Press and Publicity Room, carried on under the auspices of the Philadelphia Section, and under the direct supervision of Mr. John Walker Harrington. There the representatives of the press were able to secure not only correct abstracts of the papers being presented, but accurate information regarding events of importance and official action being taken by the SOCIETY and its divisions. We congratulate the Committee on the successful manner in which the real meat of the meeting was distributed to the lay and technical press of the country through the leading news associations and through special correspondents who attended the sessions.

SOCIAL HOURS

In arranging for the comfort of the chemists during their scientific deliberations, the local committee, with the energetic Dr. George D. Rosengarten as chairman, had not forgotten that the chemist appreciates and deserves a round of pleasure and relaxation. The Smoker, held at the Scottish Rite Hall, can be reported only from hearsay. We understand that good music, good fellowship, and soothing smokes prevailed, and that there was an interesting and instructive program including the premier exhibition of new

"pen and ink" motion picture films, and an original play, staged by local chemical talent, portraying an early chemists' meeting in Philadelphia. The cast of characters included the well-known Joseph Priestley, Prof. James Woodhouse, Prof. Ben Silliman, and the young student of chemistry, Robert Hare. Philadelphia's venerable statistician, Mr. Edward James Cattell, entertained with a fund of rich humor, the while giving a broad view of Philadelphia's part in the chemical life of America, past and present.



SOME OF THE MEMBERS OF THE LADIES' COMMITTEE, PHILADELPHIA MEETING

Left to Right—Mrs W T Taggart, Mrs A M. Comey, Mrs. Chas L. Reese, M s. Harry F Keller, *Chairman*, Mrs. A. Henwood

The annual banquet took place in the ballroom of the Bellevue-Stratford, with the tables arranged for eight hundred guests. Dr. Harry F. Keller, as toastmaster, called upon Dr. Edgar Smith, Mr. Ellwood Hendrick, Lieutenant Governor Beidleman, Mr. Miner, Mr. Cattell (who had become acquainted with his audience at the smoker), Dr. Reese, Dr. Chandler, and President Nichols for remarks. Dr. Smith spoke lovingly of the life and work of that genius of chemistry, too little known to modern chemists, Robert Hare. A pleasant feature of the evening was the presentation to each guest of a portrait of Robert Hare, and Dr. Edgar F. Smith was presented with the plate from which the reproductions had been made. Mr. Beidleman expressed the conviction that what cannot be produced in America cannot be produced anywhere, and an implicit faith in the ability of the American chemist to bring forth in time what has not already appeared. Mr. Miner and Dr. Reese brought greetings from the Philadelphia and the Delaware Sections, and pledged a loyalty far above the loyalty of any particular section, to the SOCIETY as a whole. That dean of American chemists, Dr. Chandler, was heartily greeted, and as one who has seen its progress through the years, expressed his satisfaction at the present successes of the chemical industry. Mr. Hendrick plead that the chemist put himself in a position to speak with the voice of authority on matters

pertaining to the welfare of his profession and his country. In his inimitable way, Dr. Nichols thanked our hosts for their hospitality and bade his audience carry with them to their local communities the inspirations received at this meeting.

The Research Division, Chemical Warfare Service, took advantage of the presence of so large a number of its members to hold a reunion banquet on Thursday evening, preceding Dr. Nichols' address, at which about 125 were present. Col. George A. Burrell, formerly Chief of the Division, presided, and the guests of honor included Col. Amos A. Fries, formerly Chief of the Chemical Warfare Service, A. E. F., Director Van H. Manning, of the Bureau of Mines, Professor Talbot, of the Consulting Board of the Bureau, Dr. Charles L. Parsons, and Colonel Wm. H. Walker. Mr. Richmond Levering, who has been active in organizing the C. W. S. Post of the American Legion, was the host of the evening. Major General Sibert, detained by official business, sent an appropriate telegraphic message. Director Manning, under whom the entire work of the Division was organized, and who directed activities for over a year, until it was turned over to the War Department, hoped that the lessons learned, particularly the spirit of coöperation developed, would be of practical value to the men in their civilian occupations, and asked continued coöperation with his Bureau in its peace-time problems. Other speakers were Colonel Bancroft, Mrs. W. K. Lewis, James F. Norris, and A. B. Lamb, all of whom laid particular emphasis on the necessity of maintaining the Chemical Warfare Service as a distinct and separate unit of the Army.

Meanwhile, the visiting ladies had enjoyed a series of entertainments and luncheons, under the careful supervision of a group of Philadelphia ladies, of which Mrs. Harry F. Keller was chairman.

The Delaware Section had felt a keen desire to contribute a share to the week's program, and it happily suggested a boat ride down the Delaware River. This gave the eight hundred or more members and friends who accepted the invitation a splendid opportunity to see the industrial development which has taken place along both the Pennsylvania and the New Jersey shores. A glimpse was had of the League Island Navy Yard, and it was our good fortune to be present at the launching of the Steamship "*Sinsinawa*" at the Hog Island shipyards.

Altogether, it was a wonderful week at Philadelphia. The announced purpose of this "peace meeting" was to declare the chemical independence of America. We believe it was done as thoroughly and as sincerely as that earlier declaration which emanated from the City of Brotherly Love, and that it is fraught with untold possibilities for the future of this country. The chemists had celebrated their "victory meeting" at Buffalo, and had received a share of praise for their part in winning the war, now they went soberly and seriously about the business of putting their house in order for the era of intense industrial activity which we all believe is approaching. They had come from all directions with a deeper interest in their profes-

sion and a broader realization of its significance to the country at large, than ever before. Their papers often represented work done before the war, now they presented them in a new light, as a direct contribution to the solution of the great problems of the nation. Expressing our thought graphically, public appreciation of the chemist has taken a sharp rise, and he finds himself on a pinnacle, looking into the future with enthusiasm, and with confidence. If need be, he will fight for the protection, by license and by tariff, of some of his younger enterprises, but he will work to the limit of his ability, that the independence of his science of all foreign domination may be recognized beyond any shadow of a doubt.

PRESIDENT'S ADDRESS RESEARCH AND APPLICATION

By WM. H. NICHOLS

For nearly half a century, it has been the custom in this Society to give its president every year "his day in court," and in conformity therewith many brilliant addresses have been delivered, and almost every conceivable subject has been discussed. It is therefore becoming more and more difficult for the incumbent to select a theme which shall have the merit of novelty, unless, perchance, he is himself working in the laboratory, and can bring forth some new and shining example of the progress of his science. I have not the good fortune to be so situated, and I must perforce satisfy myself with some other line of procedure in the hope that even in a discussion of old and well-known facts, some new light may be thrown, which will not be altogether without value. I have therefore selected for my subject "Research and Application," knowing that many of my hearers have been spending their lives in considering and teaching it, and are far better prepared to instruct me than I am to reciprocate. I would remind such that there is at last a large and growing number of people who are intensely interested in what the chemist has done and is doing, and still more in what he will accomplish in the future. It is therefore rather to that public, many representatives of which are present to-night, than to the chemists in this gathering, that I would address myself.

Research in the distant past was the privilege of the few. In chemistry, during the middle ages, the alchemists were practically the only ones pursuing it, and they in secret, and not always from the highest of motives. Working by themselves, as they did, they had not the great advantage of meeting and discussing with others similarly engaged, and using their progress and mistakes to intensify their own increase in knowledge. Thus it has come about that the science of chemistry is little more than a century old, and its tremendous advances only a few decades. The first chemical society in the world was born in Philadelphia in 1793, and yet the real advances have been made since the formation of this Society in 1876. Since that time, however, the advance in knowledge has been startling, not alone in this country, of course, but in all civilized countries. It is not boasting to say, however, that during all that time, the progress in this country has been in no wise behind that of the best anywhere, which our public is at last beginning to recognize. Particularly during the trying period of the war, when vast and new problems were suddenly thrust upon them, the work of the chemists has been beyond praise.

At the foundation of all this advance, research is firmly imbedded. Without it, the structure could not have risen, or the glowing anticipations of the future even been imagined. Twenty centuries ago, we were told "Seek and ye shall find;

knock and it shall be opened unto you." No one can deny that there have been accidental discoveries, some of great moment; but this has not been and will not be a safe dependence. Walking on the street one day, I picked up a roll of bills, whose owner curiously enough could not be found; but this did not lead me to give up my ordinary occupations, and wander around the streets of New York with the hope of further and continued good fortune of like character. Accidental discoveries are not to be relied on, of course, although they are not to be scorned. In chemistry the accidental good fortunes have usually come to those who were really seeking, although possibly for something different, but, note this, they were usually made by men qualified to recognize an important discovery when it flashed across their vision.

Research, of course, is not of necessity to result in invention. It may in that respect terminate in a *cul-de-sac* from which with present knowledge there is no egress, or what more frequently happens, it may lead to a line of reasoning, which in time leads to another, and so on, until suddenly a bright light illuminates the way, and a goal of the greatest possible importance is attained. Many instances illustrative of this will occur to you. I will cite only one, and that one because of the importance it has assumed in the light of recent developments.

As early as 1882 scientists rigidly established by chemical research what chemists call the "constitution" of the blue vegetable dye, indigo, and clinched that scientific conclusion by preparing the identical material in the laboratory. This particular important addition to human knowledge has remained a discovery merely; yet it so stimulated the search for practicable methods of applying that discovery to human needs that voluminous researches in a number of European countries were undertaken almost at once for that purpose. Of the host of scientific discoveries made as the direct result of chemical research in this direction, one was selected in 1897 as of such promise as to warrant the expectation that it would successfully displace vegetable indigo. Such was the ultimate fact. But, in 1901, others succeeded in devising a commercial mode of making indigo which was so formidable a rival to the mode adopted in 1897 that it seriously and at once threatened the supremacy of the latter, a thing which is now, some eighteen years later, actually coming to pass. It is worth while reflecting that the men who accomplished the scientific work of 1882 themselves never succeeded in making that work anything more than a discovery, despite the fact that for more than fifteen years they energetically tried to do so, and in their efforts they had the close coöperation of a large commercial organization. However, it remained for a college professor of chemistry in another country, himself working in quite a different field, and as a direct result of that work, to hit upon the central idea of the successful indigo mode of 1897 and to clinch it by appropriate laboratory methods. Yet his work remained for almost seven years a discovery only—a promising discovery to be sure—until the intensive work of others, overcoming many obstacles, made it serviceable to mankind. These two sets of workers were engaged in the same general class of chemical research, that is, they were working in the organic division of chemistry. As you know, chemistry is serviceably, even though crudely, grouped under two grand divisions, organic and inorganic, and for many years these were treated quite separately from each other; I know "organic" chemists who look with mild indulgence upon the "inorganic" chemists, and I also know inorganic chemists who return the compliment—with interest. In 1901, however, one of these so-called inorganic chemists in searching for new worlds to conquer, hit upon an idea which he thought would make one of the discarded and discredited methods of making indigo a worthy rival of the only commercially successful indigo method

of that day. And he was right! The owners of the 1897 method were forced to look to their laurels.

The history of the synthetic production of indigo is filled with many different discoveries of how indigo may be made in the laboratory, most of them wholly unrelated to the methods of 1882, 1897, and 1901. Two, at least, of them have made an unsuccessful and short-lived attempt to grow into an invention capable of meeting competitive conditions. Now, it is curious to note that the 1901 method was an offspring of the cyanide method of extracting gold which in turn is the gold-extraction method that made the South African gold fields so valuable. Immense amounts of that deadly poison, sodium cyanide, were needed in preparation for this gold extraction; that, in turn, called for unusually large amounts of other things and among these was that particular inorganic material that gave competitive ability in the world's markets to one of the theretofore discarded indigo methods. From gold the fields of South Africa to synthetic indigo is, indeed, a long cry. Is it, therefore, not wholly reasonable to expect that from some other equally far-off branch of chemical industry or of chemical research may come the proper stimulus to bring to active competitive life some of these other discarded indigo methods or even to create new methods superior to any we know of to-day? Among chemists we also distinguish physical chemists who are curious about subjects in that great twilight zone between the field of chemistry on the one hand and of physics on the other; also we have the electrochemist who is always searching for more or less direct chemical applications of the electric current. Just as the inorganic chemist in 1901 taught the organic chemist the secret of endowing a discarded indigo method with competitive life, may we not reasonably expect that some day the physical chemist and the electrochemist may, one or both, in the course of wholly unrelated chemical research work, come across facts which when intelligently applied to the indigo problem may still further advance it?

The chemical knowledge and research that enter into the synthetic production of indigo, as we know it to-day, come from over three generations of chemists, scattered all over the globe, speaking many languages, researching on many different and separate problems which touch almost every phase of human endeavor, and the end is not yet.

For centuries indigo has been the undisputed king among dyes. Chemists have made many attempts to displace it by other dyes but it has so far successfully withstood all such attacks upon it—except as to its source or origin. Indigo is still the king, but its supremacy is threatened and threatened seriously, and its undoing, if that should ensue, is traceable directly to itself. Chemists have long felt sure that the true reason for the supremacy of indigo lay in the manner in which it dyes fabric. It possesses the unique faculty of being, what you have all so often read of in the daily papers, a "vat" dye. It is the pioneer vat dye and until comparatively recently it was the only vat dye. Vain attempts to create or imitate this vat dyeing property in other dyes are recorded by the score in the history of coal-tar dyes. But, about twenty years ago, a real vat dye was constructed in a research laboratory which ultimately turned out to have an entirely different constitution from indigo. This supplied the key to an entirely new class of dyes. Although among the multitude of "vat" dyes constructed along these new lines many are wholly worthless, there are, nevertheless, a goodly number of them having all the desired advantages of indigo, and others equally numerous, possessing highly prized advantages which indigo lacks. All of these good ones are free from certain disadvantages of indigo and, what is more important, their shades cover every tint of the rainbow satisfactorily except the reds, and those cannot much longer elude the searchers. Some day a new blue dye may result from these researches or from other researches grow-

ing out of them and indigo will no longer be king. In still other directions the chemical study of indigo has been fruitful. By proceeding along lines similar to those of the 1897 method, but displacing the nitrogen by sulfur, an entirely new line of materials has been made accessible through chemical research, and no man is wise enough to place the limit upon the directions and the extent that chemical ingenuity and research will ultimately go in this one very small field of chemical effort, which requires and draws upon all the sources of chemical knowledge we have. The possibilities seem limitless.

A PLEA FOR TEACHERS

True research must be intentional and intensive. We must really seek if we would find. We must really knock at the doors of the secret chambers of knowledge, if they are to be opened to us. We must have imagination, it is true, but we must have more than that. There must be the foundation of sound education, and the ability to extend it to embrace new and unexpected knowledge, and apply this in turn as we progress upwards.

To fit a man for research in chemistry or in any other science, many things must be accomplished before the candidate is ready to take his first advanced step. Many methods of procedure have been suggested, and some heat of argument generated, but all agree that education which produces real practical knowledge is absolutely essential. All agree, also, that the person to be prepared must be a likely subject; and that energy and time should not be wasted on those who do not show that they possess certain necessary qualifications. I think that it will also be generally admitted that the teacher himself should not only have great attainments, but must also possess the rare quality of being able to transmit knowledge in such a way that it will be truly absorbed by the pupil and form part of him. One of the greatest mathematicians I have ever known was about the poorest teacher. He knew but could not impart. The future of the world, therefore, depends in a very large degree on the teacher in the school and on the professor in the college. They have an opportunity to mold the world, which many of them thoroughly appreciate. Alas, in most instances, the consciousness of work well done is about their only reward. Some day, and I hope not a very distant one, it will be generally recognized that, like other laborers, they are worthy of their hire, and their compensation will more nearly approximate the value of the work done. When that happy day arrives, they may experience a little less of the satisfaction of sacrifice, but they will have other comforts and hopes which will more than make this up to them and to their families. Like others before me, I advise the people of this country that they can make no better investment than one liberal enough to cause the teaching profession to attract not only those whose high sense of duty leads them to embrace it at a sacrifice, but also those who cannot afford to make the sacrifice, however anxious they may be to do so. Men preparing for research must have the best men in the country to guide them, and it is not fair to expect these men, as so many have done in the past, to live the narrowing life of poverty. Neither is it wise.

There are a few foundations specifically provided for chemical research, such as the Warren Fund of the American Academy of Arts and Sciences, the C. M. Warren Fund of Harvard University, and the Wolcott Gibbs Fund of the National Academy of Sciences. There are a number of foundations for promoting research generally which have included chemical research within their fields, such as the Bache Fund of the National Academy of Sciences and the Elizabeth Thompson Science Fund. The Rockefeller Institute for Medical Research fosters chemical research contributory to its main ob-

ject and the Carnegie Institution of Washington supports chemical research in its general policy of advancing knowledge through research. The newest of all is the fund recently placed at the disposal of the National Research Council for stimulating chemical research. There is need for many more foundations if we are to keep pace with the rapid strides of civilization, or better still, to determine the direction they will take.

The importance of research is being more and more recognized and understood by the public. One of the most encouraging evidences of this is shown in the preamble and resolution adopted recently by the American Federation of Labor at Atlantic City, indicating, as these do, a clear appreciation by that great association of how much we all depend on what science will disclose to ameliorate the conditions of the future. It is well worth while to read these in full here:

WHEREAS, Scientific research and the technical application of results of research form a fundamental basis upon which the development of our industries, manufacturing, agriculture, mining, and others must rest; and

WHEREAS, The productivity of industry is greatly increased by the technical application of the results of scientific research in physics, chemistry, biology, and geology, in engineering and agriculture, and in the related sciences; and the health and well-being, not only of the workers but of the whole population as well, are dependent upon advances in medicine and sanitation; so that the value of scientific advancement to the welfare of the nation is many times greater than the cost of the necessary research; and

WHEREAS, The increased productivity of industry resulting from scientific research is a most potent factor in the ever-increasing struggle of the workers to raise their standards of living, and the importance of this factor must steadily increase since there is a limit beyond which the average standard of living of the whole population cannot progress by the usual methods of re-adjustment, which limit can be raised only by research and the utilization of the results of research in industry; and

WHEREAS, There are numerous important and pressing problems of administration and regulation now faced by federal, state, and local governments, the wise solution of which depends upon scientific and technical research; and

WHEREAS, The war has brought home to all the nations engaged in it the overwhelming importance of science and technology to national welfare, whether in war or in peace, and not only is private initiative attempting to organize far-reaching research in these fields on a national scale, but in several countries governmental participation and support of such undertaking are already active;

Therefore be it resolved, By the American Federation of Labor in convention assembled, that a broad program of scientific and technical research is of major importance to the national welfare and should be fostered in every way by the Federal Government, and that the activities of the Government itself in such research should be adequately and generously supported in order that the work may be greatly strengthened and extended; and the Secretary of the Federation is instructed to transmit copies of this resolution to the President of the United States, to the President *pro tempore* of the Senate, and to the Speaker of the House of Representatives.

I hope and believe that this matter coming as it does from a new direction will be most seriously considered by the proper authorities—not that it has not already been well understood in Washington, but that renewed interest may be taken and even more liberal appropriations granted. The Federation resolution urges that "a broad program of scientific and technical research is of major importance to the national welfare." Good! Now that everybody is agreed, how was it possible that for so long a time this belief was held by so few, and these composed almost entirely of men of science? The question, therefore, is squarely before the country, and the urgency of it thoroughly appreciated by those who have the most to gain by it, namely, the workers on whose efficiency so much depends. Now this opens the way to a scientific solution of vital questions about which there have been such fundamental differences of opinion, based largely on what may

be called the point of view. People have divided themselves into classes—a very dangerous course—and many, a very great many, have actually believed that there must of necessity be a deeply rooted difference between capital and labor, and that the true interests of either were entirely apart from those of the other. Many have held that labor is a commodity which it was to their best interest to get the most of for the least money, while many others believed that labor was the sole source of all wealth, and that the fewer hours worked, and the smaller the output of those hours, the better it would be, somehow or another, for the laboring classes. I have cited the extreme views for purposes of illustration, realizing that somewhere between the two would be found the great body of all reasonable and thoughtful men. We may leave out of consideration here that ultra-extreme class who teach, whether they believe it or not, that the true interests of labor would be best served by sabotage and syndicalism, and all the other fantastic notions which have of late years been more or less in evidence, and liable to catch the unwary. To these, research presents no attractions.

AN OFFER TO LABOR

Now I am going to venture to suggest to the working man, who is earnestly desirous of bettering his own and his family's condition, that there are a good many sciences besides chemistry and the engineering and abstract sciences in general. Some of these he is better able to study and practice than any one else. Many of the fundamental truths concerning labor and its conditions would never be discovered by the scientist *per se*, because he has not had the benefit of practical preparation. Let our friends of the American Federation of Labor not be content with what the Government can do in the line of their resolution, good as it has been and will be, but let them start a carefully planned series of researches themselves, and follow them up until the truth stands revealed. They can depend upon the assistance of this great SOCIETY. The employers of labor have been doing this for years, singly and in groups, seeking the same end. The shining goal of all research is the truth, the whole truth, and nothing but the truth. Thus, starting from different angles, with fairness and thoroughness, the various so-called interests will arrive at the same truth, for there can be only one truth concerning any question. Thus will it come to pass that capital and labor will discover that the true interest of one is the true interest of all, and instead of bickerings and suspicions we will have that cordial cooperation which is absolutely essential if we would get the best out of this good old world of ours.

Scientific discovery is really not a haphazard matter. The art of making it can be cultivated, and definite rules of research can be laid down. Many elements enter into the problem, and these have been very well tabulated by the late Dr. Gore, F.R.S., in his book, "The Art of Scientific Discovery." While the list he gives may not be complete, it is so nearly so that it is well worth quoting here. His table is as follows:

- 1—Aid to analogy
- 2—Hypotheses
- 3—Analysis and synthesis
- 4—Application of (a) Electricity to bodies; (b) Heat to substances
- 5—Asking questions and testing such questions
- 6—Assumptions that:
 - (a) There is certainty of all the great principles of science
 - (b) Complete homologous series exist
 - (c) Converse principles of action exist
 - (d) Certain general statements which are true of one force or substance are true to some extent of others
- 7—Combined action of many observers
- 8—Comparisons of:
 - (a) Facts, and collecting similar ones
 - (b) Collections of facts with each other
 - (c) The orders of collections of facts
 - (d) Facts with hypotheses

- 9—Deducting process
- 10—Employment of new or improved means of observation
- 11—Examination of
 - (a) Common but neglected substances
 - (b) Effects of forces on substances
 - (c) Effects of contact on substances
 - (d) Effects of extreme degrees of force
 - (e) Extreme or conspicuous instances
 - (f) Influence of time upon phenomena
 - (g) Neglected truths and hypotheses
 - (h) Peculiar minerals
 - (i) Unexpected truths
 - (j) Rare substances
 - (k) Residue phenomena
 - (l) Residues of manufacture
 - (m) The ashes of rare plants and animals
- 12—Extension of:
 - (a) The researches of others
 - (b) The researches of neglected parts of science
- 13—Inductive process
- 14—Investigations of:
 - (a) Exceptional cases
 - (b) Unexplained phenomena
 - (c) Classification unexplained
- 15—Means of:
 - (a) Converse experiments
 - (b) Hypotheses
 - (c) Homologous series
 - (d) Instruments of great power
 - (e) Improved methods of intellectual operation
 - (f) Measurements
 - (g) The method of curves
 - (h) The method of least squares
 - (i) The method of means
 - (j) The method of residues
 - (k) New instruments
 - (l) Modes of observation
 - (m) Observations
 - (n) More intelligent and acute observation
 - (o) Additional observations by known methods
 - (p) Periodic functions
 - (q) More refined methods of working
 - (r) Repetition of experiments
- 16—Simple comparisons of facts of phenomena
- 17—Search for:
 - (a) So-called "impossible" things
 - (b) One thing and finding another
- 18—Subjecting series of forces or substances to new conditions
- 19—Use of:
 - (a) Known instruments or forces in a new way
 - (b) Improved instruments
 - (c) More powerful instruments
 - (d) Causes by the methods of averages
 - (e) Coincidences
- 20—Conditions of:
 - (a) Scientific discovery
 - (b) Determination of the nature of a discovery contrasted with barren reasoning
- 21—Dependence of discovery upon art of exceptional instances
- 22—Fundamental laws of discovery

Research does not always lead to discovery, nor discovery to invention, but the sequence is logical. Gore defines the difference between discovery and invention in these words: "Discovery consists in finding new truths of nature, while invention consists in applying those truths to some desired purpose;" and that definition is sufficiently accurate. The natural application of research is therefore invention. How can this application and its corollaries best be carried out?

The concrete application of a truth is of course necessary for its widest usefulness. There are various theories as to the best way of accomplishing this. Take our old friend Wackford Squeers, for instance, a highly interesting character in one of Dickens' best books:

"This is the first class in English spelling and philosophy, Nickleby. Now then, where's the first boy?"

"Please, sir, he's cleaning the back parlour window," said the temporary head of the philosophical class.

"So he is, to be sure," rejoined Squeers. "We go upon the practical mode of teaching, Nickleby; the regular education system. C-I-e-a-n, clean; verb, active, to make bright, to scour. W-i-n, win, d-e-r, der, winder, a casement. When the boy

knows this out of a book, he goes and does it. It's just the same principle as the rule of globes. Where's the second boy?"

"Please, sir, he's weeding the garden," replied a small voice.

"To be sure," said Squeers, by no means disconcerted. "So he is. B-o-t, bot, t-i-n, tin, bottin, n-e-y, ney, bottiney; noun, substantive; when he has learned that bottiney means a knowledge of plants, he goes and knows 'em. That's our system, Nickleby; what do you think of it?"

During the intense pressure of recent years, this Squeers system has had a good trial, and seems to have left more or less to be desired. The taxpayer knows the sequel, and will be reminded of it from time to time for the rest of his life.

The application of research has always required a high order of talent. In the future a still higher order of talent will be necessary, but in addition this talent must be prepared by education to do this very thing. Sir Robert Hadfield, F.R.S., has said, after England had been struggling with belated preparation for nearly two years:

Until quite recently many mistakes were made, either because the scientific man had been installed in view of his special knowledge, or, at the other end of the scale, the practical man was given the preference. In a general way neither of these types has been a success.

Admitting Sir Robert's conclusion, how can we produce the leaders who shall adequately combine both qualifications? That is one of the greatest and most interesting problems awaiting solution by our educators, and on its correct solution depends in a larger degree than many imagine, the future of successful and contented industry in this country. I shall not attempt, in the presence of so many educators of acknowledged ability to show the way, even if I felt persuaded that I knew it, as the matter is of too great consequence to run the risk of an amateur indicating the wrong road. I shall content myself by pointing out the need, with the hope of turning the attention of the great public to its existence. In our free country, the people generally get what they really want, and it is worth while to lead them to want the greater things, and not to be satisfied with the lesser.

There are certain fundamentals, however, that all will agree to, if it be true that the leaders of the future will have far greater problems to solve than have yet been conceived.

(1) The candidate for leadership should have a healthy body. Great things have been accomplished by men and women of fragile physique, but they would have accomplished greater if they had not been thus handicapped.

(2) He should have good habits, which involves good character. This is vital if we would have leaders who would be a blessing and not a curse. We can easily call to mind men of splendid health and intellect who used these gifts to the injury of their fellows, and not to their advantage. Do not waste time or energy in educating for leadership a man of bad or doubtful character or whose aims are selfish.

(3) Of course he should have a good mind, educated to the highest degree attainable. This education should be specialized in the desired direction, while good all around. No really great leader can be lop-sided if he would avoid being a "crank."

(4) He should have a thorough knowledge of human nature. To play on the "harp of a thousand strings" requires an unusual acquaintance with the instrument. How many men otherwise great have broken down here, sometimes because they have given too much confidence, sometimes not enough, sometimes because they did not know how to select assistants. The knowledge of human nature is a great gift in itself, which can be acquired and increased. It lies at the foundation of wisdom, which King Solomon pronounced the "principal thing."

With the qualifications enumerated and others which will occur to you, the candidate for leadership is well equipped. To direct him to full fruition is a noble task. Let us proceed

to fill our high places of every kind with men and women specifically prepared to fill them, being assured that the effort to do so will produce an army of those not quite qualified for the top, but of the greatest value to assist those who are, and who without such aid would resemble "faith without works," which, we are told, is "dead being alone."

Research leads to discovery. Discovery to invention. Invention—no one knows where. Applied and supervised by those prepared for the task, the strides of progress will be long, and the benefit to the human race in proportion. Let us educate for living, certainly—but let us also educate for leadership—that superlative leadership of which civilization will stand more and more in need, as it increases in complexity, and reaches higher and higher planes.

CHEMISTRY IN WARFARE

By NEWTON D. BAKER, Secretary of War

I am here, Mr. President, obviously not because I can make any helpful contribution to the great scientific subjects which engage the attention of this group of men. I suppose there is scarcely anybody who would be less competent to discuss even the most elementary chemical problems than I. I am here because the Government of the United States, and particularly the War Department, owes a debt of gratitude and appreciation to the chemists of the United States, to which I want to give the most formal public expression.

There are, I am told, some seventeen thousand chemists in the United States. Practically one-third of all the chemists of the United States were directly in the Government Service during the recent war. One-third of them were engaged in essential war industries, and the remaining one-third, outside of those who were attached to colleges (and even they were busy about war work), were all engaged in war work at home, of one kind and another, so that while comparisons are impossible in a great national mobilization of the sort we have had in which every art and every profession and every craft was appealed to, and responded with unanimity and patriotic zeal—while comparisons are impossible, I do not believe it will be discovered that any profession contributed a larger per cent of its members directly to the military service, or the results of the activities of any profession were more essential to our national success than that of the chemists.

I am aware this war has shown some very remarkable illustrations of "group contributions." Perhaps the doctors, taken as a class, made as great a contribution to our success in war as any others. This is the first war in which America has been engaged—and, indeed, I think it is the first war in which any civilized nation has engaged—in which deaths from disease are less numerous than deaths from battle wounds. Those of you who are familiar with Tolstoy's "War and Peace," or have read the story of Florence Nightingale, and know what the camp-bred diseases did to armies one hundred years ago—those of you who are familiar with the fact that ordinarily, until quite recently, the relative rate of mortality from disease, as compared with battle wounds, was five to one, will realize what enormous advance has been made by the medical profession, which is at least "first-cousin" to your own science, in the prevention and cure of disease.

In the Spanish War and Japanese-Russian War, the contending sides, leaving out Spain (the mortality in whose armies I do not happen to know)—the Japanese, in their war with Russia, and we, in our war with Spain, brought the disease rate about on a par; but in this war, had it not been for the wholly unexpected and unpredictable epidemic of influenza, which affected civilian life as well as the military, battle deaths would have been higher by two or three to one, than disease fatalities. That was due to the fact not only that medical science has made giant strides in the last ten or fifteen years, but to the fact that

in the medical profession, as in the chemical profession, the masters of that art, the greatest surgeons and the greatest physicians, left their hospitals and their practices, left their private business just as you left your laboratories and industrial institutions, put on the uniform of the Army of the United States, threw aside the tunic or gown of the student, put on the uniform, and went wherever the call of duty was—from the front-line trenches to the home front—in an effort to serve the nation and its cause.

The CHEMICAL SOCIETY presented a striking instance of preparedness. I am told by the newspapers, that one of the very large number of investigating committees of Congress has discovered that the Council of National Defense and the War Department were busy about the mobilization of America actually before war was declared, and that is regarded as a very serious indictment. I think I had better plead guilty. The proof will overwhelm me if I don't. But when the National Council of Defense was formed, it grew out of an idea—I think of Mr. Howard Coffin—that there ought to be somewhere in the United States a schedule of the industries of the United States, and of their capacity, and the facility with which they could be transformed from one form of production to another; to that idea was added one by Hollis Godfrey, who lives here in Philadelphia. Dr. Godfrey's idea was, there ought to be a tabulation and schedulization of the talent of the country; that we ought to know how many chemists there are and what kind of chemists, whether research men or engineers in chemistry; we ought to know how many physicists there are, how many could be used in sound ranging and experimentation; there ought to be an index of the leaders of thought in America. Those two ideas, I think, were the germinal ideas from which the National Council of Defense was formed, and when Congress authorized that group to get together, as the National Council of Defense, it was long anterior to our entry into the European War. Its first business was to prosecute to an end those two inquiries, so that we did have in Washington a catalogue of industries, their location and their availability by transformation from one form of production to another, and the materials on which they were obliged to rely, the substitute materials which could be used in the event of certain raw materials becoming unavailable for one reason or another, and we began to have a more or less comprehensive index of the trained minds of America. That became vastly important during the war, but we found to our very great surprise that very few of the professions of the country were integrated in any such manner that would make them available for rapid mobilization and use. The doctors, for instance, were remobilized by Dr. Franklin Martin and his associates and an entirely new classification was made of them. It was speedily done; adequately done.

SOCIETY WAS READY

But when we came to the chemical science we found that the AMERICAN CHEMICAL SOCIETY certainly had the largest body of its kind in the world and comprised in its ranks 14,500 of the total 17,000 chemists of the country, and when the country's call went out for chemists, the coöperation of this SOCIETY was a splendid substitute for any preparation the Government had to make, and almost instantly the Government was able to put its hand on the man who was needed for the particular job, to call him into Washington or service wherever he might be needed, or wherever might be needed an adequate group of properly prepared men to undertake the solution of any problem, so that your SOCIETY was by its very existence anticipatory of the calling into being of the forces to collect these data, and the Government owes to this SOCIETY, therefore, a debt of gratitude for this closeness of association and intimate knowledge of the profession, which it was able to place at the Government's disposal and thereby to render a chemical knowledge of the country speedily available.

I might go on through the work done by the chemists of this country and enumerate outstanding achievements which they accomplished in the war, and yet these must be better known to you than to me: the work of the Chemical Warfare Section of the Army, the devising and inventing of new gases for offensive warfare; the more effective preparation of charcoal for use in gas masks for defensive warfare; the association of chemists with the Bureau of Standards and other government agencies in working out non-inflammable dope for aeroplanes; the production of synthetic phenol—I have not struck in every instance the most important contributions, but from the beginning of our entrance into the war, until the end of it, the chemical mind was at the highest tension and was emitting sparks of great luminosity to the very end, with rapidity and with success, and although we were in the war relatively a brief time, there has already been written a substantial volume which I think has been called "The History of the First Chemical Regiment," which tells of the successes of an American regiment organized as a chemical fighting unit with flame projectors and gas throwers and all the other paraphernalia of this modern war, operating effectively and contributing to the victory on the Western front.

The chemists did their share. They did it superbly. No tribute which I can pay to them would be too high and yet I want to look just a little at the future as the main point of emphasis in the remarks I am making to you this morning. We have learned some things now about war. War has changed, both quantitatively and qualitatively. It has changed qualitatively, as suggested by Dr. Nichols, in the introduction of the aeroplane, submarine and chemical war instruments. Quantitatively, it has changed in the size of the masses engaged in war. I suppose when men fought who had to go to battle on the backs of elephants and camels, relatively small groups could go: somewhat larger, however, than when they had to walk. When the elephant and camel gave place to the fleet horse, and horse-drawn vehicle, with the rotary motion of the wheel, larger numbers could go; when we had the steam locomotive with the fixed track, that enabled us to mobilize still larger numbers, but now that we have electric traction and have added together this new and those old methods of transportation, the limits have been taken off, and in this war we have had the great civilized nations dealing in units of millions of men instead of units of tens of thousands of men. If the degree of progress needs any illustration one has but to compare what seemed the magnificent armies that contended on the field of Gettysburg with the armies which occupied the Western front, from the British Channel to the Swiss Frontier—we must substitute millions for tens of thousands.

I saw a picture not very long ago which illustrated the quantitative changes of war. This picture illustrated a 3-inch gun being fired by ten men, and back of it, for the purposes of contrast, was pictured a factory with its employees numbering 300, outside at the mid-day recreation, I suppose, and the legend underneath the picture stated: "It requires a factory of this size and this many employees, working continuously, to keep that gun firing continuously." One gun and ten operatives kept going by 300 production operatives and a factory. Now, as we brought the world into this mobilized condition, as millions of men marched up and down the earth in uniform and as troops were conveyed across the seas, the system and service of supply back of all this required, of course, corresponding anticipation, and probably there is no feature of General Pershing's great work outstanding more prominently than that he had the imagination and foresight to see ahead the sort of service that was necessary to maintain all this, to put into being the things that would bring about all this—the building of docks and facilities of all sorts, railroads, the sending over of cars and engines, the creation on a white sheet of paper in France of a large specimen

of America's industrial capacity. Yet all that was a part of the fighting front, and back here at home the nation had to be mobilized just as intensely, until really our mobilization for this war ran from the trenches in France to the remotest farm in the United States, and thus the character of modern warfare qualitatively considered is such that if in the future there is a war in which the United States is engaged there must be a mobilization, first, of the man power; second, the money power; and third, the means power of the people.

NECESSITY OF CONTINUED MOBILIZATION OF NATION

We have learned in this country that when we come to the mobilization of our man power, the United States accepts as axiomatic the application of the democratic principle of selection by compulsion of the Government and assignment of the individual to the task rather than an election of the individual of his choice in the national defense. I think we will accept that not only because it is obviously fairer, but because it is the only plan by which an effective mobilization of the man power of the nation can take place. If we had allowed the chemists, for instance, in this war to follow their own bent, they would have been in the front line trenches, with guns in their hands; but it was necessary for us to have the interest of the whole people in view so that we could say, "Your duty is where you don't want it to be—with a test tube in the laboratory, and not with a gun in Flanders."

The mobilization of the financial power of the United States has been rendered very much more possible in recent years by the adoption of a national system of banking in our country from which we think now we will never depart because national interest requires national control—our business life depends on it, as well as the safety of the nation in time of crisis.

Man power and money power seem to lead up to "means power"—the mobilization of the facilities of the nation, the mobilization of its brains on one side and its wheels on the other; the mobilization of its raw materials and the means of converting them into the finished product; the way of bringing back of the nation the concentrated industrial capacity of the nation which must always hereafter be an element of the forethought of those who have in mind the possibility of a great national crisis of the kind through which we have just passed. I share Dr. Nichols' hope expressed a little while ago—this is the city of the Quakers and surely this is a proper place to have emotions and sentiments of that kind—every place should have it. I assure you that I share his hope that mankind will never be called upon to mount the altar of sacrifice in the fashion it did in the last three years. I think no other thing is so important to be done; nothing else is so worth while; nothing so moral; no duty calls with such insistent demand, as to do all we can with heads, and hearts and hands, to make a just peace permanent throughout the world.

I have been on battlefields; I know what war means. I have been in hospitals—I go to them yet—filled with the wreckage of this war; and when you think this is but a sample, and count up the cost of this war—nine or ten million men in the flower of their youth, the strongest, the most virile out of all the most civilized nations of the earth, *dead*; when you count the orphanage and widowhood, the withdrawal of that vast energy from the productive forces of civilization; when you think of the waste of only the material side, the amount they spent in money, two hundred thousand million dollars—and if you try to get some idea of what that is, you look in the world almanac and find the total value of the United States—of all the real and personal property in it, all the houses and all the lands and all improvements thereon since they took it from the Indians, telegraphs, jewelry and money, all of it added together amounts to one hundred and eighty-six thousand million dollars—when we think of these things we are filled with amazement. We have paid, not with king's ransom, but with the price of civil-

lization and we have wasted a heritage greater in value than the aggregate value of the greatest country that ever existed on the face of the earth. I assure you I share Dr. Nichols' hope, and I share it most fervently, that we will never again be called upon to throw down that kind of gauge in battle. But I had that hope before the last war. When I was told Austria had declared war on Serbia, and Germany had declared war on Russia, and Russia had declared war on Germany, and Austria, and France had declared war—I said it can't be; it is impossible; that sort of loss of head might happen in an institution for sickly people, but great civilizations can't go mad over night and bring that sort of destruction on the world. I don't know whether it is possible in the future or not, but I do know that there are some things worse than going to war; there are some elements of civilization which it is better to fight for than to lose, and if the price of human liberty, the cost of perfecting our civilization, of having the freedom of spirit our democracy gives, the elevation of the soul we have long known—if the price of the preservation of this is another war, I am ready.

In any event, in the present state of mankind, it is important that we should be aware of that possibility and take those forward looking steps which, if the emergency ever comes, will enable us to do two things: first, focus our power quickly and effectively for the accomplishment of our end; and second, so wage war that we will do it with the least loss of life to the men whose lot it is to take rifle in hand and occupy the front line trenches. Therefore, it is highly important for us to bring about those arrangements which will enable mobilization of the "means power" speedily to be made.

NEW SYSTEM OF ARMY EDUCATION

We are undertaking now in the Army completely to transform the system of education in the Army. Only yesterday I was present at the opening of what is known, or what is to be known, as the "Staff College" of the Army. The old War College was a somewhat composite and many functioned institution; it has passed out of existence and the "Staff College" takes its place; it presides at the top and under it are the schools at Leavenworth, Fort Monroe, etc., where proficiency in the special branches of the Army is taught and under them come West Point and schools in which many of you are professors, the technical universities out of which young men come into the Army with the gifts you have given them. Our system of schools is to further educate them and to coordinate the education which they bring to the new purpose to which it may have to be put.

We are planning education in the Army itself so that in the future the Army of the United States will not be one hundred thousand or two hundred thousand men who have enlisted because they had fallen out of temper with the adjustment of things at home, and were not perfectly able to get along with their old neighbors, or some other cause of that sort. Rather the object is that a young man may come into the Army to get an education, and the Army itself, instead of being a mere disciplinary institution will be a useful agency, adding to the popular schooling of the people of the country, and turning men back to civilian life after they have finished their period of enlistment with crafts and callings which enable them to be more useful citizens in their communities. Your president has offered to have some lectures made at West Point by eminent chemists. I have insisted that he himself give the first lecture. We have established at Camp Humphreys, outside of Washington, a great Engineering School—you must not tell anybody, but the plans for that group of buildings comprise an ultimate cost of probably twenty-five million dollars. Congress won't do that if you tell them how much it is going to cost. That institution is to have, not merely the training school for engineers—and by engineers I do not mean civil engineers, but chemical engineers and civil engineers, all the men who constitute the bridge by which abstract science is put into practical use—not merely a training school for

engineers, but alongside of it and as part of it, a great research institution, in which the best brains of the Army and Navy, by invitation, will be operating to make fresh application of scientific discoveries to war uses and adaptations, and to which the chemists and physicists and engineers of the country will be invited to come as guests of the nation, in order that they may pool their learning to devise other modes of warfare against the time of emergency. It means an interchange of views between the scientists and the military men, so that if the hot breath of war does come sometime again and we are summoned once more to mobilize the man power, the money power and the means power, it will be available and ready for use, and the demonstration of the virility of democracy will be even more superb than the one we have just given.

This has been stupendous, gentlemen,—stupendous for the United States. Many of us now are in a questioning mood. The artist, after he has painted a picture, always has a moment of relaxed energy and disillusionment. No picture that ever was put on canvas was as exquisite as the dream of the artist and so, now when the intensity of our effort is past, when this fierce concentration upon a single set of ideals and single objective has been withdrawn, we are placid and sometimes flabby in our relaxation, and are doubtful and questioning as to what the present is, and what the future will be. But this war teaches us what the present is and what the future will be. A nation which was able in a year and a half to build the greatest army the world ever saw—and I speak no words of idle, unthinking compliment of that army—it was the soberest, sanest and least criminal aggregation of men of its size that ever stood together on this planet—a nation which has gone through that experience has learned some potent and saving lessons for its future.

Just a word of illustration: The chief scientist of the American Army was called upon to make a census of the hospitals in France, in which over 200,000 American soldiers were, to discover the characteristics of certain epidemics among the men, and he found not a single soldier in a hospital due to delirium tremens—not one out of two million men. There was a lower percentage of suicides, a lower percentage of insanity and a lower percentage of crime in the American Army and American Expeditionary Force, by actual figure, than has ever been true of any army in any country or of any equal civilian population of our own country. A country which has gathered such an army together and sent it over-seas; which has responded with such success to its scientific and material problems; a country that so adequately clothed and equipped and maintained its men and had its army singing as it marched to victory in defense of ideals which were totally devoid of any tarnishing by selfish aims, shows an undiminished virility and vigor which makes us confident of the present and makes the future very sure. These young men have saved a high and promising civilization. The world is uneasy for the moment. Its losses have broken its heart and disarranged its efforts. The loss of man power in the world is great; it is more difficult than formerly to induce persons to work, and we are going to have to substitute mechanical processes to fill the place of work—to make civilization in the future not dependent on hands; we have wasted hands; they are not here any more. The ultimate answer for that must come from the chemists and artisans. Everywhere this beautiful thing, erected in this country, this civilization more progressive and effective and beautiful all the time, reared on liberty and justice, and the democratic institutions established by our forefathers, is far too precious a thing not to conserve and develop. There will be a new union of spirits for the tasks of peace, as there was a union of spirits for the task of war. We will all join hands to bring about a more effective civilization than we have had heretofore.

CHEMISTRY AND THE NAVY

By REAR ADMIRAL RALPH EARLE, Chief, Bureau of Ordnance, U. S. Navy

In the spring of 1917 as a member of the U. S. Nitrate Commission, I first had the pleasure of meeting your Secretary and other well-known members of your great SOCIETY, one now some forty-two years old, and one having a membership of 13,600 or practically the largest organized body of scientific men in the world. My associations with these men have proved most valuable to my bureau, that of Navy Ordnance, during the war, and will continue to do so in the long years of peace which we have justly earned and must preserve.

The necessity of increased production of munitions involving all types of chemical mixtures and compounds requires chemists in large numbers, not only to inspect and analyze the substances we were using, but to develop the necessary new ones. To locate such men and enroll them I took advantage of the means your SOCIETY opened to me through Dr. Parsons. Thus the Navy early acquired its necessary force in laboratory and factory. The chemists secured came in, some as officers, others as enlisted men. This SOCIETY's register enabled those in the service to be recalled from sea and stationed on shore where the Navy could utilize their education to better advantage. Thus in the inspection service alone we acquired a large number of scientific men through this body.



Ledger Photo Service, Philadelphia

Seated, Left to Right: Secretary of War Newton D. Baker, Dr. William H. Nichols, Rear Admiral Ralph Earle.

Standing Left to Right: Dr. George D. Rosengarten, Dr. Harlan S. Miner, Officers of the Philadelphia Section, A. C. S.

At the time of the Spanish war our Navy was still using for its powder a mechanical mixture of saltpeter, sulfur and charcoal known as brown hexagonal powder, no smokeless powder fabricated having up to then satisfied the Navy. Now our Navy's and Army's powder is that nitrocellulose product made possible by Vielle's work with Nobel's gun cotton, Mendelëff's colloidizing, and Francis du Pont's dehydrating. This powder is stable and regular, a development of long years of peace, a chemical compound that is attributable to chemists, some of the most able in the profession having given their time and study to it. Its record is a testimonial to efficiency, and to the fact that the purer the substances and the more closely our powder approaches one substance, the more stable it is. What a com-

fort it is to the men who sleep with and over it to feel that the staff of men working in its development neglected nothing and gave the Navy a safe and most efficient propellant. To maintain this pure and stable the chemist is ever needed. The alcohol, the cotton, the ether and acids must be just right or trouble will develop later. Even the study of cellulose is a world in itself.

The problems of the naval service differ in one essential particular from those of general military service, in that their limitations are set by the conditions in which they must be used aboard ship and at sea. Stability, that is capacity to stand storage under adverse conditions of moisture and temperature, assumes an importance which it does not carry in military operations where munitions are expended almost as rapidly as manufactured. Many of the explosives proposed by men of science for naval use cannot so stand the conditions of stability required.

Among such proposed explosives, the ammonium nitro compounds or mixtures were most prominent. The use of ammonium nitrate powder as a propellant was advocated by an eminent chemist to relieve the almost certain shortage of materials for the nitrocellulose compounds used by the Navy. The same lack of stability rendered them unsuitable for even the still more extensive use in mines and torpedoes. The hygroscopic character prevents their storage even in well ventilated magazines and when assembled in impervious packages.

The powders having nitroglycerin in their composition for reason of insufficient stability and others are not suited to the Navy. The attempt to avoid excessive corrosion was one of the causes which led to the adoption in this country of a pure nitrocellulose powder as a propellant instead of nitroglycerin compounds used generally in the European countries, with the exception of France. Here again in this field some of the most extensive chemical experiments have been carried on for many years, the difficult element of the problem, in whatever form of explosive, being the lack of experimental knowledge on the behavior of chemical compounds when subjected to high temperatures and pressures, exceeding often many times those under which they can be manipulated in the laboratory.

The chemical reactions under pressures and temperatures that cannot be reproduced in laboratory are well discussed by M. Berthelot. The relations of detonation and explosion are complex indeed.

There is a need in the Navy of the development of a powder with the minimum amount of flash. Now at night the gun pointer, or, as in the case of "Broke" and "Swift" engagement, in the English Channel, the navigator is blinded for several seconds. To effect this some smoke must be accepted, but, with the high speeds or winds at sea in a modern engagement, particularly on destroyers, the smoke given off by the discharge will quickly pass astern and not interfere with the gun pointer or navigator. The blinding effect of a flash from smokeless powder at night cannot be realized by those who do not actually know it. Chemists are now at work on this problem but before a satisfactory solution is reached, more attention must be given to it. Possession of satisfactory star shell and flashless powder for use in an engagement at night will change its character in a large measure. A flashless powder to be satisfactory must, of course, suit the guns at present in use in the Navy.

The extensive development of high explosives during the recent war has shown the close relation between organic chemistry and ordnance.

Wet gun cotton has been discarded as an explosive for torpedo warheads on account of lack of stability. The danger of its drying out and becoming easily exploded by shock or other cause led to the substitution of TNT, about 1908, which, with quite as much explosive power could be melted at a relatively low temperature and cast solid into a mold, in which con-

dition it could be copper plated, if desired, and rendered impervious to moisture, which, however, produces no deleterious effect on its explosive power or its stability.

Trinitroaniline, a comparatively new invention, was advocated as having higher explosive power than any other stable compound. Stability tests, however, showed that it was affected by moisture, freeing nitric dioxide (NO_2), which rendered it unsuitable for storage aboard ship or in torpedo warheads, or in mines where the protection against moisture is impossible. The adoption of this explosive was urged on the ground of its utilizing a surplus product not heavily taxed by the demands of the war, *i. e.*, di-nitrobenzol, a substance of quite extensive commercial production. As the manufacture of this explosive had not progressed beyond a large laboratory scale, it was not considered practicable to develop and construct a new plant for its manufacture on the large scale demanded by the war. Di-nitrobenzol when treated for its further conversion into TNA emits poisonous fumes, and its further use as a diluent of TNA was objectionable because of the difficulty of protecting workmen from the serious consequences of handling this poisonous compound.

Trinitroxylol, or TNX, was proposed by the du Pont explosives chemists as a substitute for TNT, and to make up the difference due to the expansion of the demands on toluol and other coal tar products involved in the manufacture of TNT, picric acid and similar high explosives. Xylol is one of the lighter oils accepted in the production of toluene, and its use thus saved a by-product to meet the demands of the situation. This interesting compound was extensively tested at Indian Head, proving to be stable but of slightly inferior power to TNT itself.

This xylol development was one which removed the Navy from any bargaining for its allotment of high explosives from this nation and the Allies. TNX does not cast alone readily except at temperatures too high to be safe but it is used when in a semifluid state—that is of a consistency of heavy oil—when it can be poured. TNT, 40 per cent, and TNX, 60 per cent, was called "Toxyl." The mixture gives the same or equal underwater explosive effect as straight TNT. Amatol was 20 per cent TNT and 80 per cent ammonium nitrate. Amatol was not used in the Navy as a shell filler, only Explosive D (am. picrate), black powder, and TNT.

Another interesting development was an attempt to produce an explosive of the Sprengel class, a mixture of two inert substances, which, when united, would be highly explosive. Experimentations in the chemical section of the Bureau led to the interesting result that a stable mixture of liquid nitric dioxide (N_2XO_4) with benzol produced a (N_2O_4) mixture insensitive to shock and thus provided an explosive for limited purposes. Its explosive power was considerably higher than that of any of the other explosives in use, but difficulties in its use as an explosive for shell filler were encountered owing to the effect of temperature variations. The close of the war prevented the further development of this interesting mixture.

During the war the Navy was represented upon a committee appointed by the National Research Council called the Committee on Explosive Investigation, which committee is headed by Professor C. E. Munroe, one of the best known explosive experts in the country. The Navy was represented on this committee by the officer of the Bureau in charge of the research section. The committee collects and collates all information obtained here and abroad in relation to the manufacture and use of explosives, and this information is placed in shape for use of everyone. It is hoped that this committee will continue during peace.

Depth charges were cylinders known affectionately as "ash cans" with at first 50 lbs. TNT. This charge was not effective, in fact the Germans called them "ticklers." Later the 300-lb.

and then the 600-lb. charges were used. The vessel dropping these charges must, of course, be some distance away not to be hurt by the explosion. The commander of one of our destroyers returning from search duty and having sighted no submarine wished before going in to port to test the firing mechanism of his depth charges. He steamed too slowly and a leaky condenser resulted.

Large quantities of TNT were required, amatol was not powerful enough, so TNX was adopted by the Navy for use in depth charges. These weapons, after the United States got into the war and saw that there were plenty of depth charges available, were the most dreaded of weapons by the German submarine commanders. The American and British depth charges differ in several particulars. The American depth charge is fired by means of hydrostatic pressure, while the English type fires by seepage. The American firing mechanism was installed inside the cylinder or "ash can" so that it could not be damaged accidentally, while the British mechanism protruded several inches beyond the cylinder head. The American depth charge was also provided with a safety chamber which held a detonator in such a position that until the charge had dropped some distance into the water the explosion of the detonator could not fire the charge. It is of interest that the Germans complained of the excessive violence of the depth charges and it is believed that this was because of the fact that TNT was used in the American charges while amatol had been used in foreign-made charges.

The American mines also, including all those that were planted in the North Sea, were loaded with TNT, although the replacement mines were being loaded with toxyl. These mines, after the planting of the Northern Barrage by American vessels, were mentioned by every German submarine commander captured, and seem to have taken the place of depth charges as the instrument of destruction most dreaded.

The chemists' knowledge came into place in the development of detonators and fulminates for explosive purposes.

Here, gentlemen, is a problem in which the Navy is vitally interested and which is awaiting the solution of the chemists and physicists to-day—the development of a new source of motive power for the Navy's underwater automobile torpedo.

In order to explain the problem a short description of the torpedo is required.

The present type of torpedo is propelled by a gas turbine. The nature of the gas is partly steam, and the rest the products of combustion of burning alcohol in air. A general description of the torpedo generating plant is as follows: A container for compressed air under high pressure, a container for fuel (alcohol), and a container for water. Air, fuel and water are admitted to a superheater or boiler simultaneously. The alcohol burns and the water is used to reduce the temperature of this reaction, so that the resultant mixture of steam and products of combustion enter the turbine nozzle at about 1500° F. as the motive fluid.

The weight within reasonable limits is determined and the combined volume of the three containers is fixed. Therefore the results of such a system depend upon, first, the efficiency of the boiler, or superheater, to realize the maximum efficiency of the oxygen contained in air and produce the most efficient gas at the turbine nozzle, and second, the results depend upon the turbine and mechanical efficiency of the mechanism to turn the motive fluid into useful work. The efficiency of the boiler system has been developed to a point where any great gains in efficiency can no longer be expected. From time to time minor increases may be discovered and made. The mechanical end of the torpedo is now very highly developed, and is quite efficient, and no great gains in efficiency can be expected here. In other words, for the given weight and size the present torpedo may be considered to be at its maximum efficiency.

The Navy and Bureau are confronted with the problem of developing a torpedo of vastly more range than the present type. This problem calls for a radical change in method of carrying energy aboard the torpedo, for into the present size and approximately the same weight must be stored two to four times the present amount of energy.

Several methods have been proposed and sufficient study has been made to show that they are not developed or practical as yet to base any assurance of a solution on. The substitution of pure oxygen for the air, the substitution of hydrogen and oxygen for the air, the use of motorite, aluminum oxide, thermite, etc., have been suggested to the Navy. Some of these may eventually give a solution, but at present all of them lack development, and very little is known about their properties with reference to control of the reaction, safety, and general use and handling.

The Navy was interested in the building of a plant for the fixation of atmospheric nitrogen because of the fact that in December 1917, January, February, and March 1918, the importation from Chile of nitrates had been but one-half the consumption of that product for war uses by the United States and the Allies. This was one effect of the submarine warfare which caused a shortage of ships. The Navy back in 1909 had recommended the establishment of such a plant but it remained for the Army first to establish one, in accordance with the recommendations of the Nitrate Commission, at Sheffield, Alabama. The Navy proposed to erect one exactly similar to Plant No. 1 at Sheffield, that is, one following the modification of the Haber process developed by the General Chemical Company whose president is the president of this Society, namely, Dr. William H. Nichols.

The Navy's plan was to manufacture an amount of synthetic ammonia from the oxidation of which there could be made sufficient nitric acid to handle the daily output of 100,000 lbs. of powder, which is the capacity of the Navy's plant at Indian Head, Md. The project was given up shortly before the armistice was signed.

In fuses, the field of development is by no means exhausted. The time fuses used against aircraft do not perform satisfactorily as yet because in the rarefied air at high altitudes, the time train refuses to burn uniformly. Mechanical fuses are being tried out but are not suitable as yet. The shock of discharge so often deranges the mechanism. This then is a problem between the chemist and mechanic.

And, speaking of aircraft, the development of helium, or its trade name "Argon," is pertinent. Helium for use in balloons and dirigibles in place of hydrogen was first proposed by the British, who were, however, without a suitable source or process from which to secure a supply. It was known that natural gas from certain gas fields in the United States contained helium, and, on the entrance of this country in the war, the British proposed that we undertake to find a process by which the helium could be extracted from this source. A study of the various processes of gas reduction was made and one process (Linde process) was decided upon as being suitable for adaptation to the extraction of helium from natural gas. A survey of existing gas fields was made and it was found that the gas from the Petrolia field in Texas contained the highest percentage of helium. Control of this field was secured and a plant for producing helium put into operation. This plant has a maximum production of 30,000 cu. ft. per diem. The gas from which the helium is extracted is not lost in the process, but most of it is returned to the lines, the gas being metered going in and coming out and the Government merely paying for the difference. While the cost of helium so produced is higher than the cost of hydrogen, safety considerations plus the loss of balloons through ignition of the hydrogen more than offset any increase in cost. Undoubtedly, the production of helium in quantity is a step

forward in the art of ballooning and is a triumph in chemistry. In using this argon or helium, it has been decided to adopt a mixture composed of 85 per cent helium and 15 per cent hydrogen, which should give a lifting power of 70.18 pounds per 1000 cu. ft. of gas. Such a mixture then gives 93.4 of lifting power of hydrogen, and yet is practically non-inflammable.

Passing to metallurgical chemistry, I note that we demanded high-quality steel in all our forgings and in such quantities that the number of firms capable of producing such steel was increased five times. In future, there will be no difficulty in purchasing high-grade steel. Perhaps we benefited the designer and the country more than we did the steel makers. No new compounds or alloys were found that increased the strength of steel. The point is that the improvement in quality appears to depend upon scientific heat treatment. This seems to be the only real line of advance at present.

One of the most interesting fields of investigation, and one in which extensive experiments have already been made, is the erosion of guns. Into this problem enters the metallurgical chemistry of the steel or alloys of which the gun is constructed as well as the chemical products of explosion, their temperature and pressure. The ultimate cause of erosion seems to lie in the high temperature of gases as well as their dynamic effect when moving with the enormous velocities resulting from the explosion.

Metallurgists are now endeavoring to find an open-hearth steel which will be sufficiently strong and yet possess great non-corrosive and non-magnetic properties, such a steel for use as periscope tubes.

Much work has been done with zirconium steel but no uniform results are obtained. Some melts called "freak" have resulted in 315,000 lbs. tensile strength, 290,000 lbs. elastic limit, 45 per cent reduction in area and 15 per cent elongation. One-quarter inch steel plates for light armor do not yet resist the rifle bullet. Nickel zirconium gives a higher recovery of zirconium than does a silicon alloy.

Among the interesting service which chemistry rendered this Bureau was that of economizing fuel by establishing a plant for the extraction of gasoline from the natural gas fuel, as is used at Charleston, W. Va.

When firing guns, often there are left in the bore deposits of copper from the rotating bands of the projectiles, due to the scouring away of this band by the metal of the gun linings. These deposits tend to make the gun inaccurate and might some time so constrict the bore as to result in the bursting of the gun. An alloy composed of zinc 5 per cent, lead 25 per cent, tin 70 per cent, or thereabouts, is introduced into the gun with the firing charge so that it is vaporized by the heat of the burning powder and while at a high temperature unites with the deposits of copper in the rifling. These alloys that are formed by the union of copper, lead, zinc, being softer and less tenacious than copper, are scraped away by subsequent shots, thus freeing the gun from objectionable copper deposits. Chemical and metallurgical investigations have indicated the most suitable alloy for this purpose.

One interesting aspect of the late war from a chemical standpoint was the great increase in pyrotechnic devices, such as smoke-producing apparatus, marker-shell, pyrotechnic signals, illuminating or star shells, smoke shells, incendiary bombs, and all type of signal devices. In respect to this class of apparatus, all countries were in about the same state of unpreparedness when the war began despite the fact that devices of this nature, though in simpler form and smaller variety, have been employed in warfare from time immemorial. The manufacture of fireworks and pyrotechnic devices was based principally on empirical methods and there was no information at hand on which to base new developments. Accordingly each new device called for a chemical investigation.

The star shells already spoken of are well along, but they function satisfactorily for only a part of the time. As used abroad they would be fired only by a vessel when using reduced charges in guns. This was a restriction our Navy was not prepared to accept. The chemical part of the shell is the illuminating mixture and the methods adopted to insure its lighting.

The Navy is also desirous in a pyrotechnic way of obtaining a compound or mixture which when placed in a shell will, upon its bursting under water, cause a vivid red smoke, and another to cause a brilliant yellow smoke to float off. White smoke is produced by black powder, black smoke can be produced by detonation, or another chemical mixture not found yet. These are needed for use in distinguishing fall of shot from the various turrets in order to discover errors in gun fire.

During the war, one of the methods which the merchantmen used in order to hide themselves from submarine attacks and thus escape was to produce a cloud of dense smoke and, when under this cover change course and thus elude the submarine. This is spoken of often in the blockade runners of days in the civil war where wood high in pitch and rosin was freely introduced into the furnaces of blockade runners, in order that they might escape under cover of this smoke.

As another pyrotechnic device we have the Mark I smoke box, an emergency production following British specifications, and containing a smoke producing mixture composed of sulfur, saltpeter, pitch, orpiment, bicarbonate of soda and minor quantities of other chemicals. This mixture proved to be unstable and caused a few fires. When examined critically, it was seen that there were many inconsistencies in the chemical mixture, besides disadvantages in the mechanical arrangement, means of ignition, and so on. It was, therefore, decided to develop a more satisfactory apparatus, and the Mark II smoke box was developed. In developing the Mark II smoke box, which was done at the American University Experiment Station of the C. W. S., many mixtures were investigated, special instruments were devised to measure the obscuring power of the smoke evolved, the persistency and density were noted, and reactions which militated against smoke production were avoided. The mixture finally adopted produces an astonishing amount of dense white smoke of great persistency, and is undoubtedly superior to other mixtures employed for this purpose. Likewise, the Mark I smoke funnel, which was designed to produce a smoke cloud from the ship itself, used white phosphorus as a smoke-producing agent, which while satisfactory in regard to smoke was dangerous to handle aboard ship, was hard to control and caused fires. The Mark II smoke funnel, mainly the product of the Bureau of Mines, which superseded the Mark I, produces smoke by spraying together ammonium anhydride and silicon tetrachloride which are carried in drums. The silicon tetrachloride drums are charged with carbonic acid to force the liquid out of the spraying nozzles. The result is a dense white cloud of the atomized ammonium chloride which is extremely persistent, entirely harmless and can be controlled at will. Another method of forming a smoke screen is by spraying oleum, or fuming sulfuric acid into the funnels, where it is vaporized and blown out in a dense white cloud.

Hundreds of thousands of signals—rockets—were manufactured for use as distress signals and recognition signals. They employ colored smokes as well as colored lights, the formula being developed only after extensive chemical investigation.

The first German noxious gas attack was made in April 1915 against Canadian troops and was composed of clouds of chlorine gas. This type of warfare had been forbidden by the Hague Conference and the Allies did not expect the Germans would use it. From that time offensive and defensive methods of gas warfare were continuously developed by the Allies. A certain amount of speculative interest was aroused in the United States by this mode of warfare, but it can be said that our acquaintance with the subject dates from our entrance in the war.

You may remember that it was a German by the name of Count von Ostwald who prevailed upon the Kaiser and military authorities to adopt the use of noxious gas in this war. This Count was among the 1000 foreigners who were members of your SOCIETY and I notice that he was expelled. I had the pleasure of lunching in a fine house at Coblenz belonging to a Count von Ostwald (said to be the one) in April, with General Dickman, who was then using it as the headquarters for the 3rd army of the A. E. F.

The Navy was represented in the membership of the original commission that chose the site of the American University near Washington for gas or air research and this commission was one that vested the work and responsibility for the development primarily in the hands of the Bureau of Mines, your Secretary having very much to do with the remarkable success therein made by this Bureau. That the Army, with the great help of the Bureau of Mines, was able, with this late start, to reach at the time of the armistice, a point of development of gas warfare which equaled, if not surpassed, that of all other combatants, speaks volumes for the chemists and chemical engineers and is one of the real achievements of the war. The Navy also faced the possibility of gas warfare, and developed a gas mask and gas-shell filler suitable to its needs. The main point of difference in the Navy gas mask is that the canister is carried on the helmet in such a way that the ears are uncovered, permitting head telephone sets to be used, and at the same time more freedom of action in loading and pointing the guns is secured. The Navy gas-shell filler is designed to meet the special conditions of naval warfare. In connection with gas shell in naval warfare, it is interesting to note that in the Battle of Jutland, both the German and British thought that the other side had employed gas, but it was subsequently shown that neither side had actually used gas, but that the toxic effects noted had resulted from the inhalation of fumes from the explosive shell fillers.

To be on the safe side the Navy then had to develop gas shell. Our conditions are quite different from those of land warfare. Our prime mission is to sink the enemy's vessel; therefore all shells must penetrate armor. These are then made of a very high grade of steel, thick-walled, and require a large explosive charge to burst them. Thus this limits space assigned noxious gas. At first an unsuccessful search was made for one that was also explosive, then we got the best you chemists could give us, which was said to be the best or worst in the world—another testimonial of the chemists' ability. The Navy thus had and had loaded before the war ended shell containing two different types of most efficient noxious gas which released in a confined ship compartment would be drawn into the ship's ventilating system and thus distributed throughout the ship, greatly to the discomfort of the personnel inhaling it.

During an encounter with some German destroyers, the "Botha" went through a smoke screen laid by the Germans, as the result of which the crew of the destroyers were taken with violent sneezing and hence the Germans are credited with having used sneeze gas in this screen.

Our relations with chemists have been so advantageous and so happy during the war that the Navy earnestly hopes you gentlemen will not lose interest in us. You note there are plenty of problems remaining.

Doctor Herty has suggested that military and naval schools be given talks explanatory of what the mission of chemistry is and its application to all problems made clear. If students could be made to realize the practical use of what they study, how much easier it would be to keep them enthusiastic. This plan I hope may be carried out. We trust that the post-war days will find its officers and the members of this great organization closer together than did the pre-war days, and I believe that the Navy will meet your offers of assistance more than half way and gladly utilize your research power.

STEAM POLLUTION AND ITS RELATION TO THE CHEMICAL INDUSTRIES

By EARLE B. PHELPS, Hygienic Laboratory, Washington, D. C.

The relation of steam pollution to the chemical industries is twofold. Many industries require for their purposes water supplies of good quality, and most of them produce wastes which if discharged without treatment into the water courses tend to pollute those waters to a more or less harmful degree.

Pure water has been defined as a water that contains no harmful or deleterious substances with respect to the purpose for which it is to be used. In accordance with this very practical definition typhoid germs constitute an impurity and calcium salts do not in the case of a drinking water supply, while the reverse is true in the case of a boiler water. The various industries have their special requirements in the matter of undesirable constituents in the water supply. Hard waters are objectionable for boiler purposes and for the textile industries, while the brewer used to demand a certain degree and quality of hardness. Iron salts and organic color and all suspended matters are especially distasteful to the maker of fine papers; the laundryman sees wasted dollars in calcium salts, while the gas house can put up with anything that is wet and will run.

As long as the manufacturer has to deal only with the natural impurities of the water supply he can first of all choose his supply with discretion and then, if necessary, treat it by some simple purification method designed to meet the special requirements of his case. With the growth of industry, however, and the increasing joint use of streams for the purposes of water supply and waste disposal, conflicts of interest arise which, unless rightly treated at the start, may lead to litigation, unnecessary expense, serious economic loss, and often the actual destruction of an industry. The first and best remedy lies in the proper appreciation upon the part of the manufacturer of the iniquity and menace of stream pollution. It is good law as well as good economics that a riparian owner is entitled by right to any proper use of the stream that flows by his land, with due regard to the exercise of a similar right on the part of lower riparian users. This dictum of the common law has been interpreted by the courts in some extreme instances to mean that there shall be no appreciable reduction in the flow or alteration in the quality of the water by any user. Such extreme interpretation, however, would of itself defeat the very purpose of the law by prohibiting almost every valuable use of the water. In the main, the courts hold that there must be no serious or unreasonable pollution such as would materially damage another and with due regard to the character of the stream and of the uses to which it has customarily been put.

State legislation has not always been based upon a similar application of the law of reason and in some instances has worked unnecessary and unjustified hardship upon the industries. In general, however, the states have lagged behind rather than pushed ahead in good engineering practice and scientific advance along these lines. One phase of the state control of stream pollution, which although of especial interest to the manufacturer has generally been overlooked by him, ought to be referred to here. It is the fact that in most states this entire matter comes under the administrative activity of the public health officials, who likewise initiate or assist in framing the various legislative enactments. Manufacturing and other interests have in the past exerted merely obstructive influence and have in certain cases defeated good public health legislation because of the unnecessary breadth and generality of the proposed law. The public health interest in stream pollution, where it exists at all, is necessarily paramount, and frequently controlling, but in few cases is it so great as to be unique. It is believed that the drafting of anti-stream pollution legislation and the administrative control of streams should be placed in the hands of competent boards similar to the British "River Boards" upon which

there shall be adequate representation of hydraulic, sanitary and chemical engineers, and a minimum of medical representation.

The problems of the scientific control of stream pollution are problems of engineering, chemistry and biology. Of immediate and pressing interest is the fixing of standards of permissible pollution, which will comply with the common law conception of reasonable use and develop the maximum advantageous use of the streams. Such standards will necessarily vary in the individual cases and have already been fairly well developed in the case of domestic water supply. No better illustration of the inadequacy of the present system of state legislation could be cited than the fact that in general state laws place a uniform blanket restriction upon the pollution of all the waters of the State, regardless of their size, character or uses.

Of especial interest to chemists is the other great problem of stream pollution, namely, that of remedial measures. The treatment of industrial wastes may in certain cases be worked out along the line of biological oxidation, which has been developed to such a high degree of efficiency in the case of domestic sewage; but as a rule, and this is especially the case in the chemical industries themselves, chemical methods of treatment are required.

The problem is, of course, specific for each industry, but there are certain general fundamentals. A satisfactory process may involve clarification, neutralization of acidity or of excessive alkalinity, decolorization, deodorization, or any combination of these. As a rule dissolved substances that are neutral, colorless and odorless are unobjectionable in moderate quantities. At times, however, it becomes necessary to remove such substances if they are distinctly poisonous, as in the case of arsenic compounds, if they produce a taste in a water used for domestic purposes or by stock, or if they are putrescible.

For clarification there are available the ordinary methods of the chemist: sedimentation with or without the addition of chemical precipitants or coagulants, or filtration, gravity pressure or centrifugal. Neutralization of excessive acidity or alkalinity should really be classed with the removal of other objectionable dissolved substances. These all constitute simple chemical problems which need no extended discussion here. It may be well to point out, however, that in the majority of cases the protection of fish life becomes the controlling factor in the matter of the discharge of acids, alkalies or toxic compounds.

Decolorization is especially indicated in the treatment of the wastes from dye manufacture and from textile dye-houses. While it may be justly urged that because of its extreme dilution this type of pollution works the minimum of harm upon a stream, it must in fairness be admitted that the appearance of a stream constitutes a considerable part of its value to a community. It is, indeed, the fact that, next to pronounced odors of putrefaction, no effect of pollution is more quickly resented by the public than a marked and continuous discoloration. Successful treatments have not yet been developed. For the treatment of small volumes the writer has employed filtration through charcoal. For certain dyes chlorination has also been found satisfactory, although somewhat expensive. This phase of the subject represents an interesting unsolved problem of a strictly chemical nature. Contributions toward its solution would be of the greatest practical value.

Deodorization is a still more special case and fortunately is demanded but rarely. In the writer's experience the danger of pollution of a drinking water supply by the wastes from a plant in which several nitration processes were being carried out necessitated a study of the possibilities in the matter of odor removal. In this case the problem resolved itself into one of the virtual destruction of the offending compounds or else of their removal by steam distillation or treatment with charcoal. That this is a phase of the problem well worthy the attention of industrial chemists is illustrated by the fact that the United

States Government found it necessary to advise the shutting down of a large phenol plant working on government orders, because it seemed impossible in any other way to relieve the very slight pollution of the water supply of a large city. The actual amount of phenol present in this water was too slight to taste but after the water was disinfected by chlorination a taste was imported to it which aroused serious resentment throughout the city.

This illustration also serves well to show the influence of the specific uses of a stream upon the character and extent of the permissible pollution, and the accepted principle of preferential use in the case of conflict.

A fact of especial interest to the manufacturing chemist in connection with studies on the treatment of industrial wastes is that such studies may frequently lead to the recovery of valuable by-products. The early history of hydrochloric acid is, perhaps, not as well known to the present day student of stream pollution as it should be. This important commodity was at one time an extremely undesirable waste product, which was disposed of only at great expense and under continuous pressure from legislators and the courts. The necessities of the case led to investigation and ultimately to the development of a market for the acid. A similar history might be recited concerning many by-product recovery processes, one notable case being that of gas-house wastes.

In just so far as the chemist is a broader man than the chemical manufacturer, so this problem of stream pollution has to him a broader significance than is included in its legislative or remedial phases. It is a part of the problem of the maximum development and utilization of our waterways. It is bound up with such matters as water power, navigation, public water supplies, sewage disposal, the fish and shell-fish industries, scenic beauty, and the recreational activities of the people. The subject of waterways and their development and utilization is one of the important economic subjects now before us. It is broader than its public health interests and the continued control of stream pollution matters by health authorities, having no appreciation of the magnitude or diversity of the problem, cannot long be tolerated. The subject is broader than state jurisdictions, for the great rivers and river systems of the country are interstate. It is essentially a Federal problem calling for the broadest possible viewpoint and especially for uniform treatment. Of what avail, for example, is a law for the protection of the Ohio River, enacted in the state of Ohio, when the communities of Kentucky, just across the stream, may pollute without restriction. An economic discrimination would in fact be imposed upon a manufacturer in Ohio in favor of his business rival across the stream. These and kindred shortcomings of state control have actually delayed the progress of the whole movement, and, as in the case of Ohio, resulted in the exemption of an interstate stream from the operation of an otherwise fairly satisfactory pollution law.

The present writer has previously suggested and wishes here to emphasize the desirability of Federal control of stream pollution under conditions that permit of adequate scientific study of the problems involved and of correlation of these problems with those of public health, navigation, fisheries, and all other matters related to waterways. To this end there might well be formed an interstate Waterways Commission, such as has already been proposed by a committee of the American Society of Civil Engineers. That committee has quite naturally considered in greatest detail the requirements of navigation and water power and has not fully presented the importance of Federal control over the public health and industrial phases of stream pollution. The former is in good hands and will not be neglected. It would seem, however, to devolve upon the membership of this Society to keep advised of these developments and see to it that any Federal agency that may in the future be created for the general control of waterways shall take proper account of the problems of industrial wastes and their disposal and of the

importance of protecting streams from pollution which will affect them adversely with regard to their use in the chemical industries. It will also be of ultimate benefit to those industries if the chemists and the chemical organizations of the country lend the weight of their influence, whenever they may properly do so, in favor of the centralization of stream control under some form of Federal authority.

THE CHEMICAL LABORATORY AS A PUBLICITY FACTOR

By ROBERT P. FISCHER, Technical Department, Matos Advertising Co., Philadelphia, Pa.

Not long ago the chemical laboratory was considered by many industrial concerns merely as an expensive luxury, and while this viewpoint may still be held by a very few concerns, it has largely been supplanted by genuine respect for the accomplishments of the control and research laboratories directed by chemists. American industries are convinced that the chemist and the chemical laboratory are valuable assets, that they have enabled the industries to develop new products, make standard products more economically, find outlets for by-products, eliminate waste, and have helped to place industries on a more substantial foundation.

Unquestionably, the world war has been a marvelous stimulant in arousing the public interest in chemistry. Our newspapers and magazines have been filled with stories of the wonders of chemistry and the average layman is to-day more familiar with the place of chemistry in the sphere of American industry than he ever was before. This is to the advantage of the industry and to those connected with it and this advantage must be held if our country is to remain a world factor in the field of chemistry.

Undoubtedly, the chemical laboratory will play even a greater part in the industries from now on and its place with respect to other subdivisions of business organizations will depend largely upon the effort, personality, and accomplishments of chemists.

Advertising men have their ear to the ground and know the trend of public thought and opinion. They direct their advertising along the line of least resistance, that is the line along which the public has already been educated to think. Those who are engaged in advertising the chemical industries to-day are in a position to take advantage of the vast amount of education that has been carried on by the public press. Due to these efforts, the public no longer looks upon chemistry as a dry, uninteresting subject and one to be avoided. There has been a transition from a feeling of indifference toward this science to one of intense interest. The advertising man will take advantage of this transition. If there is anything "chemical" about any business which lends itself to popular publicity, it will surely be made use of in promoting the sale of merchandise.

It seems almost paradoxical to state, in an address to chemists, that the chemical laboratory should receive greater attention on the part of the advertising and sales organization of the businesses with which they are associated, yet a glance over the advertisements in various publications will convince one that such reference is not at all out of order. There was a time when the chemical laboratory was considered the least important place in the industry, as far as sales and advertising were concerned. To-day the laboratory is continually being sought out by the wide-awake advertising and sales manager for talking points and specialized information about products. When the question of discontinuing a research laboratory came to the attention of the management of one of our large corporations, not long ago, the advertising manager offered to pay the expense of the laboratory out of his advertising appropriation because he considered it the most valuable asset, from an advertising point of view, that the firm possessed. This is getting to be the attitude of most wide-awake business men and it should be fostered on the part of the laboratory man.

The AMERICAN CHEMICAL SOCIETY is spending considerable money, through the A. C. S. News Service, to disseminate knowledge regarding the science and art of chemistry throughout the country. This is of benefit to every one connected with the industry and the ground work thus performed for the industry as a whole offers an excellent opportunity for follow-up work by large commercial institutions in the interests of their own products.

While the newspapers are ready to accept general publicity about chemistry in their editorial and news pages, these pages are not open to the advertising of specific articles, but the advertising pages of these papers are of much greater value while the news and editorial pages are carrying chemical stories. The two go hand in hand and the chemical industries, while profiting indirectly from the news service, cannot hope to profit directly without making use of the advertising pages. Furthermore, public interest which has now been aroused in behalf of chemistry cannot be maintained unless the application of chemistry to every-day life is kept before the public in new and varied form and this can only be done through the advertising pages of the magazines and newspapers of the country.

There has been a general feeling among chemists that their products must be advertised through the technical press. Chemical and other trade journals have their place, of course, but when an advertising medium is to be selected, one must consider the persons who are to be reached and sold. The question is not how much circulation has your paper, but rather who reads your paper? - Is the purchasing agent, superintendent or president of the concern, to whom you want to sell chemical apparatus, quantities of chemicals or other merchandise apt to pick up a technical paper and come across your announcement and ponder over it, or is he more apt to be attracted to a less technical announcement appearing in a newspaper or magazine which he is apt to read during his leisure hours when your message, if properly presented, will have a chance to sink in? This is not mentioned to disparage advertising in trade journals, because the careful buyer consults his chemist before he buys anything for technical use, that is what he has his control and research laboratory for, and when he speaks to the chemist of a certain type of equipment or product which has been called to his attention, the chemist must be able to answer by having at his command information that is drawn largely from the adver-

tising pages of the technical press. Few concerns in the chemical field have thus far added the lay press to the technical press as a medium for announcing their products, but those who have taken the step are continuing such advertising. What further proof is needed of its effectiveness?

Advertising is largely a work of education, in fact, pure advertising is nothing but education. It is the education of the public to the use of something new. As soon as competitive brands of the new product appear, the advertising takes on a sales aspect. That is to say, it not only educates the public regarding the use of a new product, but also speaks of the superiority of a given brand of that product. This is where the chemical laboratory has a wonderful opportunity to show its usefulness to the business organization as a whole. Who but the chemist can pick out the fine points of superiority in quality of one paint over another, the greater value for some purposes of a pig iron which contains vanadium over one which does not, the superiority of one source and kind of asphalt over another, the greater value of certain chemicals for specific uses over the same chemicals which, though quite as pure, may not have the same physical characteristics? These are points which even the most imaginative advertising writer, without a knowledge of chemistry, would never think of, and yet they are so much more telling in their business-producing value than the products of the imagination of the advertising writer, that the advertising man will recognize their value in a minute and put them to good use.

It is generally recognized that the outside point of view or the customer's viewpoint is absolutely essential for the success of any business. The chemist in the past has confined his thought to the laboratory. His point of view has almost without exception been an inside point of view. He has seen the laboratory day by day and watched its increasing importance to the plant, but as an insider he felt that the laboratory was a thing apart from the general organization. This feeling no longer portrays the attitude of the modern chemist. He has seen the light, and while the chemist still deals largely with atoms and molecules and the business man deals in dollars and cents, recent events have pointed out very plainly that our success in building chemical industries requires a combination of atoms and molecules with dollars and cents. Continued publicity, general and specific, is the catalyst needed to bring about this very desirable reaction.

SYMPOSIUM ON ANNUAL PATENT RENEWAL FEES

Papers presented before the Division of Industrial Chemists and Chemical Engineers, the Division of Pharmaceutical Chemistry, and the Section of Dye Chemistry at the 58th Meeting of the AMERICAN CHEMICAL SOCIETY, Philadelphia, September 2 to 6, 1919.

AN ANSWER TO THE PROPOSAL OF ANNUAL PATENT RENEWAL FEES

By EDWIN J. PRINDLE, Chairman, American Chemical Society Committee on Patent and Related Legislation

I desire to submit the following reply to the open letter of Dr. B. C. Hesse, proposing annual renewal fees for United States patents as the price of their continued validity. Before taking up the precise question proposed by Dr. Hesse, I wish to state that I am quite as much opposed to Germany's peaceful penetration and quite as desirous of seeing her prevented from using unfair methods as he can be. We should, however, consider any such proposal in the light of all its reactions, as well as of the one purpose in view, and its effectiveness to accomplish that purpose.

Any amendment to our patent law should conform to the fundamental purpose of that law; and that purpose is to secure the production of inventions. The assumption and the fact are that inventions would not ordinarily be produced if it were not for the inducement of the monopoly provided by the patent system.

Under the stimulus of that inducement, inventiveness was first developed to any considerable extent in the United States, and it has become much more common here than elsewhere, so that we lead the world in the volume and importance of our inventions. This has not been due to any natural difference, because we are all descended from Europe.

From the standpoint of the public (which is the one which must be considered), it would be ideal if inventions would be produced without any patents and were free as soon as made, but experience has shown that under these conditions very few inventions would be produced. Neither an individual nor a corporation can afford to spend the time and money and incur the overhead expense usually necessary to produce an invention of any value, unless he is assured of an opportunity to reap a return directly or indirectly from a monopoly of the invention.

The inventive faculty has been slowly developed, and any change in our law which decreased the incentive to invent would cause it to atrophy. This condition could not be corrected by

a mere restoration of the law, for the same slow process of development would have to be gone through with again for many years. Experiments are, therefore, dangerous, and it is necessary to be sure before any action is taken.

The path which the inventor must travel before he can reap any return is already so difficult that many doubt that it is worth while to make inventions. Added to the time and expense of development of the invention is the question whether it really will stand when used under the stern and unsympathetic conditions of commercial requirements, or will have objections greater than its advantages. Capital must be interested at a sacrifice of a portion of the invention. The danger must be faced that the search in the Patent Office will develop some earlier patent or publication showing all or a vital part of the invention to be old and, therefore, unpatentable. Perhaps, one or more interferences must be fought in the Patent Office with other claimants of the invention. After the patent is obtained, if the invention is good, suits will have to be fought to establish the validity of the patent and to demonstrate that it cannot be safely infringed. The inventor would, therefore, seem already to have all the discouragements he is likely to face and still make inventions.

The Patent Committee of the National Research Council has taken the position that the incentive of the inventor should be increased, rather than diminished, and its report to that effect has been approved by this SOCIETY and by many other scientific societies and by several of the largest trade organizations.

Let us consider what the effect on the incentive to produce inventions would be, of the proposal to require the payment of annual renewal fees under penalty of forfeiture of the patent.

I wish parenthetically to observe that the paper under discussion contains a fundamental error in the statement that "an inventor who allows his patent to lie idle transgresses the spirit underlying the patent system. He is reserving to himself a field of endeavor which he has agreed to exploit and is not exploiting and by his reservation he prevents its exploitation by others and thus retards progress."

The Supreme Court of the United States, in the *Continental Paper Bag Case*, has decided that the patent law does not require the inventor to work his invention, but that, on the contrary, he may not only refrain from using it himself but can prevent anyone else from doing so during the life of the patent, saying that such is the price which the public has agreed to pay to the inventor as an inducement to make the invention and to give a full disclosure of it to the public, in order that the latter may know how to use it and be free to use it forever after the expiration of the limited monopoly to the inventor. Therefore, the proposal to require annual renewal fees is not justified insofar as it is for the purpose of compelling the inventor to perform a supposed duty of working his invention, for the law neither imposes nor implies any such duty.

What, then, would be the effect of these annual renewal fees on the incentive to invent?

First, the taxes impose a burden which many individuals and corporations would hesitate to face. Many of the most important inventions have been made by poor or comparatively poor inventors entirely on their own financial resources. And if, after having obtained their patents, they would still have to pay a series of annual taxes totaling a possible \$550, and which in no way aided the exploitation of the invention, many of them undoubtedly would not attempt to make inventions.

There is a large class of small inventions, which are not of enough merit to affect the price of or control competition in the article to which they relate, and so do not bring their inventors any substantial return, and yet these inventions, even when never getting beyond the stage of being patented, occasionally lead the way, step by step, to a point of view from which a really great advance is made. They are thus of importance, and yet

the proposed renewal fees would particularly discourage the making of such inventions.

The possibility of overlooking to pay the renewal fees, and of thus losing all of the time and money which had already been put into the invention and patent and all hope of future return, would act not only as a deterrent to the inventor but to any purchaser as well.

Many an invention is ahead of its time and the commercial art does not become ready to use it until the later years of the patent—when it may become very valuable. Also, an apparently trivial invention may, by the unforeseen development of the art, become of substantial or prime importance. If annual renewal fees were required, the inventors, in such cases, would often, and I think usually, have allowed the patent to lapse early in its life, resulting in a feeling of resentment in him and in others which would not tend to increase the production of inventions.

A successful invention is often attained only after development extending over a long period and protected by a considerable series of patents which as a whole are necessary to protect the final invention and are, therefore, equivalent only to a single patent. Yet, if the proposed annual renewal fees were required, an intolerable burden would be imposed on the inventor and he would be paying these multiple taxes for much longer than the life of one patent.

Similarly, it is occasionally necessary to make auxiliary inventions, or inventions necessary to enable the main invention to be manufactured or used, and here again both the number of fees and the period over which they would have to be paid would be multiple, both for the single product from which revenue could be derived and the period during which it was ready for sale.

The annual renewal fees would work a discrimination in favor of the rich man and the corporation against the average inventor, for the former could afford to pay them, when the latter often could not.

The effect of requiring annual fees is shown by the fact that comparatively few American inventions are patented abroad, chiefly because such fees are required in most foreign countries, and it, therefore, follows that a great many American inventions would not have been made if only patents requiring annual renewal fees could be obtained here.

If foreign countries had, by their system of annual fees, induced the production of more inventions than has the United States, there would be more justification for introducing them here, but such is far from being the case.

I am, therefore, strongly convinced that the imposition of annual fees, or taxes, on patents would seriously decrease the incentive to invent.

Furthermore, I do not believe the imposition of annual taxes on our patents would materially alter the German advantage under our patents. If a German-owned American patent were of value in suppressing competition here, the Germans would unhesitatingly pay the renewal fees, even if they were much larger than the proposed taxes. If, on the other hand, the patent was so unimportant that the Germans would allow it to lapse for failure to pay the renewal fees, it would be of no advantage to us to be free to use it, for we should not want to use it.

To be worth while, a remedy must be one which will not only effectively check the Germans, but one which will not at the same time injure us—and more than them. The proposed remedy is not such a one.

Since the establishment of our patent system, we have risen from poverty to the greatest wealth and to preëminence in manufacturing, and our labor has been enabled to live on a scale far above that of any other country. It cannot be denied that our patent system has been one of the primal factors in bringing about this happy condition. The sole price (for the Patent Office is more than self-sustaining) has been an unrestricted monopoly to the inventor for the short period of seventeen years of that

which was the product of his own brain, and which but for him the public would not have known, and after which period the public has been free to use the invention forever. We need our inventors to keep us not only abreast but ahead of the strenuous efforts which Europe will make as soon as she has calmed down, and, as Marshal Foch has said, to keep us ever ready to meet another scientific war.—a condition which would not only enable us to win that war, if it should come, but would tend to prevent its coming. Desirable as it is to reduce the commercial advantage of Germany in this country to a minimum, let us not take a step which would do us infinitely more harm than her, and that without substantially accomplishing its object.

ARGUMENTS AGAINST ANNUAL PATENT RENEWAL FEES

By ELIHU THOMSON, General Electric Company, West Lynn, Mass.

I am, in general, opposed to complicating our patent system and establishing bureaus which have to deal with renewal fees, with their armies of clerks, etc., a folly which has grown sufficiently in our government affairs, and which should not be extended in other directions. I do not think that the principle of patent renewal fees is a sound one for the United States to adopt. My chief reason for this, aside from the consideration just mentioned, is that an inventor, whose vision is some years ahead of his time, may take out a patent on an invention which the art is glad enough to adopt after, say, 10 or 15 years. I think that such an advanced idea should, at least, receive protection for the few years of the patent's remaining life, without being penalized in any way when the development has been delayed, or when the art wakes up slowly to the need of a thing which the inventor had seen a long time ahead. In such a case, should he delay patenting, he runs the risk of having some one else step in and get the patent; so that he cannot delay, if he desires to hold the benefits for himself. He must patent within a reasonable time, or undergo great risk of losing the whole, since it is a principle of the patent law that due diligence in patenting must be exercised to confer validity. It must be remembered that there are patents and patents, some applying to some small simple affairs, gim-cracks, as one may say, which can be developed with great readiness and put into use at once. There are also inventions relating to large structures, for example, a steamship or other large engineering work, and it may be years before the inventor (however meritorious his idea may be, and no matter how much he exerts himself) will get the hearing or get the means for putting his invention into practice. If there is any principle which needs amendment in the patent law, it might be suggested that classes of patents should be formed, and the duration of the patent depend somewhat upon the difficulty of exploitation.

The patent renewal fee, while it might not tend to stifle activity for certain classes of inventions, would tend to stifle inventive activity for inventions which require expenditure and a considerable time to introduce. It often happens that an invention has at first a limited application, and as the public gets educated to its advantages, its application grows, and just about the time the patent is to expire there is some chance of its being remunerative.

Such fees would be something of a handicap to an inventor without financial resources. Anything is a handicap which creates difficulty, which acts in any way as a cloud upon the title. Inventions do not differ much from real estate in this respect. Then there is, of course, the possibility that unless proper safeguards are set up, an inventor (when the renewal fee may be due) is either ill, absent, or restricted in funds, and unless due and ample notification a considerable time ahead be given him, he may not be prepared when the time comes for the renewal fees to be paid, unless he has continually kept in mind the matter. He may be too busy to do that. With a clean title he has no such handicap to attend to, no such vigilance to exercise.

The popular idea that wealthy corporations use patents for "blocking" or "protecting" is, to a large extent, false, and where it is done it is a natural procedure, because of the uncertainty of court decisions. It is very easy, after a thing of importance is done, for others to come along with colorable imitations or variations and take out separate patents and then attempt to work them, in spite of the main patent. If the courts were always sure to regard these "steppings-up-behind" in the proper light (which is, that they would never have been made in the absence of the main invention), the case would be different. Where a fundamental and very valuable advance has been made, it is perfectly natural for an individual, as well as a corporation, to take out as many patents on departures from, or modifications of the general idea, as he can afford. In my opinion, this is perfectly legitimate, under the conditions as they exist. It is unfortunate that it has to be resorted to in order to procure that degree of protection which a good patent should confer. If, of course, the decisions in the courts were based upon the opinions of a technical jury, high salaried, composed of the best men that could be found, I think the case might have a different aspect. As it is, there is no such tribunal; the judges have to take what they are told, and it is marvelous that they should get at the real essentials of the case as often as they do. The present method of taking testimony, as compared with that which used to exist in the past, is a great improvement, and tends to the obtaining of just decisions.

As to whether patent renewal fees would tend to open up for development fields in fact, though not formally abandoned by patentees, I would say that I do not think that fields, generally speaking, are abandoned by patentees when there is a chance to pursue them to a valuable result.

Whether the added cost of patent maintenance due to such a system would be sufficient to deter corporations from disclosing their inventions through patents would entirely depend upon the actual cost of patent maintenance. If the cost were nominal, the influence might not be great; if it were large, the effect would be great. Here again, I object to the complications involved, the bookkeeping, the keeping of accounts, the slavery to figures.

The United States inventor has for many years suffered a serious handicap, as compared with the foreign inventor. In some countries it is required that a patentee shall work his invention within a certain period, or the invention is forfeited. A foreign inventor, a citizen of a country making these restrictions in regard to a United States inventor, takes out a patent in the United States, and is not required to do anything. The result is that the foreign country in question gets the benefit of the invention being made free to the public, while the United States manufacturer has to wait for the expiration of the patent to a foreign inventor before he can take up work in the field, even though nothing may be done during the life of a patent by the inventor himself. This is a case where "sauce for the goose is not sauce for the gander." It is a great folly which has been many times pointed out. It is a discrimination against the American inventor which should never have existed, and a good deal of the energy spent on tampering with the patent laws might well have been spent in considering the equitable aspects of this question. Surely, a foreign inventor patenting in the United States should be put under similar restrictions to those imposed by his country on United States inventors. Such fees would tend to induce foreign owners of United States patents to forfeit them, just as the foreign fees have induced and do induce United States inventors to forfeit foreign patents in the case where such fees are demanded, or where continuance fees are required. The hardship in this case is, of course, greatest when the man who has made the invention is considerably ahead of his time, when his vision of the future is the clearest, when his imagination as to what should be done teaches him to improve an art, even before the public has any realization of the need of such improvement.

While I do not favor such fees, I think if they were imposed, there should be, at least, a ten-year period free from any fees. The size of the fee is a matter for discussion, and largely depends, it seems to me, upon the invention in question. It is doubtful if the fees exacted should be the same for all inventions. It would be desirable to have them so, but this right work injustice in many cases. Let me reiterate that I think the system as it stands is quite good enough without these renewal fees. It seems to me it would be better to make them uniform, if they were proposed. I am in favor of anything which tends to diminish the grip of bureaucracy upon the people or the industries. It is a growing fungus, which tends to sap the national vitality and divert effort from its proper channels. I am not in favor of experimenting with a system which has worked well in the past and which, if improved, could be better improved in other directions.

I may say, in conclusion, that I am not much in sympathy with the means proposed for diminishing "the grip which foreign—and especially German—inventors have on our domestic industry," because I would take care of that by penalizing the foreign inventor as the American inventor is penalized by foreign patent laws. We have been very foolish and very lax in the past, and unfortunately the outlook for the future is not much better, without some considerable reform. I do not see why our home inventors should be taxed generally to secure the result which could be much more simply secured in another way, without trouble to such inventors.

SHOULD WE HAVE ANNUAL RENEWAL FEES?

By L. V. REDMAN, President, Redmanol Chemical Products Co. Chicago, Ill.

We begin by assuming that the principle is sound upon which our present patent system is based, namely, that the granting of monopolies and exclusive rights for a term of years to those persons who have new and novel ideas will stimulate invention and discovery. We will not argue this point. We will assume that it is true. Then are patent renewal fees justified?

First let us take up the question, what practice exists in other countries? Other countries have patent renewal fees. It has been urged that since all other countries have patent renewal fees, the United States should have them. There is nothing in this reasoning which is fundamentally sound, as other countries may be and probably are in such financial difficulties that it is necessary for them to have renewal fees in order to have sufficient funds to maintain their government. What applies to a rich country like America may not apply to a poorer country with large national debts. What others are doing is irrelevant in this case.

Patent renewal fees in the United States will be justified if it can be shown that present abuses in our patent system can be thereby eliminated or remedied.

Our proposition, the correcting of abuses of our patent laws by levying a renewal fee, holds good, provided we can show that certain abuses in our present system can thereby be corrected. What are these abuses?

We can hardly expect that any abuses will be corrected by taxing legitimate corporations for practicing their patents. It is obvious that there should not be renewal fees on American patents if these patents are being practiced in this country.

Should a corporation be taxed on patents which are taken out solely to protect the patents owned by the corporation and at present practiced by them? A practice which Dr. Hesse, in the *Journal of Industrial and Engineering Chemistry*, labels as abusive of the patent system is the method practiced by corporations of taking out large numbers of patents which are contingent to their business, but upon which their business does not vitally depend and under which patents these owners do not practice or pretend to practice. Is this an abuse of privilege? We think it questionable whether this is an abuse, even in the aggravated

case cited by Dr. Hesse that is, that of the Bayer Company who owned 1200 patents at the time of their transfer from German to American owners.

Fundamentally, a patent is intended to be a monopoly on an idea for a term of years and this monopoly is supposed to stimulate inventive genius. We cannot enter into an argument as to the soundness of this theory. Let us all agree that it is sound, for it is the foundation of all patent systems in the world. What we would like to discuss here for a moment is the question as to whether the taking out of contingent patents by large or small corporations, or individual owners for that matter, is necessarily an abuse? We think not, and our reason is that in order that an inventor may have and maintain the monopoly granted to him by our patent laws, it is necessary that his invention be given as wide and as comprehensive interpretation as possible. He takes out contingent patents which are really an interpretation of his original patent, and are taken out in order to protect what our Government has agreed is right, namely, the monopoly of a new idea. The contingent patents are, in every case, patents which run parallel to the original idea and all the inventor or corporation is doing is providing protection against the possibility of closely paralleled ideas growing up to destroy the monopoly. These parallel ideas, although in many cases patentable, do not change appreciably the number or usefulness of things invented. Consequently, they have no fundamental right to exist as a patent. However, the original patentee in taking out these contingent patents saves himself endless litigation and endless trouble in the courts, and he is justified in doing so, remembering always that the intent of the Government in granting a patent was to give him a monopoly on his idea.

It has been urged that large corporations prevent advancement by buying up and pigeon-holing new and useful improvements in the lines of manufacture in which they are interested. This is an assertion without proof. Seldom do we find a manufacturer or a corporation of prominence who does not recognize the necessity of producing the best possible article in order to prevent competition. It is impossible for corporations to buy their way in leadership if they refuse to take advantage of the new and novel ideas they have originated or purchased. The corporation that buys its supremacy by suppression is in the position of the country which pays bandits to stay away from its boundaries. The fee invites piracy. The corporation is already on its way to decay if it buys patented ideas which are in advance of its present practice and then suppresses the practice of those patents.

Now let us consider those patents which are taken out by patent pirates who prey upon new and useful knowledge without attempting in any way to manufacture or practice under their patents. They take out patents in order to tie up new patented industries. The outstanding abuse of our patent system (which allows very liberal and promiscuous patenting) is the abuse which creeps in, due to the patent pirate, who without attempting to manufacture explores at his desk a new series of ideas which are being patented by others, and, adding at random, without trial or practice, such knowledge as he may possess in the plying of his trade, he takes out accessory patents in the hope that he may be able to complicate the situation to such a degree that the original inventor or corporation owning the basic patents may be compelled to buy him off at a handsome figure to prevent costly litigation. Renewal fees on unpracticed patents will certainly eliminate a great deal of this sort of piracy.

If these pirate patents can be taxed out of existence a good purpose will be served. The elimination of the pirate is the greatest possible improvement that could come to our existing order.

Obviously there should be a non-taxable period beginning with the granting of the patent; it should be sufficient to allow

three years as the non-taxable period, after which time the taxable period should begin. A flat rate of \$100 per year, no sliding scale, would certainly be the easiest to remember and would be sufficient for the purpose. A sliding scale would not be a tax on the patent but a tax on the memory.

There should also be a period during which a lapsed patent is redeemable. For this we advocate a two-year period. This gives the inventor a total of five years during which time, without cost, he may prepare to manufacture. Certainly if the five-year period is any serious hardship to him the remaining twelve years of the life of the patent will not be of any great value. Five years should be sufficient to enable the poorest to get their processes under way.

Our conclusion of the whole matter, in brief, is this—no taxes for revenue only should be imposed on any patents. Patents which are practiced and operated legitimately should not be taxed, as such taxation is contrary to the principle of granting patents. Accessory patents without renewal fees should be allowed to those who hold the basic patents providing the accessory patent is taken out with the sole intention of preserving a monopoly on the original basic patent, for it must be recognized that the inventor has as much right to protect his monopoly as the Government has originally to grant it. Renewal fees should be levied on unpracticed patents in case it can be shown that the patentee does not propose to and cannot practice his invention because of basic patents which stand in his way.

ANNUAL PATENT FEES IN THE UNITED STATES

By R. L. STINCHFIELD, Eastman Kodak Company, Rochester, N. Y.

The subject of annual patent fees ought to be first examined in the light of the fundamentals of our patent system. The principal object of this system is to promote the progress of science and the useful arts by obtaining for the public valuable technical information which it did not before possess. Inventors have such information and the public gets it from them by offering patents in exchange for it. In effect the Government says, "We will swap a limited monopoly for a disclosure of your invention." This disclosure (and not the fee) is the inventor's payment for his patent.

But the negotiations leading to the exchange cost money. The official expenses incident to the prosecution of patent applications, while insignificant in proportion to the value of the resulting patents, must nevertheless be borne by somebody. Here is where the fees come in. Their legitimate purpose is to help defray the cost of the Patent Office, each applicant chipping in his share for the examiners' services.

When an inventor thus yields up his nugget of knowledge and contributes his bit toward the running expenses of the Patent Office, he has done all that can be expected of him. He has paid in full, and his patent, for that reason, ought to be equally full—ought to run its entire term. It must be remembered that the disclosure, once made, cannot be recalled by the patentee. Any system would surely be inequitable which would permit the Government to tie the strings to its offer when, from the nature of things, the inventor can have none tied to his disclosure.

If annual taxes could be regarded as the consideration for the patent, it would be perfectly just to let the patent endure only in proportion to the taxes paid. But such taxes are not the consideration. They are not what patent systems are maintained for. We do not have patent laws and a Patent Office to collect funds. Science and the useful arts progress on inventions, not on dollars.

Suppose, however, that annual taxes should be imposed, contrary to the spirit of our present American patent system. What good would be accomplished?

Let us first consider those patents which claim inventions that never become of any commercial use or which, having once been useful, cease to be of further service to society. They harm

nobody. The public obviously cannot be injured by a patent that prevents it from doing something that it does not want to do. Of course, nobody would pay the fees if an annual tax system were in vogue and such patents would then become legally dead. But they are, for all practical purposes, just as dead under our present system. To enact laws to kill them would be like shooting a corpse.

Next we have patents covering inventions of established commercial value. They will undoubtedly be kept alive regardless of what tax system is in force, simply because it pays their owners to do it. Annual tax laws would not alter their status at all.

It is the same with those patents which control useful inventions which the patentee does not care to use himself or let others use—sometimes called "smothered" inventions. If it pays to smother them, their owners are going to do exactly that, even if annual taxes have to be met. Whatever may be said about the compulsory working of patents (and that is another and larger story) the compulsion in an annual tax is too weak to accomplish such a purpose.

European experience does not prove the contrary. In every important country where annual taxes are required other and more powerful forces are acting to shorten the patents, particularly the "working" laws. After a patent has run three or four years its owner must substantially work the invention in the country granting the patent, under penalty of having it held void. While we sometimes meet with the belief that these working laws can be avoided by inexpensive subterfuges, such is not the opinion of the best European counsel. Actual experience indeed has shown that in France and England an unworked patent can be smashed by any competitor who wishes to do so. Of course, few unworked patents actually get into court. Their owners, knowing that they can be declared void at the will of a competitor, stop wasting money on further annual taxes. Thus non-payment of fees becomes the immediate symptom, but non-working is the real cause of the patent's death. It is unsafe, therefore, to predict success for annual taxes alone, merely because of results contributed to by other causes in European countries.

Inventions that appear practically valueless may unexpectedly become important several years after the patents on them have been granted. An organic chemical of only academic interest may, under stress of war, be used in immense quantities. Under our present patent system the owner of the patent would then reap his reward. Under the annual tax system the patent would become void for non-payment of taxes during the years when the invention was apparently valueless. Thus the public would later reap the benefit and the inventor or his assignees would receive no reward. Undoubtedly the immediate effect would be to get the public something for nothing. But as in every other business, it is to be doubted whether a something-for-nothing policy pays in the long run. The stimulated reaction is too strong.

Undoubtedly an American citizen taking out foreign patents is at a disadvantage relative to the foreigner who takes out a patent under our generous American laws. But annual taxes would not make for complete or even substantial reciprocity, so long as the United States citizen applying abroad is subject to working, compulsory-license, non-importation, and other onerous laws. A cure must be found in some other and more complete way.

Besides failing to accomplish any material benefits, annual taxes would be a burden to the poor inventor, and indeed to many small businesses built on patents, particularly during their earlier years of struggle. The tendency of our patent laws ought to be toward, rather than away from, solicitude for such individuals. The annual tax system will have to promise extraordinary benefits to counterbalance this defect, if it is ever to be considered by the average legislator.

Finally, if fees must be changed, let us slightly increase the present ones, and apply the proceeds toward increasing the personnel of our badly undermanned Patent Office and toward paying its examiners salaries sufficiently large to retain plenty of good men at work so indispensable to the inventors and the industries of the country.

ANNUAL RENEWAL FEES FOR U. S. PATENTS

By EDWIN A. HILL, U. S. Patent Office, Washington, D. C.

As a member of the Committee on Patent and Related Legislation I have been asked for an expression of my views on the subject of patent renewal fees.

These views I find are in accord with those of other officials of the Patent Office and of patent solicitors with whom I have conferred upon this matter, and are based upon my own twenty-four years of experience in the Patent Office as secretary to three different commissioners, and, for some years past, as an assistant examiner.

As a general proposition I think the burden of proof rests upon those who seek to change the existing laws. A tree is always judged by its fruits, and it is universally admitted that the fruits produced by our patent system far surpass those of any other system or country. Why then change what is good, and experiment with the more or less unknown? Certainly the reasons therefor should be convincing.

I do not think the principle of patent renewal fees a sound one for this country to adopt. Probably the best argument in its favor is that it would limit the number of patents necessary to be considered when capital is entering the field of industrial production, and must necessarily determine to what extent, if any, it will be dominated by existing patents.

On the other hand, the fundamental principles upon which our patent laws are based, and the trend of the modern court decisions expounding them, indicate the patent as a reward for the disclosure of and subsequent dedication of an invention to the public. We grant the patent as an inducement to the inventor, who, having conceived an idea and succeeded in reducing it to practical form, comes forward and in his application makes such a complete disclosure of it to the public that at the expiration of the limited grant of a 17-year monopoly, the public will have full knowledge of the invention, and be able to use and practice it without further instruction. Any change in the present system which removes, curtails, or otherwise nullifies either in whole or in part this inducement offered to bring about the desired disclosure to the public, is against the fundamental principles upon which our patent laws are based. A recent decision of the Commissioner has gone so far as to hold that in an interference proceeding, where the Office has determined the question of priority as between rival inventors, if the inventor to whom priority is awarded, having made no public disclosure of it, allows his application to become abandoned so that the public will never have the invention disclosed to them, the opposing inventor, though proved in the interference proceedings not to have been the first inventor, will nevertheless receive a patent, because his disclosure to the public is the consideration for the grant, and so when he makes the disclosure he thereby becomes entitled to the grant.

The question then stands about like this: Granting that renewal fees would eliminate some of the patents which might otherwise dominate a given line of manufacture, and which if not so eliminated might cause capital to hesitate about embarking in that enterprise, is it equitable or advisable to remove or diminish any of the inducements which the law now offers to the inventor to make it an object to him to disclose his ideas to the public? My answer to this is emphatically, "No, it is not advisable." The value of the inventions, which, under such circumstances, would never be disclosed, and ultimately

dedicated to the public, would much more than offset any advantage which the public might gain by thus occasionally removing supposed obstacles to the investment of capital arising from the fear of possible suits for infringement.

In most cases if broad unexpired dominating patents were found apparently neglected and undeveloped, and upon which no large investment of manufacturing capital up to that time had been based, it would be possible to obtain working rights under such patents at prices far short of what would be prohibitive.

I do not therefore consider the principle of patent renewal fees a sound one and do not think it should be adopted.

The question of additional revenue to the Office derived from renewal fees cuts no figure whatever, for while the final decision to change the law should be based upon broad principles rather than upon the narrower view of increasing the Office fees, it is doubtful whether the income derived from such renewal fees would not be more than offset by the reduction in the number of applications filed, for in my judgment such renewal fees would tend to stifle and restrict inventive activity, and would be a serious handicap to the average inventor. One of the chief advantages of our system over that of other countries, as already indicated, is the reward offered to the inventor as compensation for his disclosure to the public. The practical result of this difference in laws may be measured by the number of patents already granted in this country, a number commensurate with those of all other countries of the world combined, and is also illustrated by the fact that in its manifestation of inventive genius this country stands upon a pedestal apart from all others. When the Japanese government, some years ago, investigated the patent systems of the entire world they attributed the wonderful growth and development of the United States primarily to our patent system, and so modeled their own upon ours.

Many poor and struggling inventors would hesitate long before applying for a patent if faced with a series of fees payable year after year perhaps in increasing amounts, and so would never apply, and thus would never disclose their valuable ideas to the public.

It should not be forgotten in this connection that very frequently inventors are often far ahead of their time so that their patents must be held many years before the time becomes ripe for making a proper commercial development of their inventions. In such cases the necessity of keeping the patent alive from year to year, by a burdensome system of renewal fees, would be a very serious handicap upon them and would in many cases postpone the time of filing of their application, leaving the inventor the chance of losing his rights to some later rival who was ready to assume the burden and come forward and take out the patent at once; or by the possible death of the inventor while waiting for a suitable season to arrive at which to obtain and develop his patent, the public would never receive the disclosure and so the valuable idea be lost forever to the world.

I can but think, then, that a renewal fee system would not only very seriously handicap these deserving citizens, but would in general tend to stifle and restrict the inventive activity of the country in a marked degree.

I do not think that the system would in any way tend to restrict or restrain wealthy corporations in the matter of so-called "blocking" or "protecting" patents, nor do I consider this matter as great an evil as it is by some considered. In almost all of these cases the disclosure to the public is fully worth the limited monopoly which it confers in exchange for same.

Would such fees tend to open up for development fields in fact, though not formally, abandoned by patentees? Probably not to any great extent, as, so far as I have observed, inventors never hesitate to apply for a patent on any improvement that may occur to them, regardless of the fact that the same is

dominated by and can only be used in connection with some patented machine or device. And so, likewise, I do not believe the question of whether a dominating basic patent is alive or dead will have any effect in either promoting or retarding applications for improvements to be used in connection therewith. If the improvements are meritorious they will be used whether there are dominating patents in existence or not, and patents for them will be applied for, without regard to whether such basic patents are alive or dead.

Would the added cost of patent maintenance through such a system be sufficiently great to deter corporations, large or small, from disclosing their inventions through patents? Probably not, as the question of expense is one of the last matters considered by such corporations and the expense to them is always a small matter. As they all maintain a patent department in charge of a skilled patent attorney, the government fees and a small compensation to the inventive employee are the chief items of expense.

On the whole, then, I emphatically do not favor renewal fees, but if we are to have them then there should certainly be a reasonable time given to the inventor before the first fee is payable, to enable him to dispose of his invention or determine its utility. Seven years is none too long; a longer term would be better.

As to the size of the fee, it should probably be nominal; five dollars a year would be sufficient, the idea being merely to require the owner, by the payment of the fee, to definitely put himself on record as not yet being willing to dedicate his invention to the public. Any considerable increase in the size of the fee would be merely playing into the hands of the great corporations who would wait to freeze out the small inventor and force him to dedicate his invention to the public, so that they could then use it free, whereas if they had to wait out the 17 years for his rights to expire, if a corporation really needed the use of the invention they would be ready at once to agree to pay the inventor a reasonable compensation for the use of his invention.

In conclusion I desire to call the attention of this Division of the AMERICAN CHEMICAL SOCIETY to three bills now pending before Congress relating to the Patent Office and which are receiving the active support of and have been already approved by the Research Council, the various Patent Bar Associations and Chambers of Commerce of the United States, and of scientific and technical societies and organizations in general, and to earnestly request this Division to endorse these bills by some such resolution as that with which I will close this article.

These bills have in view the following objects:

First—An increase of salaries to a point commensurate with the high cost of living which apparently is as high if not higher in the city of Washington than elsewhere.

Second—The organization of a Court of Patent Appeals in order to relieve the various Circuit Courts of Appeal from the consideration of cases requiring special training in patent law and applied science and so doing away with the conflict of decisions in the various independent circuits, there now being no last court of resort to which appeal therefrom can be taken to settle the law.

Third—The separation of the Patent Office from the Department of the Interior and its organization as an independent department responsible to the President direct.

Salaries in the Patent Office particularly in the case of the corps of examiners are notoriously inadequate to attract and retain in office a force having the necessary legal and technical training. For many months the lower grade of assistant examiner has been to some little extent filled by temporary appointees who have not passed the Civil Service Examination required by law, the Civil Service Commission having been wholly unable to fill the existing vacancies in the corps of examiners from those passing the necessary examinations. Even before the declaration of war with Germany the Patent Office had become a mere training school for young men who after a

few years' service would resign to accept better positions with patent attorneys and manufacturing corporations; and with the greatly increased cost of living, matters have reached the point where unless relief is given the condition of affairs will go rapidly from bad to worse.

The fact that the office revenues are ample should also be considered. The Patent Office, however, has never been allowed to expend its own revenues; all fees are covered into the Treasury of the United States and the office can expend only such moneys as Congress cares to appropriate for that purpose. Up to the present time the Patent Office has turned into the Treasury of the United States about eight millions of dollars over and above all moneys which it has expended.

As to the desirability of the establishment of a Court of Patent Appeals to take final jurisdiction of all patent cases it is wholly unnecessary to advance any arguments; the desirability of such a court is so manifest as to be self-evident.

As to the separation of the Patent Office from the Department of the Interior, the matter is simply the question of cutting a little government red tape. At the present time practically all appointments in the office are made under Civil Service rules, but solely on the nomination of the Commissioner of Patents approved by the Secretary of the Interior. The Secretary cannot himself appoint. The proposed change should simply leave all matters where they belong—in the hands of the Commissioner, the legal head of the department.

Will some one of the members present kindly offer a resolution in some such form as the following:

Resolved, By the Division of Industrial Chemists and Chemical Engineers, the Pharmaceutical Division, and the Dye Section of the AMERICAN CHEMICAL SOCIETY now in session at Philadelphia, Pennsylvania, that we heartily endorse the three bills now pending before Congress looking to

First—An advance in the compensations of Patent Office Employees covered by the bill H. R. No. 7010.

Second—The establishment of a Court of Patent Appeals, covered by the bill H. R. 5013.

Third—The separation of the Patent Office from the Department of the Interior and its organization as an independent department, covered by the bill H. R. 5011.

And we earnestly urge upon the Congress of the United States that the same be passed at the present session.

Resolved, That a copy of this resolution be transmitted to the Clerks of the House of Representatives and the U. S. Senate at Washington, D. C.

PATENT RENEWAL FEES

By W. R. WHITNEY, General Electric Co., Schenectady, N. Y.

The object of this paper is to express opinions on the principle of patent renewal fees, not because I know all the facts necessary for executive action, but because I want to contribute in order to learn more of them. My first thought on reading Dr. Hesse's letter of June 4 was that he had made a good case for renewal fees. As his facts receded from the foreground of my memory, I saw as the most appealing point of argument, the fact that the "dead German patent, therefore, still lives and rules in the United States," but on looking at it from different angles, I am not sure that even this is an evil to counterweigh added burdens to American inventors. There might be simpler ways to kill a living dead German patent, if that were desirable, than strangling American inventors. Judging, superficially I admit, from the enormous activity of American inventors, which has become a national characteristic, I am led to ask "Why change?" I do not know that added fees would have serious effect, but as Dr. Hesse points out, we ought to inform ourselves by contributing discussions.

I do not think added fees would greatly stifle or restrict inventive activity, because most inventors are persistent fellows, delayed, but not stifled, by such matters. I think that those who are not well backed financially would be handicapped,

however. They would not so generally get their financial reward as at present. It may now come to them long after they have ceased to hope. To-day a man who is willing to consistently back himself, as an inventor, may prepare a wonderful future. This vision greatly stimulates experimental work. The way up hill is steep, and few are successful, but the thing is logical. He may make an invention, which, at the time, promises absolutely no commercial value, but which, owing to his foresight, will produce great returns. Finally he, or someone else, sufficiently develops the field which he foresaw and to which he contributed. I would not increase charges to him, nor reduce his chance of finally having his reward, where his foresight, as to public wants, has been so exceptional.

It may seem strange, but I do not know anything about "wealthy corporations maintaining blocking patents," and so the effect of added fees thereto seems uncertain. I believe that any additional fee would fail to deter them, if this fee were one which the average inventor could pay. There may be a blocking system in action where a manufacturer operates only one of his several patents on different products for the same service, or different processes for the same product. A would-be competitor is kept from using either, but the public has no interest in having second-rate things made, nor second-rate processes used, because finally it has to pay for them.

My impression is that the more complex the law and the more costly or complicated the patent processes, the greater will be the relative load on the individual inventor. Large companies employ experts whose business it is to be proficient in the law and efficient in its application. The individual inventor, on the other hand, is almost universally negligent in these matters, because he is properly and necessarily preoccupied by his inventive work. For that reason we ought to consider first the interests of the "authors and inventors" whom it is the object of our American patent law to encourage. Let us make their way smooth and their encouragement great, rather than sell them at, perhaps, almost prohibitive prices, and well above cost, something which even to themselves has only one chance in a hundred to win. It might be argued that the public need fees in order to pay for the clerical work connected with supplying a patent or renewing it from year to year, but no one has made this claim. I think it will be found that our Patent Office still makes a profit for the public out of the present method of encouraging inventions, and that there is nothing philanthropic in it. Is it not true, that even with what we think is liberality, the public, in order to encourage invention, practically sells the inventor at a first profit to itself, a piece of paper, a license to legal battle, which on the average is not worth its cost to the purchaser? Whenever it is valuable, we, the same public, take a second very much greater profit for all time in return for a small percentage allowed the inventor for a limited period. Might we not go farther in encouraging invention so that a man might even educate himself for it, instead of discouraging it to any increased extent, as proposed?

Any patented idea is more apt to be developed and made useful than the same idea without patent. The manufacturer only takes it up for the profit he expects to make. Frequently he must run a great risk in extensive development, and it is still to public interest that he do so. Therefore, there would be fewer inventions actually developed if the patents lapsed from failure to pay annual fees. An undeveloped invention, which all people are equally free to sell, if it requires expensive development, will find few who are willing to take the risk of development. A definite period of assured monopoly is often as necessary for the manufacturer as for the inventor. This necessary period may in cases be short and frequently constitutes, in practice, only the last few years of a patent's existence. Even the chance that the patent may prove to be valuable shortly before it expires, is a boon to the inventor which we might well

leave to him. I think the kind of information we need before we form a fixed conclusion on this point, is, to what extent lack of a fee system in America has benefited or encouraged American inventors, and to what extent the foreign fee system has stimulated or advanced the arts and industries of those countries.

I do not know that I should object to encouraging the inventor type of young man even more, if possible, so that he would deliberately study science and engineering with the object of becoming a better inventor. Few aim to do this to-day, though men study to prepare themselves to be chemists, lawyers, poets, etc. This would seem to indicate that the present encouragement for inventors is insufficient and that most of them just happen, in spite of everything.

AN ARGUMENT AGAINST ANNUAL PATENT RENEWAL FEES IN THE U. S.

By A. D. LITTLE, Arthur D. Little, Inc., Cambridge, Mass.

Prior to the request that I express my opinion on it, I had given no thought to the subject of annual patent renewal fees in the United States, but in my past experience with foreign patents, I have always regarded such fees as an unmitigated nuisance, and I should expect them to prove equally burdensome here. This is not because the payments themselves are especially burdensome, but because of the necessity of keeping track of them from year to year and paying them in season. If the purpose of such fees is to throw open to the public, through lapses, patents which have been granted to an inventor who has fulfilled his part of the contract by making public disclosure of his invention, annual fees will undoubtedly tend to accomplish their object and they should obviously be made as large and as troublesome as possible. They would undoubtedly be some handicap to the poor inventor and might be expected to have a moderate inhibitive influence on inventive activity. I do not think they would tend at all to weaken the wealthy corporation, by whom the money value of fees would not be felt, and who could have the payments attended to by their legal departments.

There is something to be said in favor of the fees as regards their tending to open up for development fields which have in reality been abandoned by patentees. They would tend to clear away dead wood. Upon the whole, however, I am opposed to annual fees and the fundamental basis of my objection is this—the inventor is under no obligation to disclose his invention to the public. It is, however, to the advantage of the public that such disclosure be made. A patent is a contract between the Government and the inventor, by which the Government in order to induce the inventor to make the desired disclosure, and in consideration thereof, grants him a monopoly for seventeen years. Obviously, the inventor delivers the goods when he makes the disclosure, and in the nature of things, he cannot recall them. The Government, having induced him to make the disclosure, should not, in fairness, cut short his monopoly or make it contingent upon a succession of burdensome fees and regulations.

PATENTS AND ANNUAL RENEWAL FEES

By J. M. FRANCIS, Parke, Davis & Company, Detroit, Michigan

It happens that the writer has, for the past year or two, served as chairman of a special committee of the American Drug Manufacturers' Association on Patents and Copyrights.

I have given a great deal of study to the various published articles upon this subject and have corresponded with officers of similar organizations who have the same interest in view.

At first glance, one is inclined to indulge in rather precipitate conclusions and hence freely to point out the shortcomings of

American patent law and procedure, and then to offer a panacea.

After devoting several months to a close study of the question, however, one begins to get some small idea of its ramifications and furthermore, to appreciate its tremendous influence upon the development of industrial life in America. By this time comes a realization of the tremendous stake involved and that our laws are so broad and so just that we cannot but feel that its few disadvantages or imperfections are greatly outweighed by their benefits and excellencies.

The main difficulty in my mind lies in the fact that there are so many diverse interests involved in the consideration and enforcement of the patent laws of this country, that when Congress once begins to attempt to modify some of these manifestly imperfect sections, it will let loose the floodgates with the possibility that narrow and even fanatical opinion may rule, and that some of the manifest advantages of our patent system may be lost in the attempt to correct some of its minor features which appear disadvantageous.

This all leads up to a recommendation on my part that while discussion should be indulged to an unlimited degree, any action or resolution on the part of the SOCIETY should be controlled with the utmost care; and by all means let us refrain from doing anything hastily.

I can see the disadvantages pointed out by Dr. Hesse in his article published in *The Journal of Industrial and Engineering Chemistry* of July 1919 and I am frank to say that I can conscientiously support his proposition insofar as the principle is involved.

As the matter appears to me, however, I really fear that Dr. Hesse's remedy will wholly fail to accomplish the desired result.

The gist of his contention is that inventors allow patents to lie idle, thus transgressing the spirit underlying the patent system, and that this may be partially remedied by the payment of an annual tax.

He states furthermore that the annual tax shall consist of a modest sum of perhaps \$25; in other words, one which will cause the surrender of a large number of such patents and yet not large enough to be a burden to the comparatively poor inventor.

I cannot for an instant believe that a patent which promises to be of any very considerable value *per se* or which may be indirectly valuable in blocking the efforts of others, could be released by requiring the annual payment of any such sum as \$25 or even \$100.

The majority of such patents as are held in quiescent condition and which are calculated materially to interfere with industry are not those that are taken out, or at least *permanently held*, by men of small means, but are generally taken out by or quickly fall into the hands of institutions of great wealth, who would no more hesitate at the paying of an annual fee of \$100 or \$200 than they would at paying a fee of \$10 or \$25.

Inversely, demanding a fee sufficiently high properly to penalize the great institutions who are most likely to indulge in such practice would, on the other hand, prove a most serious burden to the inventor of small means.

Frankly, I believe that very little is to be accomplished by the proposed measure. Nevertheless, I am prepared to support it in principle, at least, leaving the details as to the sums to be collected annually to be determined after proper discussion.

In carrying out a scheme of this kind, however, I would certainly most positively favor allowing patent control without any fees whatsoever (more than those necessary for registration) for a term of five years.

TAXING UNITED STATES PATENTS

By T. HART ANDERSON, Patent Lawyer, New York City

Concerning the question of taxing United States patents, I do not advocate such a proceeding as a matter of general application to all patents. In all my experience of thirty years' practice of the law, particularly devoted to patent law, I do not know of a single instance where a patent has been used solely for the purpose of "blocking" the inventor of an alleged improvement. My experience has been that patents are relied upon by the owners thereof to protect a business built up and founded thereon and not otherwise. I am in favor, however, of taxing all United States patents granted to citizens of those foreign countries in which a tax is imposed upon patents granted in their own countries to United States citizens and to the same extent, as a means of preventing citizens of foreign countries from preserving in the United States patents for inventions for which patents granted in their own countries have been allowed to lapse. I would restore that provision of our laws which provided that United States patents granted for the same invention covered by lapsed patents in a foreign country should lapse in this country also. This, it seems to me, would have the effect of opening up competition with foreign owners of United States patents whose patents have been allowed to lapse in their own country. In my judgment a tax, no matter how high it might be, would be paid by any one who had a valuable and comprehensive patent. As for the thousands of useless patents—the imposition of such a tax might cause the owner to allow them to lapse, but as to such patents it is immaterial to any one whether they lapse or not.

RENEWAL FEES ON PATENTS

By T. B. WAGNER, Vice-President U. S. Food Products Corporation, New York City

I am deeply interested in anything pertaining to our patent system, and while heretofore I have not been able to form a conclusive opinion on the subject of renewal fees, a reading of Dr. Hesse's article published in the July issue of *The Journal of Industrial and Engineering Chemistry*, inclines me strongly towards the affirmative. I find myself usually in accord with Dr. Hesse's utterances and the present is no exception. I believe that the suggested progressive fee, totaling \$550 at the end of the seventeenth year, ought not to work any hardship upon the inventor with limited means, but it ought to prove a distinct burden upon those foreign corporations who take an altogether too liberal advantage of our feeless system.

PATENTS—AMERICAN AND FOREIGN

By JOHN URI LLOYD, Lloyd Brothers, Cincinnati, Ohio

My experience with patents both American and foreign leads me to state that I prefer the American process, wherein one payment covers the patent from the beginning to its end.

DR. HESSE'S SUGGESTION OF RENEWAL FEES

By L. H. BAERLAND, Patent Office Committee, National Research Council

Although there are some good arguments in favor of the suggested reform of Dr. Hesse, the matter will specially prove detrimental to individual inventors of limited means. A wealthy company or a rich inventor can well afford to keep patents alive, by paying a small annual renewal fee.

There is no reason, however, why the subject should not be freely discussed. But I am under the impression that this suggested reform, as well as many other small reforms, will only distract attention, at this time, from the much more important fundamental reforms, such as the reorganization of the Patent Office and the reorganization of our system of court procedure through the creation of one single Court of Patent Appeals.

ORIGINAL PAPERS

MODIFICATIONS OF PEARCE'S METHOD FOR ARSENIC

By JOHN WADDELL

Received March 27, 1919

Owing to the difficulty my students experienced in using the Pearce method for determining arsenic in a cobalt ore, I decided to carry out some experiments.

Pearce's original method consisted in fusing the ore with sodium carbonate and potassium nitrate, extracting the fused mass with water, boiling the filtrate with excess of nitric acid to drive off carbon dioxide, neutralizing with ammonia, precipitating the arsenate as silver arsenate, dissolving this precipitate in nitric acid, and titrating the silver with potassium or ammonium thiocyanate. Since silver arsenate is soluble not only in nitric acid and in ammonia, but also to a slight extent in ammonium nitrate, the results are not quite satisfactory.

Canby¹ recommends neutralization of the nitric acid with zinc oxide in excess. He directs that should the zinc oxide cause precipitation of silica or alumina (Canby fused in a porcelain crucible) to filter off, and to the filtrate add more zinc oxide.

Bennett² criticizes Canby's method, stating that it is practically impossible to get the zinc oxide to neutralize the nitric acid and that, therefore, silver arsenate is not completely precipitated. He himself recommends that after fusion and filtration from the residue obtained by leaching in hot water the filtrate shall be acidified with acetic acid and boiled. After cooling, phenolphthalein is added as indicator and caustic soda solution to slight alkalinity and then just enough very dilute acetic acid, drop by drop, until the color is discharged. Silver nitrate is then added and the arsenate titrated as usual.

It may be noted that Bennett read his burette only to the first place of decimals and that the quantity of potassium thiocyanate was small, ranging for the same quantity of arsenic between 8.3 cc. and 8.7 cc., the greater number of the determinations being 8.6 cc. This last number he probably considered nearest correct, for he took for each determination what was supposed to be 0.025 g. of impure arsenic trisulfide, and 8.6 cc. gave 0.024725 g. of arsenic trisulfide, and 8.7 cc. gave 0.025013 g. It is to be noticed that Bennett, while he reads the burette to the first place of decimals only, calculates the weight to the fifth significant figure. Since silver acetate is only sparingly soluble, especially in a solution containing, as Bennett's did, considerable sodium acetate, I think it probable that not only 8.7 cc. but also 8.6 cc. was too high and that the 8.3 cc. may have been nearer right. Bennett gives no method for checking his results.

A number of my students got entirely discordant results in using the two methods, and in fact got discordant results in determinations by the same method.

In some cases, if not in most, in the Canby method,

the zinc oxide had been filtered off before precipitating with silver nitrate and as zinc nitrate gives a precipitate with sodium arsenate it was natural to conclude that arsenic had been lost in this way. Concordant results, however, were not obtained even when the zinc oxide was not filtered off and it seemed likely that the zinc arsenate was not all changed into silver arsenate. Even if the silver nitrate was added first and the zinc oxide afterwards, the results were still unsatisfactory. It seemed evident then that the zinc nitrate reacted on silver arsenate and gave an error, and it was found by a qualitative test that silver arsenate when digested with a concentrated solution of zinc nitrate became lighter in color, white zinc arsenate doubtless replacing silver arsenate.

It seemed then reasonable to conclude that when in the Canby method any considerable excess of nitric acid was present, the zinc nitrate produced prevented the precipitation of all the arsenic as silver arsenate, and that if the excess of nitric acid was very small the results might be accurate.

Accordingly, a solution of sodium arsenate, $\text{Na}_2\text{HAsO}_4 \cdot 12\text{H}_2\text{O}$, of approximately 4 g. per l. was tested. Four lots of 100 cc. each were boiled in Erlenmeyer flasks with 5 cc. of concentrated nitric acid. In Flask A, zinc oxide was added and allowed to stand for about an hour before addition of silver nitrate solution. The precipitate of silver arsenate did not come down at once, but after a few minutes a considerable amount was precipitated. In Flask B, the silver nitrate solution was added first and afterwards zinc oxide. No precipitate appeared for an hour or two. In Flask C, the nitric acid, after cooling, was neutralized and the solution made slightly alkaline, using phenolphthalein as indicator, by dissolving pure caustic soda directly from the stick, so that carbon dioxide would not be taken up from the air. Then the color of the phenolphthalein was discharged by adding very dilute nitric acid drop by drop; excess of silver nitrate was added and a small quantity of zinc oxide. In Flask D, the solution was made alkaline as before and dilute acetic acid was added until there was a drop or two in excess, after which the precipitation was made with silver nitrate.

It may be mentioned that the silver arsenate precipitate in A and B was dark brown; and often, though not always, the precipitate from the nitrate solution was slightly darker than that from the acetate solution. This did not seem to be due either to the contrast of color with the white zinc oxide on the one hand, or to the presence of white silver acetate with silver arsenate on the other. So far as I could detect, the composition did not vary with slight differences of shade.

The four flasks were allowed to stand for a fortnight, being occasionally shaken so that the zinc oxide should have every opportunity to react on the nitric acid. The filtration was done in Gooch crucibles with asbestos, and the crucibles after filtration were placed

¹ *Z. anal. Chem.*, **29**, 187, abstracted in *J. Chem. Soc.*, **68** (1890), 923.

² *J. Am. Chem. Soc.*, **21** (1899), 431.

in beakers; the Erlenmeyer flasks were washed out with about 20 cc. hot nitric acid (1 : 1) which was then brought into the crucibles in the beakers. The silver arsenate dissolved easily, the solution was made up to about 200 cc., the crucible was removed, the asbestos being left in the beaker, and after addition of 5 cc. saturated solution of ferric alum, the silver was titrated with ammonium thiocyanate. The results were as follows:

AMMONIUM THIOCYANATE REQUIRED	
	Cc.
A.....	18.90
B.....	20.40
C.....	19.10
D.....	39.25
	38.69

It was thus seen that with zinc oxide used to neutralize a large amount of nitric acid the results were valueless. This was not, however, as Bennett suggests, because zinc oxide does not neutralize the acid, for the filtrate from the mixture of zinc oxide and silver arsenate was neutral to methyl orange, though a drop or two of very dilute nitric acid gave the red color.

To test the method, I dissolved 1.5 g. of Kahlbaum's pure arsenious anhydride in nitric acid made up to 500 cc. and took lots of 25 cc. each. After I had done some titrating myself I asked one of my students, Miss Lucille Corbett, to do some determinations, which she carried out both on my solution and on one which she prepared for herself. In my determination by the Bennett method I added sodium acetate in considerable excess to use up the nitric acid, while Miss Corbett added caustic soda to slight alkalinity and then acetic acid until slightly acid. Her figure thus obtained was less than mine and more nearly those of the Canby method which in this and subsequent tests was carried out in the modified style with only a slight excess of nitric acid to be neutralized by zinc oxide.

Miss Corbett and I used the same solution of thiocyanate and the same burette and took, respectively, 27.10 cc. and 27.20 cc. thiocyanate for 0.5 g. of silver nitrate. We used the second figure which gave 1 cc. thiocyanate = 0.002704 g. arsenic ($Ag = 108$; $As = 75$). One of Miss Corbett's determinations in each case was made with my solution and the other with her own. Another student, P. A. Poynton, using a different burette and a different thiocyanate solution which was, however, of almost exactly the same concentration as mine, made this determination also.

	Canby Method Cc.	Bennett Method Cc.
Waddell.....	20.98 21.00 21.05	21.40
Corbett.....	20.83 20.86	20.93 20.90
Poynton.....	20.81	21.08

With my solution of thiocyanate, 21.00 cc. corresponded to 75.68 per cent of arsenic, while with Poynton's 21.08 cc. gave the same percentage, the calculated value being 75.75.

The next experiments were made with arsenious anhydride fused with ten or twelve times the amount of sodium peroxide. In all the fusions which follow

sodium peroxide was used instead of a mixture of sodium carbonate and potassium nitrate, a nickel or iron crucible being employed.

The fusion, after extraction with water, was made up to a liter or half a liter as the case might be, and a sufficient quantity taken to require at least 14 cc. of the thiocyanate. Miss Corbett evidently lost some arsenic by volatilization but the results by the two methods agreed closely. The freeing of the residue from arsenic, by extraction of the fused mass with water, is difficult. In my experience, it was not possible to wash out all the arsenic when filtering through asbestos in a Gooch crucible. I filtered by preference through a large filter paper and washed till the washings were no longer alkaline. The residue should always be dissolved in hydrochloric acid and tested with a current of sulfureted hydrogen. It is needless to say that delicate tests such as the Gutzeit in even its crudest form would be certain to show arsenic in the residue, and are not worth trying.

	Canby Method Per cent As	Bennett Method Per cent As
Waddell.....	74.54	75.96
Corbett.....	75.21	76.49
Poynton.....	70.91	71.06
	76.15	78.46

The average of my lowest Bennett and highest Canby is 75.64 per cent As, the calculated being 75.75 per cent. It may be noted that in taking only 15 cc. of thiocyanate a difference of unity in the second place of decimals in reading the burette makes a difference of five in the second place of decimals in the percentage. It will thus be evident what degree of accuracy Bennett attained when his determination required only 8.6 cc. and was read merely to the first place of decimals.

Analyses were made of mispickel. Miss Corbett, Poynton, and I each fused separate lots of 0.2 g. and determined the arsenic in the whole amount. Afterwards the other two fused 0.5 g. of mispickel, made up to a definite volume, and took sufficient of the solution for the determination. The second line for each in the table gives these results.

	Canby Method Per cent As	Bennett Method Per cent As
Waddell.....	22.91	23.38
Corbett.....	23.00	23.79
Poynton.....	24.04 23.68	24.23 23.61

It will be noted that one of Miss Corbett's results by the Canby method was the same as mine by the Bennett method.

Three other students also made analyses of mispickel taken from the same bottle as before but at a different time, their sample being sifted through an 80-mesh sieve. They all used the same burette and the same thiocyanate solution, both burette and solution being different from those already mentioned. H. K. Rowley had already in another laboratory done a number of analyses using Bennett's original method in which there was a large excess of sodium acetate, assuming that his results there obtained were correct. He was asked to compare his former procedure with the proposed modification; and the results given below indicate that the suspicion that Bennett's results

were too high was correct. R. J. Young and J. S. Stauffer used only the modified method.

	Canby Method Per cent As	Bennett Method Per cent As
Rowley.....	24.92	125.48
Stauffer.....	24.39	124.82
Young.....	24.55	24.90
		25.02

With the single exception mentioned, none of the students had attempted the analysis before and in the case of all it was part of their prescribed course. None of them was able to spend enough time to carry out a complete research; but to all, the difficulties were explained and the object to be attained was pointed out and they carried out their analyses with the aim and in the spirit of research.

Two other students, H. C. Boehmer and I. L. Sills, did some pioneer work over a year ago, chiefly in varying tests of Canby's method, and though their results are not included in this paper, their work was as important as that of the others. I may add that in work like this, I think it is possible for students in the second year of their analytical course to get some insight into the methods of research which will help them towards the initiative and judgment so much desired by the industries employing university students and graduates.

SUMMARY

I—Bennett's modification of Pearce's method for arsenic, if carried out as he describes, is likely to give too high results, unless arsenic has been lost by volatilization or otherwise, while Canby's modification, if carried out as he describes, may be so low as to be valueless.

II—Both methods may be modified to give practically concordant results; and if duplicates, determined one by the Bennett method and the other by the Canby method, each modified as described, agree, then the result may be considered correct.

III—In the modification of Bennett's method, any large amount of alkali is acidified with nitric acid, made slightly alkaline with pure caustic soda and very slightly acid with acetic acid, before precipitation of the arsenate as silver arsenate. In the modification of the Canby method the process is similar, except that instead of acetic acid, nitric acid is added in very slight excess and, after addition of silver nitrate, this small excess is neutralized by zinc oxide.

IV—Various determinations are given illustrating the degree of accuracy.

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AN IMPROVED METHOD FOR DETERMINATION OF CARBON BY WET COMBUSTION, USING BARIUM HYDROXIDE AS ABSORBENT

By P. L. HIBBARD

Received March 10, 1919

For the determination of carbon by wet combustion, the writer has for more than a year used a modification and combination of previously published

methods^{1,2,3,4,5} with much success. The method is simple, convenient, inexpensive, rapid, and accurate. It is here presented, with the hope that it may be of use to others.

Complete combustion is secured by suitable proportion and quantity of reagents. Carrying over of volatile acid fumes to the absorbent is avoided by an efficient purifying train. Convenience and accuracy in use of barium hydroxide as absorbent for carbon dioxide are secured by a simple and efficient apparatus without difficult manipulation.

The operation is briefly as follows: The substance is heated in a Kjeldahl flask with chromic anhydride and sulfuric acid whereby carbon is oxidized to carbon dioxide which is carried into a solution of barium hydroxide by a current of purified air. After the reaction is completed the excess of barium hydroxide is determined by titration with standard hydrochloric acid. The amount of barium hydroxide neutralized by carbon dioxide measures the amount of carbon in the substance taken.

DESCRIPTION OF APPARATUS

By reference to Fig. 1 the various parts and arrangement of the apparatus may readily be discovered. First is a bubble tube A, containing a few drops of colored liquid as indicator of the speed of the air current. B is a large test tube filled with soda lime for purifying the incoming air. C is the regulating stopcock; D is a funnel tube with a long stem extending down to the bulb of the Kjeldahl flask F. The end of this long stem is somewhat drawn out to a small opening. Upon D, connected by a two-hole rubber stopper rests E, a graduated dropping funnel for measuring the reagents. F is a long neck, 300 cc. Kjeldahl flask, used for the combustion chamber. From this the gas passes through a glass tube to the bottom of G, a large test tube drawn out at the lower end and fitted with a pinchcock and rubber tube. This acts as the condenser to remove most of the water from the gas. After each combustion is finished the water is drained out of this tube by opening the pinchcock. From G the gas passes through a long tube down to H, a 50 cc., wide-mouth flask containing about 10 cc. of strong sulfuric acid. Upon H, which is fitted with a two-hole rubber stopper, rests a glass tube, I, filled with glass beads wet with sulfuric acid, the purpose of which is to dry the gas. Upon I, connected by a rubber stopper, rests J, a similar tube filled with granulated amalgamated zinc, the function of which is to remove sulfuric acid or other acid fumes from the gas. From the purifying tube J the gas passes through a long tube down to the 500 cc. Florence flask K, which is connected by a two-hole rubber stopper to the Meyer bulb tube L. The lower end of this bulb tube is bent so as to almost touch the bottom of the flask. At the upper end the bend next to the large bulb is partly straightened out so that the bulb stands upright.

¹ Ames and Gaither, *This Journal*, 8 (1916), 1126.

² Truog, *Ibid.*, 7 (1915), 1045.

³ Schollenberger, *Ibid.*, 4 (1912), 436.

⁴ Gortner, *Soil Science*, 2 (1916), 395.

⁵ Brady, *This Journal*, 6 (1914), 843.

This Meyer bulb tube stands at an angle of about 30° with the horizontal. Above the large bulb of the Meyer tube, connected by a rubber stopper, is a small bulb, M, used as a safety trap to prevent carrying over any of the liquid. This bulb M is connected with the suction by N. The suction apparatus may be any form of aspirator or vacuum pump which gives a vacuum equal to about 2 in. of mercury. I use a pressure regulator consisting of a narrow cylinder containing mercury and fitted with a three-hole rubber stopper. One hole is for the connection to the Meyer bulb, one is for the connection to the suction, the other carries a straight glass tube extending about 2 in. below the surface of the mercury. This regulates the vacuum so that if there is more than enough to raise a column of 2 in. of mercury it is relieved by air passing in through this open tube.

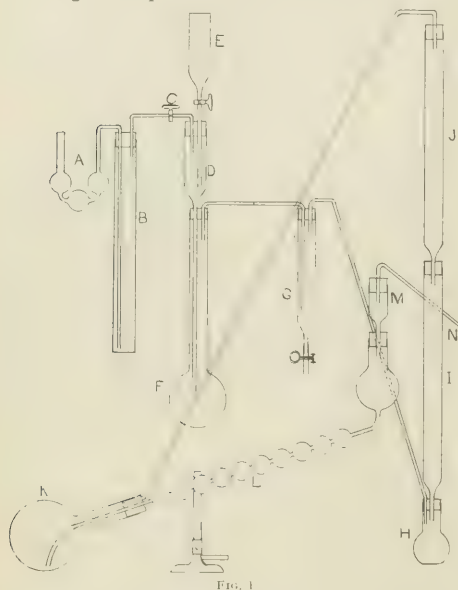


FIG. 1

The whole of the purifying apparatus and the combustion flask are carried on a single, ordinary ring stand. The absorption flask, which may be either a Florence flask or an Erlenmeyer, in an inclined position rests on the table and supports one end of the Meyer bulb tube, the other end of which is supported by a small ring stand.

The above described combustion apparatus comprises a single unit. If it is desired to use more than one the primary purifying train and suction apparatus may be used in common for all of them and it will be easily possible for one person to handle half a dozen units like this at once.

It has been found that this absorption apparatus is more easily handled, more easily washed out, and works better than Truog's ingenious bead tower.¹

The difficulties which previous experimenters have

found in preventing the passage of acid fumes from the digestion flask into the absorbent liquid is perfectly overcome by means of the bead tower with sulfuric acid followed by the tube of granulated zinc. It was found that it was necessary to keep the zinc dry in order to secure efficient working.

THE CONTAINER FOR BARIUM HYDRATE

This consists of a large bottle fitted with a good sized soda-lime tube for purifying all the air that enters the apparatus. The barium hydroxide is drawn off and measured by means of a 50 cc. automatic overflow pipette. The upper end of this pipette is connected back into the top of the bottle so that only air which has passed through the soda lime can enter it. By this means the barium hydroxide may be readily measured out in exact amount and preserved indefinitely from contamination by the air.

DESCRIPTION OF THE METHOD

In the combustion flask place the substance which may contain from 0.10 to 0.15 g. of carbon, for example 0.3 g. of sugar, or 10 g. of soil; connect up with the purifying apparatus. In the 500 cc. Florence flask place 100 cc. of $N/3$ barium hydroxide and 50 to 60 cc. of carbon dioxide-free water. The amount of water added should be such that the barium hydroxide will rise only into the lower part of the large, upper bulb of the Meyer tube when the suction is in operation. This may also be partly regulated by raising or lowering the absorption flask K on the lower end of the Meyer tube. Connect up and turn on the suction so that carbon dioxide-free air passes at the rate of 150 to 200 cc. per min. Place 15 cc. of chromic acid solution in the dropping funnel E over the combustion flask and run it into the combustion flask. If the substance to be burned is readily decomposed the chromic acid must be added slowly in order to avoid a too violent reaction with consequent back pressure, causing low results. Now add 45 to 50 cc. strong sulfuric acid to the dropping funnel and run it cautiously into the combustion flask to avoid too violent reaction. During this time the current of air should pass regularly with no back pressure. After the reagents are added heat gently with a small flame until the acid boils. Continue boiling about 15 min. or until the mixture bums. The whole time should be 25 or 30 min. The reaction is probably complete as soon as the acid boils, but the rest of the time is allowed to sweep all of the carbon dioxide into the absorption vessel. When completed, remove the heat, shut off the suction, disconnect the absorption tube and flask, and rinse out the barium hydroxide from the Meyer tube into the absorption flask with carbon dioxide-free water, using about 200 cc. Stopper the flask and set it aside. The apparatus is now ready to start another combustion, as at first, by substituting a new evolution flask and a freshly charged absorption flask. When this has been properly started it requires no attention for about 20 min. At any convenient time the final titration may be made, or one may wait until ready to make a number of them at once.¹ Add to the liquid in the absorption flask

¹ Loc. cit.

¹ Loc. cit.

4 drops of phenolphthalein solution, 0.2 per cent, and run in standard $N/3$ hydrochloric acid until the pink color disappears. There is no means of knowing when the titration is nearly completed so that it is necessary to proceed cautiously in order to avoid adding too much acid. If this should happen it may be remedied by immediately adding one or two cc. of the standard barium hydroxide, then continuing with the acid carefully to the end-point. A blank should be run for the same length of time and with all the reagents and the same amount of barium hydroxide. The amount of hydrochloric acid required for the determination subtracted from the amount required for the blank gives the amount equal to the carbon dioxide formed: 1 cc. $N/3$ acid = 2 mg. of carbon

APPLICABILITY OF THE METHOD

As the temperature in the reaction flask is that of boiling sulfuric acid it is obvious that the method is not suited for the combustion of volatile substances. It does serve well for the determination of carbon in soils, manures, and agricultural products in general, such as grains, fodders, etc.

PREPARATION OF REAGENTS

BARIUM HYDROXIDE—This is approximately $N/3$. If the solution is much stronger than this it is apt to crystallize out when it gets cold.

STANDARD HYDROCHLORIC ACID—This is $N/3$, standardized by any convenient method. 1 cc. is equivalent to 2 mg. of carbon.

CHROMIC ACID—170 g. of chromic anhydride (CrO_3) is dissolved in 300 cc. of water. Add 25 cc. of sulfuric acid and boil gently for 15 min. to remove any carbon that might be present. Cool and make up to 500 cc.

SULFURIC ACID—Ordinary C. P. concentrated acid, free from carbon.

CARBON DIOXIDE-FREE WATER—This is easily made in quantity by bubbling air which has been freed of carbon dioxide by passing over soda lime or caustic potash, through the distilled water for an hour or two. To determine its freedom from carbon dioxide add a drop or two of phenolphthalein to 100 cc. of the water, then add a drop of barium hydroxide and mix. The water should be strongly colored.

ACCURACY OF RESULTS

The accuracy of the results obtained may be tested by the combustion of substances of known composition. The following results were obtained:

	PER CENT CARBON		
	Theory	Found	
Urea.....	20.0	20.08	19.84
Sugar, 99.6 per cent pure.....	41.9	41.6	41.5
Soil.....	1.374	1.374	1.370
CaCO_3	12.0	11.86	11.86

The strength of barium hydroxide used is such that 1 cc. equals about 2 mg. of carbon. As it is possible to duplicate results within 0.1 cc. this indicates that the error would be 0.2 mg. of carbon. By using an absorption apparatus similar to the Truog tower and with barium hydroxide of one-tenth the above strength and with some extra precautions, it has been found possible to determine accurately carbonate carbon in soils with an error of only one or two p. p. m.

COMPARISON WITH THE GRAVIMETRIC METHOD USING SODA LIME FOR ABSORPTION

The above described apparatus is somewhat simpler and more easily obtainable than that required for the gravimetric method and there is no difficulty due to moisture which must be guarded against in the gravimetric determination. It seems probable that a larger number of units of the volumetric apparatus could be operated by one person than of the gravimetric apparatus. Furthermore it is probable that the error of determination is less in using the volumetric apparatus. This is because the soda-lime absorption bulb is very heavy so that small changes in weight are not readily detected except by means of an extra good balance. On the other hand, in case but few determinations are to be made it will be simpler to use the gravimetric method, as in this case there are fewer solutions to be prepared, and fewer reagents are required. Consequently a few results would be more quickly obtained by this method. As to errors of manipulation it is largely a question of personal error as to which method will prove more satisfactory.

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THE DETERMINATION OF METHYL CHLORIDE IN GAS MIXTURES¹

By V. C. ALLISON AND M. H. M'RHAN

Received March 28, 1919

In the chlorination of natural gas, some method of quickly and approximately determining the methyl chloride produced was necessary as a control over the operation.

In looking over the literature the only method which the authors found described for analyzing methyl chloride was that of heating over soda lime.²

As it was desired to analyze a great number of samples a day, the soda-lime method was far from satisfactory from the standpoint of rapidity.

Considerable time was expended in investigating and developing various suggested methods of determining methyl chloride and part of our results appear in this paper.

PHYSICAL PROPERTIES OF METHYL CHLORIDES³

The gas is colorless and burns with a bright flame, edged with green
Vapor Density = 1.73 (calculated = 1.75)
Specific Gravity = 0.9915 at -23.5°C , and 0.9523 at 0°C .
Specific Volume = 50.8
Solubilities: 1 volume of water dissolves 5.03 volumes of methyl chloride at 17°C . and 3.46 volumes at 20°C .
1 volume of alcohol dissolves 35 volumes of methyl chloride
1 volume of glacial acetic acid dissolves 40 volumes of methyl chloride
(the authors found a somewhat greater solubility in glacial acetic acid)

Vapor Pressure ⁴ Atmospheres	Temperature Deg. C.
2.48	0
4.11	15
6.50	30

CHEMICAL REACTIONS⁵

When passed through a red-hot tube it deposits carbon and yields hydrochloric acid, methane, ethylene, carbon monoxide, and naphthalene.

MATERIAL USED

In our chlorination apparatus the chloroform and carbon tetrachloride were removed by water scrubbers,

¹ Published by permission of the Director of the Bureau of Mines.

² Watts' "Dictionary of Chemistry."

³ *Ibid*.

⁴ Thorpe's "Dictionary of Applied Chemistry."

⁵ A. Ferrot, *Technical Paper* 101, 375.

the dichloromethane and most of the water vapor by an ice-salt bath, and the excess chlorine by a soda-lime tower. It is assumed that no carbon monoxide or hydrogen are formed in the reaction. The effluent gas then consisted of methyl chloride, natural gas, and water vapor.

The authors also secured some commercial methyl chloride from the Frigidor Corporation of New York. It was desired to establish the purity of this commercial product so as to use it in developing a rapid method of analysis suitable as a control in our chlorination work.

This methyl chloride was analyzed by fractionation at low temperatures and low pressures in the low temperature gas fractionation apparatus,¹ modified according to the diagram given in Fig. 1.

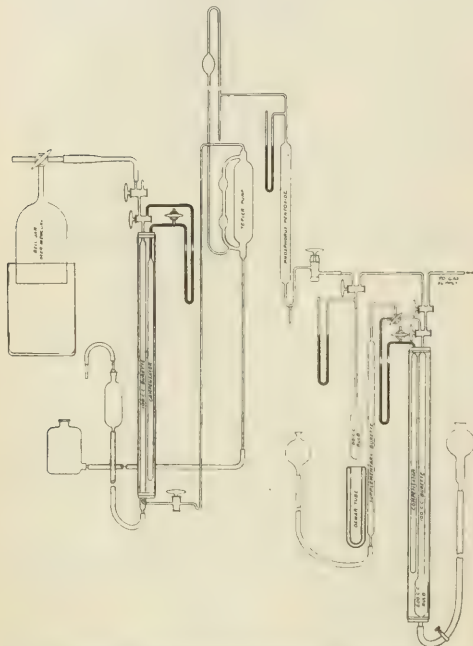


FIG. 1—APPARATUS FOR ANALYSIS OF GASES BY FRACTIONATION

The procedure is essentially as follows:

Before the analysis the whole system is evacuated up to the stopcock of the measuring burette. The gas to be analyzed is run into a burette and measured. It is then condensed into a small bulb which is immersed in a liquid air bath. If the gas in the bulb contains any constituent which possesses a measurable vapor pressure at this temperature, it is pumped off by means of the Toepler pump into another burette and measured. It is then removed and subjected to a combustion or other suitable analysis.

The temperature of the bulb is now raised until some other constituent of the condensed gas possesses a

¹ G. A. Burrell, F. M. Seibert and I. W. Robertson, "Analysis of Natural Gas and Illuminating Gas by Fractional Distillation at Low Temperatures and Pressures," Bureau of Mines, *Technical Paper 104* (1915).

measurable vapor pressure. This gas is then handled as before. The bath used above the temperature of liquid air is a pentane bath cooled to the desired temperature by means of liquid air. The temperature of this bath will rise about 5° C. while a given gas is being pumped off.

The vapor pressure of the methyl chloride from the Frigidor Corporation was as follows:

Temperature Deg. C.	Vapor Pressure Mm. of Hg
-103	3
-95	5.5
-81	12

At about -75° C. the vapor pressure rapidly dropped and was practically negligible at -70° C. (We started pumping off at -103° C. and stopped pumping at -70° C.) This fraction which came over between -103° C. and -70° C. was assumed to be all methyl chloride. Two samples thus gave 98.8 per cent and 100 per cent, or an average of 99.4 per cent methyl chloride. There was no water vapor present in the sample.

DETERMINATION BY THE GLACIAL ACETIC ACID METHOD

The high solubility of methyl chloride in glacial acetic acid immediately suggested its use in its determination.

In this method the gaseous methyl chloride or methyl chloride mixture is measured in a gas burette and passed six times into a Hempel pipette containing glacial acetic acid. The remaining gas is brought back into the burette and measured. The contraction indicates the methyl chloride present in the sample. The number of passes is limited to six on account of the solubility of natural gas in the acid (4 volumes of natural gas are soluble in 1 volume of glacial acetic acid) and we wished primarily to analyze samples containing natural gas.

The absorption of methyl chloride by glacial acetic acid is apparently a physical phenomenon as indicated by the following:

(a) The residual partial pressure of methyl chloride, in a series of gas mixtures varying in methyl chloride content from 10 per cent to 90 per cent, was approximately a constant after absorption in the glacial acetic acid.

(The solubility of methyl chloride in glacial acetic acid is so great that the increasing vapor pressure in the gas phase, due to the increasing methyl chloride concentration in the liquid phase, can be disregarded over an interval of several analyses.)

(b) After saturating glacial acetic acid with methyl chloride it was neutralized and titrated with silver nitrate for hydrochloric acid and less than 1 per cent of the hydrochloric acid equivalent to the methyl chloride present was found, indicating that the reaction $\text{CH}_3\text{Cl} + \text{CH}_3\text{COOH} = \text{HCl} + \text{CH}_3\text{COOCH}_3$ did not take place.

(c) A sample of the acid that had been used for several days (not nearly saturated, however) was neutralized with carbonate-free sodium hydroxide

and each cubic centimeter of the acid gave up 5.3 cc. of methyl chloride.

Water vapor and air decrease the methyl chloride value obtained by the glacial acetic acid, while natural gas increases this value due to the solubility of the natural gas in the acid. As the acid becomes saturated with methyl chloride its powers of absorbing it are correspondingly reduced and low values result.

The natural gas used in these mixtures was supplied from the mains at Pittsburgh, Pa., and has the approximate analysis of 86.3 per cent methane, 9.9 per cent ethane, 2.7 per cent propane, and 1.1 per cent nitrogen.

The curves obtained by plotting the methyl chloride content of known mixtures against that given by the glacial acetic acid on the same sample are given in Fig. 2.

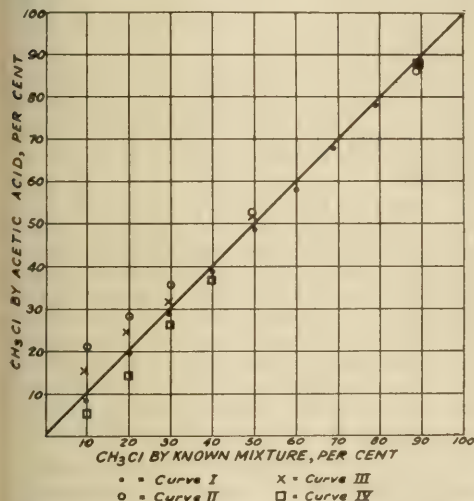


FIG. 2

Curve I, Fig. 2, is a methyl chloride-air mixture with no water vapor present except that contained in the air used and varying from 10 per cent to 90 per cent methyl chloride. The straight line indicates where the points would fall if the acetic acid gave the true value of the methyl chloride in the mixture. The distance of the points from the line probably lie within the limits of experimental error although air slightly decreases the absorption of methyl chloride by glacial acetic acid.

Curve II, Fig. 2, is a methyl chloride-natural gas mixture with no water vapor present except that present in the gas. The methyl chloride content of the various mixtures ranges from 10 per cent to 90 per cent. In the mixtures of low methyl chloride content the solubility of the natural gas in the acetic acid, although only one-tenth that of the methyl chloride, becomes of great importance because of the large partial pressure of the natural gas in the mixture in comparison with the low partial pressure of the methyl chloride. Above 40 per cent methyl chloride, the solubility of the natural

gas plays a minor part. Natural gas mixed with methyl chloride increases the apparent methyl chloride value obtained by the glacial acetic acid method, especially at low concentrations of methyl chloride.

Curve III, Fig. 2, is a methyl chloride-natural gas mixture saturated with water vapor. The discrepancy at low methyl chloride concentrations in this case is not so pronounced as in the methyl chloride-natural gas mixtures with little water vapor present.

Curve IV, Fig. 2, is a methyl chloride-air mixture saturated with water vapor. The repressive action of water vapor on the absorption of methyl chloride by glacial acetic acid is quite pronounced in this case.

In all these mixtures with a methyl chloride content of 40 per cent or more, the glacial acetic acid method gives fairly good results. With lower concentrations of methyl chloride the results are not so accurate.

THE PARTIAL PRESSURES METHOD OF DETERMINATION

An unmeasured sample of the effluent gas from the chlorination apparatus was introduced into the bulb of a low temperature fractionation and apparatus¹ and adjusted to atmospheric pressure which was recorded. The bulb was now cut off from the rest of the system, immersed in a liquid air-pentane bath below $-135^{\circ}\text{C}.$, and left for 10 min. The bulb was now connected with the Toepler pump and the methane pumped off. The bulb was cut off from the rest of the system again, the bath removed and the bulb allowed to come to room temperature and the vapor pressure read. As the sample contained only natural gas (which had been pumped off below $-135^{\circ}\text{C}.$), methyl chloride and a small amount of water vapor (which was removed by having the bulb two-thirds filled with phosphorus pentoxide on glass wool), the ratio of the partial pressure of the methyl chloride to the total pressure at the start (barometer) gave the percentage of methyl chloride direct.

Fig. 3 gives the results of the partial pressures method plotted against the results of the glacial acetic acid method on the same sample.

THE COMBUSTION METHOD OF DETERMINATION

The methyl chloride was assumed to burn according to the reaction



The sample was mixed with an excess of oxygen in an Orsat and subjected to slow combustion over a 5 per cent sodium hydroxide solution. The carbon dioxide and gaseous hydrochloric acid not absorbed by the sodium hydroxide were absorbed in the potassium hydroxide of the Orsat, without measuring, and the residual gas then returned to the burette and measured. The carbon dioxide and hydrochloric acid were absorbed by the sodium hydroxide and potassium hydroxide and the water condensed, leaving zero volume on the right side of the equation. This gives a total contraction of the left side of the equation or $5/2$. The total contraction then, divided by $5/2$, would give the methyl chloride which has been oxidized.

The sodium hydroxide solution was neutralized and

¹ Loc. cit.

the hydrochloric acid absorbed was titrated with silver nitrate. One volume of methyl chloride should give one volume of hydrochloric acid.

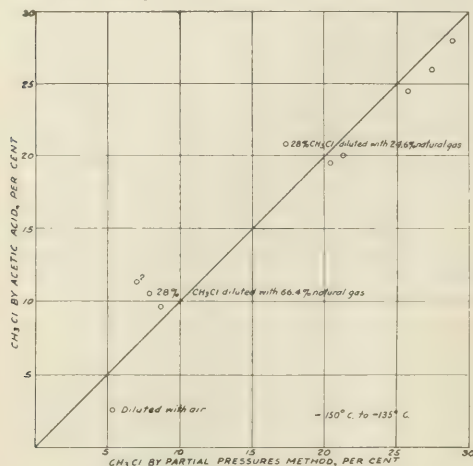


Fig. 3

On nine samples of the methyl chloride, the combustion data gave a value of from 86 per cent to 93.3 per cent. The hotter the platinum spiral in the combustion pipette, the greater the percentage of methyl chloride obtained. The corresponding values obtained by titrating the hydrochloric acid formed varied from 62.7 per cent to 79.8 per cent. This discrepancy may be due to part of the hydrochloric acid not being absorbed by the 5 per cent sodium hydroxide solution and later being absorbed by the potassium hydroxide pipette on the Orsat. This amount of hydrochloric acid would, therefore, not appear in the titration.

This method, moreover, is not suitable where other combustible gases are mixed with the methyl chloride.

CONCLUSIONS

The glacial acetic acid method is by far the most rapid method of determining methyl chloride in mixtures, and in mixtures with a methyl chloride content of 40 per cent or more, the results lie within the limits of experimental error. Below 40 per cent, the probable error of the determination is about 4 or 5 per cent.

Water vapor and air decrease the absorption of methyl chloride by glacial acetic acid.

The partial pressures method gives results on methyl chloride-natural gas mixtures comparing with the glacial acetic acid results on the same sample to a probable difference of 0.6 per cent.

The combustion method is not suitable on mixtures of methyl chloride with other combustible gases, and on pure methyl chloride the temperature required for complete combustion is too high for the platinum spiral to last long.

For control work on the chlorination process, where relative values only are required, the great rapidity and ease of manipulation of the glacial acetic acid method makes it the most desirable.

ACKNOWLEDGMENT

The authors wish to thank Dr. G. B. Taylor, Mr. G. W. Jones, and Mr. W. L. Parker for their valuable suggestions and assistance in this work.

BUREAU OF MINES
WASHINGTON, D. C.

EQUILIBRIUM STUDIES UPON THE BUCHER PROCESS

By J. B. FERGUSON AND P. D. V. MANNING

Received April 19, 1919

The solution of the many-sided problem of nitrogen fixation required the carrying out of a number of researches, and at the request of the Nitrate Division of the Ordnance Department, the Geophysical Laboratory of the Carnegie Institute undertook, with the cooperation of that Division, several of these investigations, one of which was a study of the Bucher process. In this work the Nitrate Division was represented by Mr. Manning.

The so-called Bucher process¹ consists essentially in heating a mixture of sodium carbonate, carbon, and iron in an atmosphere of nitrogen. The rôle of the iron is generally assumed to be purely catalytic, and according to Bucher the equation for the reaction may be written



In his original article, Bucher states that at moderate temperatures, such as 900° to 950° C., the process may be operated using producer gas instead of pure nitrogen without loss in efficiency, provided that the product be not allowed to cool in the producer gas. The validity of this assertion seemed to be questioned by several results obtained during the operation of semi-commercial plants and for this reason we were asked to determine, if possible, the influence of carbon monoxide in the furnace gases upon the yield of sodium cyanide.

The character of this influence may be seen from the following theoretical considerations: Assuming, as Bucher has done, that the reaction involves only the two salts, sodium carbonate and sodium cyanide, and knowing that these salts when melted together form a homogeneous liquid,² and also that at temperatures at or above 950° C. metallic iron is the stable phase³ in the presence of equilibrium mixtures of carbon monoxide, carbon dioxide, and carbon, then the phases present at equilibrium at these temperatures will be iron, carbon, a liquid phase and a gas phase. The components are iron, carbon, nitrogen, sodium, and oxygen, and hence from the application of the phase rule in its simplest form⁴ the degrees of freedom are three in number. This means that if the temperature and pressure be fixed, variations in the composition of the gas phase must be accompanied by corresponding variations in the composition of the liquid phase and *vice versa*. Thus the yield of cyanide will be directly dependent upon the composition of the gas phase present during the operation of the process. The magnitude of the variations in the composition

¹ THIS JOURNAL, 9 (1917), 233.

² Unpublished results of Dr. E. Posnjak of this laboratory.

³ Hilpert and Dreckmann, *Ber.*, 43 (1915), 1281-6.

⁴ $P + F = C + 2$.

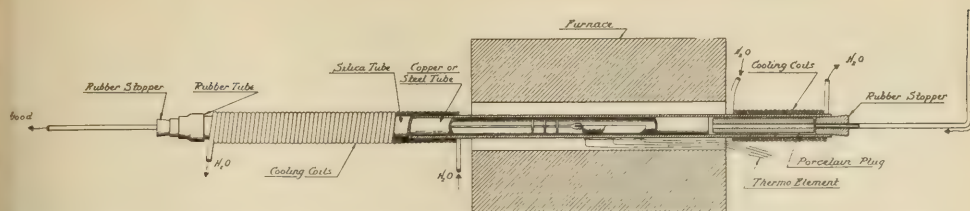
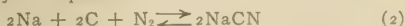


FIG. 1—CROSS SECTION OF FURNACE USED FOR HEATING CARBONATE-CYANIDE-IRON-CARBON CHARGE IN CURRENT OF CO CO₂ N₂ MIXTURE

of one phase caused by given variations in the composition of the other phase is not indicated by the phase rule and Bucher evidently thought that at temperatures as high as 950° C. the deleterious effect of the presence of considerable percentages of carbon monoxide in the furnace gases was inappreciable. But the complicated relations which exist at equilibrium are in no wise indicated by Equation 1. In addition to nitrogen and carbon monoxide, the vapor phase must contain carbon dioxide,¹ sodium or an oxide of sodium, and sodium cyanide,² and possibly other substances as well. Similarly, in addition to sodium carbonate and sodium cyanide, the liquid phase must contain carbon dioxide, carbon monoxide, nitrogen, and some excess sodium,³ the exact form of combination of the sodium is unknown, but probably most of it is present as oxide. The calculation of the equilibrium constant for the gaseous or for the liquid phase can only be made if we know the concentration of all of the reacting constituents of the phase in question. Thus if we assume that the reaction in the vapor phase is represented by the equation



the equilibrium constant will be defined by the equation

$$K = \frac{C^2_{\text{NaCN}}}{C^2_{\text{Na}} \cdot C_{\text{N}_2}} \quad (3)$$

and no matter how small the values of C_{NaCN} or C_{Na} may be, unless they are constant they cannot be neglected. In the liquid phase the relations are much more complex and here also the concentration of the various constituents, regardless of their magnitude, cannot be neglected unless they are constant. The determination of the equilibrium constants is, therefore, probably unattainable experimentally. In view of this situation our problem resolves itself into the determination of certain empirical relations which may be considered a measure of the actual equilibrium conditions, and we therefore set out to determine the variations in the amount of the alkali in a charge which was converted at equilibrium to cyanide, with known variations in the composition of the gas stream passing over the charge.

For this purpose boat experiments were thought best suited and the apparatus used is shown in Fig. 1.

¹ Carbon monoxide dissociates to form carbon dioxide according to the equation $2\text{CO} \rightleftharpoons \text{CO}_2 + \text{C}$.

² Bucher and others have shown that sodium cyanide is volatile at temperatures in the neighborhood of 1000° C.

³ Sodium carbonate is supposed to dissociate according to the equation $\text{Na}_2\text{CO}_3 \rightleftharpoons \text{Na}_2\text{O} + \text{CO}_2$, but the relations which obtain at small CO₂ pressures have not been thoroughly investigated.

The furnace was one especially designed for the production of uniform temperature in a central region 12 to 15 cm. in length, and has been previously described elsewhere.¹ The temperatures were measured by means of a differential platinum-platinrhodium thermoelement with a suitable potentiometer set-up. The outer tube of silica was protected by an inner tube of copper or iron from the fluxing action of the furnace vapors.² For the quantitative studies the copper tube was used. The boat was made of iron, 12 cm. in length, divided transversely into two compartments, and was welded to a small steel rod which served as a means of inserting or withdrawing it. The baffles on the rod and the porcelain plug in the other end of the furnace tube all served to reduce the end heat-losses from the furnace. In front of the boat in the metal tube was placed some pure charcoal which was intended to reduce any carbon dioxide formed in the gas mixtures at the lower temperatures and to ensure that the gas mixture passing over the charge contained carbon monoxide and carbon dioxide in equilibrium proportions.

The charges were made up by mixing together sodium cyanide or sodium carbonate (Squibb's reagents) with carbon and iron, at first in varying amounts and finally in the proportions 3 of carbonate (or cyanide) : 1 of carbon : 1 of iron, by weight. The carbon used was pure untreated gas-mask charcoal furnished us from the supply at the American University Experiment Station of the Chemical Warfare Service. The iron was a hydrogen-reduced product obtained from Merck and was preheated at 800° C. in a vacuum for several hours to remove hydrogen.

The gas mixtures were prepared from commercial (Linde) nitrogen from which the oxygen had been removed, and pure carbon monoxide prepared by the sulfuric acid-formic acid method. Before such mixtures entered the furnace they were carefully dried with sulfuric acid and phosphorus pentoxide. They were kept in gasometers over mercury. The procedure was as follows:

(1) The furnace was brought up to temperature with the empty boat inserted and a slow stream of nitrogen flowing through.

(2) The boat was pulled into the cold portion of the tube and when cooled, removed.

(3) The boat was filled with the charge or charges as desired, and slowly inserted into the furnace, a gradual heating reducing the danger of the charge being carried out of the boat by the gases released at the high temperatures.

¹ J. B. Ferguson, *Phys. Rev.*, **12** (1918), 81.

² E. Posnjak and H. E. Merwin, *J. Wash. Acad. Sci.*, **9** (1919), 28.

(4) When the boat was in position, the nitrogen was shut off and the gas mixture allowed to flow slowly through the furnace for some hours (usually 3 to 5 hours) during which time the furnace was again brought up to and maintained at the desired temperature.

(5) The experiment having run for a sufficient time, the boat was pulled into the cold part of the tube and when cold, removed from the furnace.

(6) The charges were taken from the boat, bottled, placed in a desiccator, and as soon as possible after removal examined microscopically. Later, chemical analyses of the charges were made, for which purpose aqueous extracts of the charges were used. These analyses consisted in most cases in determining the cyanide by the Lundell¹ method in which nickel ammonium sulfate and di-methyl-glyoxime are used and the total alkali by titration with standard sulfuric acid, using methyl orange as an indicator. Cyanates were sometimes tested for by boiling the solution with an excess of sulfuric acid and determining this excess with standard alkali, using methyl orange as an indicator. The difference between this latter titration and the direct titration with acid should represent approximately twice the amount of cyanate present.² In several experiments tests were made for free alkali. This was done by determining, in addition to the cyanate and cyanide, the carbonate, and then getting by difference from the total alkali the alkali not present in the form of these salts. The carbonate was determined by precipitation with barium chloride with suitable precautions.

Experiments at 950° to 1000° C. with concentrations of carbon monoxide as high as 80 per cent did not cause any change in the iron boat, thus confirming the observations of Hilpert and Dreckmann who found that iron was stable in the presence of equilibrium mixtures of carbon monoxide and carbon dioxide at these temperatures.

After several experiments it was found necessary to remove the protecting metal tube and clean it, as the sublimate which condensed in the colder portions of the tube interfered with the movement of the boat. This sublimate, when gas mixtures containing carbon monoxide were used, was always mainly sodium carbonate, but when pure nitrogen was used was sodium cyanide. The amount of this sublimate appeared to be greater when sodium carbonate was in the initial charge than when cyanide only was present, and this indicates that the alkali present in the vapor phase is only partly there in the form of cyanide. In some experiments evidence of the presence of sodium vapor was obtained but the evidence is not conclusive, as an equilibrium condition may not have existed in these experiments. These observations indicate that appreciable amounts of cyanide and alkali are probably present in the vapor phase at equilibrium.

Posnjak and Merwin³ found that when the process was carried out in a copper tube in the laboratory the product was essentially a mixture of carbonate and cyanide, but that the sinters prepared commercially contained mainly an unknown compound. The former observation using pure nitrogen has been confirmed by us at 950° and 1000° C. and also with gas

mixtures which contained initially from 5 to 80 per cent carbon monoxide. However, when we used an iron tube we were able to prepare small amounts of the unknown compound mixed with cyanide. The only reasonable explanation of this, in view of the fact that an iron boat was used in all experiments, seemed to be that the iron had at low temperatures taken the oxygen from the incoming gases and so changed their composition that the unknown compound could be formed. To test this hypothesis one experiment at 950° C. using a copper tube and an initial gas containing but 1.9 per cent of carbon monoxide was made. The initial mixture placed in the boat was a pure cyanide mixture and after four hours was found to contain definite traces of the unknown compound. This compound would, therefore, appear to form very slowly in the presence of low concentrations of carbon monoxide and carbon dioxide.

The presence of cyanates in the liquid phase could not be proved, even when high concentrations of carbon monoxide were used, by either the microscopic or chemical methods, but charges containing carbonate always contain also some free alkali. One charge was found to contain as high as 5 per cent free alkali and the commercial sinters often contain even higher percentages.

TABLE I—RESULTS OF COPPER TUBE EXPERIMENTS AT 1000° C.

Expt. No.	Initial Charge	Initial Gas Per cent	A Cyanide Titration Cc.	B Total Alkali Titration Cc.	Cyanide Conversion = 100 X A/B Per cent
1	Carbonate	CO = 5 N ₂ = 95	8.2	2 X 5.2	79
	Cyanide	CO = 5 N ₂ = 95	9.9	2 X 6.1	81
2	Carbonate	CO = 7.2 N ₂ = 92.8	9.2	12	77
3	Carbonate	CO = 15.3 N ₂ = 84.7	10.8	15.4	70
4	Carbonate	CO = 19.1 N ₂ = 80.9	5.8	9	64
5	Carbonate	CO = 48 N ₂ = 52	3.7	6.4	58
	Cyanide	CO = 48 N ₂ = 52	8.1	13.6	60
6	Carbonate	CO = 47.3 N ₂ = 53	2.4	4.0	60
7	Carbonate	CO = 81.5 N ₂ = 18.5	3.4	14.1	24
	Cyanide	CO = 48 N ₂ = 52	1.5	8.3	18

TABLE II—RESULTS OF COPPER TUBE EXPERIMENTS AT 946° C.

Expt. No.	Initial Charge	Initial Gas Per cent	A Cyanide Titration Cc.	B Total Alkali Titration Cc.	Cyanide Conversion = 100 X A/B Per cent
1	Cyanide	CO = 4.5 N ₂ = 95.5	8.8	11.8	75
2	Cyanide	CO = 9.5 N ₂ = 90.5	6.4	9.8	65
3	Cyanide	CO = 16.9 N ₂ = 83.1	3.9	6.6	59
	Carbonate	CO = 16.9 N ₂ = 83.1	2.9	5.6	52
4	Cyanide	CO = 48 N ₂ = 52	3.5	12.3	28
	Carbonate	CO = 48 N ₂ = 52	2.1	7.7	27

The same liquid phase could be obtained with a given gas mixture, but different initial solids. Thus when the boat was filled with two mixtures, one in each section (a pure carbonate and a pure cyanide mixture) and the gas stream allowed to flow over the charges for a sufficient time (about 5 hrs.), the charges appeared to be identical both by microscopic and by chemical tests. Were it not for the volatile nature of some of the constituents, this result might be taken as absolute proof that an equilibrium condition had been reached. It

¹ Lundell and Bridgman. *THIS JOURNAL*, 6 (1914) 554.

² Cyanates are decomposed by strong acids like hydrochloric or sulfuric to form ammonia and carbon dioxide. The small amount of cyanic acid which may form when sulfuric acid is used would not interfere appreciably with this test.

³ *J. Wash. Acad. Sci.*, 9 (1919), 28.

does act as a rough check on the uniformity of the temperature of the boat, but if any constituent were to volatilize more rapidly from a given charge than it is formed in that charge, then the resulting condition found is a stable one representing a balance of reaction velocities, and this condition may be quite different from a true static equilibrium. The method we have used is susceptible to this rather grave source of error but we believe our results, given later, indicate that the errors involved in its use are not of any great magnitude. Our quantitative results are given in Tables I and II. In these tables the column headed "Initial Gas" gives the composition of the gas mixture as made up, the "Titrations" are actual titrations in cubic centimeters, and the "Percentage Conversion" is the weight percentage of the total sodium carbonate which has been converted into cyanide.

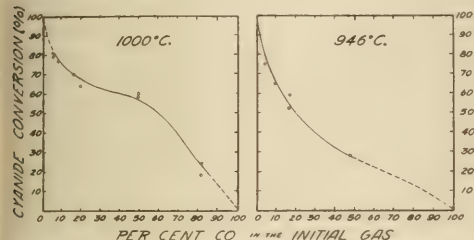


FIG. 2.—RELATION BETWEEN CYANIDE CONVERSION AND PERCENTAGE OF CARBON MONOXIDE IN INITIAL MIXTURE AT 1000° AND 946° C.

In Fig. 2 the percentage conversions given in Tables I and II are plotted against the carbon monoxide content of the initial gas upon the assumption that no complications occur at very high or very low concentrations of carbon monoxide. This assumption must involve some error at low concentrations, since under these conditions some of the unknown compound is formed, and may also not be justified at the high concentrations, although the error here is probably less than at low concentrations.

The following interesting deductions relative to commercial cyanide processes¹ may be made from the location of these curves:

(1) The effect of temperature upon the possible yield of cyanide (yield at equilibrium) is relatively small at small concentrations of carbon monoxide, but if producer gas containing say 30 per cent carbon monoxide were used, would be an important factor.

(2) At 1000° C. producer gas can be used with a possible conversion of 63 per cent. A higher temperature would probably increase this conversion² but even at 1000° the advantages gained through the use of producer gas might more than offset the smaller conversion due to the use of producer gas in place of pure nitrogen.

(3) The presence of 15 per cent carbon monoxide

¹ If a process involves components in addition to those considered by us, this fact must be borne in mind in the application of our results to such cases, in which quite different yields might be obtained.

² Bucher's ideas regarding the use of producer gas were probably based upon experiments in which the temperatures of the charge were not accurately known.

in the initial mixture causes a reduction of 30 per cent in the conversion at 1000° C. The presence of 60 per cent carbon monoxide reduces the conversion to 50 per cent.

Therefore, if the initial gas contains carbon monoxide in small amounts, efforts should be made to keep this content as small as possible, but if the initial gas contains relatively large amounts of carbon monoxide, such as 25 or 30 per cent, slight variations in this content will have little effect upon the yield.

The mechanism of the reaction was conceived by Bucher to consist first in the reduction of the sodium carbonate by carbon to form sodium and, second, the reaction of this sodium with carbon and nitrogen to form cyanide. The first stage may well be the controlling one.

Now the rôle played by the carbon in this stage may be merely to control the carbon dioxide pressure and ensure that it is kept well below the dissociation pressure of the carbonate. The equilibrium between carbon monoxide, carbon dioxide, and carbon is very dependent upon both the temperature and the total pressure, so if our speculations even approximate the truth one would expect the yield of cyanide to be less dependent upon the temperature when referred to a carbon dioxide basis than when referred to a carbon monoxide basis. In Fig. 3 are curves showing the variation of the cyanide conversion with the carbon dioxide content of the gas phase. The results of Rhead and Wheeler¹ were used to calculate the carbon dioxide content from the carbon monoxide content, but their work did not extend to the low pressures and the curves are, therefore, only approximately correct. They do bear out, to a considerable extent, the speculations in which we have just indulged.

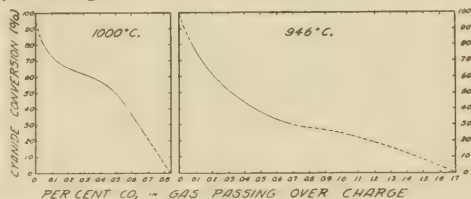


FIG. 3.—RELATION BETWEEN CYANIDE CONVERSION AND PERCENTAGE OF CARBON DIOXIDE IN GAS PASSING OVER CHARGE (GAS CONSISTING OF EQUILIBRIUM MIXTURE OF CO AND CO₂ TOGETHER WITH NITROGEN)

The microscopic examinations were made by Dr. H. E. Merwin of this laboratory, and thanks are due him for his generous assistance.

SUMMARY

Experiments were made on the Bucher process using pure chemicals and mixtures of pure nitrogen and carbon monoxide in known proportions. Curves have been obtained showing (1) the relation between the carbon monoxide content of the furnace gases and the yield of cyanide, and (2) the relation between the carbon dioxide content of the furnace gases and the yield of cyanide, both at two temperatures. The

curves indicate that under certain conditions producer gas may be used in the process and that the dissociation of sodium carbonate is probably one of the controlling chemical reactions.

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A STUDY OF THE OIL FROM SUMAC (*RHUS GLABRA*)

By H. W. BRUBAKER

Received April 24, 1919

Since the demand for fats has increased so greatly and their price has reached such a high level it has become imperative that we make use of all the available sources of this most important material. A great deal of the rocky wasteland of Kansas and other states is covered with the common sumac (*Rhus Glabra*). It occurred to the author to make a chemical study of the oil from the sumac seed to determine its fitness as a food or for industrial purposes and the amount available.

The berries from which this oil was obtained were gathered at Manhattan, Kansas, in February 1919. The husks were removed from the berries by rubbing gently in a mortar and sending the material through a small fanning mill. The clean, air-dried seeds were ground in a mill and the fat extracted with dry ether in a continuous extraction apparatus large enough to hold 2 or 3 lbs. of the material. Two determinations gave an average of 11.71 per cent of oil in the ground seeds. Table I summarizes the results of the physical and chemical examination of the oil.

TABLE I

SAMPLE No.	Sp. Gr. at 15° C.	Index of Refraction at 20° C. Abbe's Refractometer	Acid Value	Acetyl Value	Saponification No.	Iodine Value	Insoluble Fatty Acids	
							Per cent	Per cent
1.....	0.92568	1.4710	0.9	9.27	193.2	126.55	0.85	92.68
2.....	0.92587	1.4710	...	9.20	193.8	126.98	0.67	93.55
3.....	0.92577	1.4710	...	...	190.8	...	0.78	94.38
Av.....	0.92577	1.4710	0.9	9.235	192.6	126.76	0.766	93.54

Table II gives the characteristics of the insoluble fatty acids.

TABLE II

Melting Point Deg. C.	Solidification Temperature Deg. C.	Index of Refraction	Iodine Value
17	6	1.470	121.8

The oil of sumac has a mild odor, pleasant taste, and a deep yellow color. It is quite viscid at ordinary room temperature. Upon being cooled it thickens gradually until at -16° C. it has the consistency of soft vaseline. The oil was not cooled to its freezing point; G. B. Frankforter and A. W. Martin give the freezing point of the oil from *Rhus Glabra* gathered in Minnesota as -24° C.¹

TABLE III

Oil Tested	Percentage Increase in Weight in 7 Days of a Thin Film of Oil	RISE IN TEMP. ON TREATMENT WITH CONCD. H ₂ SO ₄	
		Initial Temp. Deg. C.	Highest Temp. Deg. C.
Linseed oil.....	9.30	20	94
Sumac oil.....	1.66	20	70
Cottonseed oil.....	0.65	20	55

These authors also found an iodine value of 87 which differs materially from that found for the Kansas oil,

126.76. The high iodine value would indicate that the oil should have fairly good drying qualities. This conclusion is substantiated by the results of comparative tests shown in Table III.

A small amount of the oil mixed into a paste of the consistency of paint with sublimed white lead and spread on a plate of glass dried completely in three days.

The oil saponifies readily, giving a sodium soap of semisolid consistency.

It seems fair to conclude from the above study that sumac oil compares favorably in properties with other vegetable oils such as cottonseed oil and corn oil. It might readily find a use as an edible oil or in the soap-making industry or as a semidrying oil in the paint industry, if it can be put on the market at a reasonable cost. The amount which might be made available can only be estimated. The author believes a conservative estimate of the amount of sumac seed in the state of Kansas alone to be 60,000,000 lbs. containing 6,000,000 lbs. of oil. Whether sumac can be made a practical source of oil or not can be determined only by some manufacturer situated so as to be able to handle the extraction of the oil. Those companies which extract the coloring matter from sumac or extractors of other vegetable oils are probably best situated to work out the problem.

DEPARTMENT OF CHEMISTRY
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COLOR STANDARDS FOR COTTONSEED OIL

By H. V. ARNY, CHARLOTTE KISH AND FRANCES NEWMARK

Received April 21, 1919

As is commonly known, the commercial grading of cottonseed oil is largely a matter of color, and much work has been done in attempting to find an ideal standard for the color of this commodity.

The glasses of the Lovibond tintometer have been largely used for this purpose, but I. G. Priest of the Bureau of Standards has shown¹ that out of 219 glasses borrowed from cotton oil concerns and tested by him, 9 per cent of the red glasses between 0.1 and 3.0 were not matches against the Bureau of Standard sets; 51 per cent of the red glasses between 4.0 and 20.0 were not matches; 14 per cent of the yellow glasses between 0.1 and 3.0 were not matched; and 40 per cent of the yellow glasses between 4.0 and 20.0 were not matched.

This report shows that the Lovibond apparatus is not the ideal standard upon which to base a country-wide valuation of cottonseed oil. Priest, in turn, attempted to solve the problem of authentic samples of cottonseed oil enclosed in sealed vacuum cells of the proper shape and dimensions to be examined in a colorimeter. While it is known that the color of cottonseed oil is susceptible to change when exposed to the air, Priest's preliminary experiments led him to the conclusion that a sample inclosed in a sealed vacuum cell would not be thus altered. The test of time, however, showed that such changes did take place and

¹ Am. J. Pharm., 76 (1904), 151.

¹ Proc. Soc. Cotton Products Analysts, 1913, p. 6.

he reported (in an address before the International Cotton Seed Crushers Association, June 7, 1916) that after 15 to 25 wks. the color of his samples changed 1 point red on the Lovibond scale when viewed in a $5\frac{1}{4}$ -in. cell.

One of us has interested himself in standardized colored fluids since 1911¹ and having become convinced regarding the uniformity, permanency, and simplicity of the acid cobalt-ferric-copper solutions (the "Co-Fe-Cu" fluids) and of the ammoniacal cobalt-chromate-copper solutions (the "Co-Cr-Cu" fluids) devised by him, he enlisted the services of Miss Charlotte Kish and Miss Frances Newmark, in carrying out during the past year the experiments reported below. While there were some difficulties encountered in the work, he feels justified in stating that in his opinion the matching of cottonseed oil with the standardized fluids is entirely feasible.

Summarizing information concerning the "Co-Fe-Cu" and the "Co-Cr-Cu" fluids that has been already published, the former are prepared by the blending of the three basic fluids, a red *N*/2 solution of cobalt chloride in 15 per cent hydrochloric acid (14.74 g. cobalt (Co) per l.), a yellow *N*/2 ferric chloride solution in 15 per cent hydrochloric acid (9.308 g. iron (Fe) per l.), and a blue *N*/2 copper sulfate solution in 15 per cent hydrochloric acid (15.8925 g. copper (Cu) per l.).

The "Co-Cr-Cu" fluids are prepared from three basic fluids, a red *N*/10 cobaltamine solution in 2.8 per cent ammonia water (2.9485 g. cobalt (Co) per l.), a yellow *N*/10 ammonium chromate solution in 2.8 per cent ammonia water (0.8666 g. chromium (Cr) per l.), and a blue *N*/10 cuprammonium sulfate solution in 2.8 per cent ammonia water (3.1785 g. copper (Cu) per l.). It is obvious that the three basic fluids of either sets can be blended in any imaginable proportion, giving a variety of hues limited only by the tints of the basic fluids themselves.

TABLE I—COTTONSEED OIL SAMPLES, No. 1

Lovibond readings in $\frac{1}{8}$ -in. cells Lovibond glasses: red, No. 200; yellow, No. 510; blue, No. 1180			
Prime White	Red	Yellow	Blue
Dec. 1917	0.10 + 0.09	1.0 + 0.4 + 0.2	....
Feb. 1918	0.20	1.0 + 0.4 + 0.1	....
Apr. 1918	0.10 + 0.05	1.0 + 0.2 + 0.05	....
Oct. 1918	0.2	1.0 + 0.2	....
Choice Summer Yellow			
Dec. 1917	1.0	5.0 + 4.0 + 2.0 + 0.1	....
Mch. 1918	1.0	5.0 + 4.0 + 2.0 + 0.1 + 0.05	0.1
Apr. 1918	1.0	5.0 + 4.0 + 2.0 + 0.1	0.09
Oct. 1918	1.0	5.0 + 3.0	-0.11
Off. Summer Yellow			
Dec. 1917	1.0 + 0.5 + 0.2 + 0.1	5.0 + 4.0 + 3.0 + 2.0 + 1.9	-0.391
Mch. 1918	1.0 + 0.5 + 0.2 + 0.1	5.0 + 4.0 + 3.0 + 2.0 + 1.5 + 1.0 + 0.4	-0.41
Apr. 1918	1.8	5.0 + 4.0 + 3.0 + 2.0 + 1.8 + 1.0 + 0.04 + 0.01	-0.41
Oct. 1918	1.6	5.0 + 4.0 + 3.0 + 2.0 + 1.3 + 1.0	-0.21

¹ The minus values mean that to secure a perfect match, it was necessary to place blue glasses of the value designated in front of the cell containing the oil that was being tested.

In commencing the work, a study of the keeping qualities of the fluids was first taken up and it was with much gratification that we found that samples prepared four years before had not faded to any perceptible degree, as readings with the same Lovibond

¹ See notably *J. Frank. Inst.*, August 1915, p. 199, and *THIS JOURNAL*, (1916), 309.

glasses that we have used during six years showed. In all our work we have used these same Lovibond glasses as our empiric standards in fixing the color value of our fluids and in examining the fluids to note whether they lose color on standing. Readings of our fluids with our batch of Lovibond glasses are found in the *Druggists Circular*, 57 (1914), 131, and in the *Journal of the Franklin Institute*, 180 (1915), 199.

In fact, the "Co-Fe-Cu" and the "Co-Cr-Cu" tints are less prone to change in color than are the three samples of oil examined thus far, the Lovibond readings at different periods of the first set of samples being given in preceding table.

Table I shows that one of the difficulties confronting us arose from the fact that the oils that we were to standardize as to color had a shifting value: a variation distinctly more than the basic color variation dependent on light conditions.

After establishing the Lovibond value of the standard commercial samples that we were to study, we turned to the tables of color values of our fluids published in the *Druggists Circular* and in the *Journal of the Franklin Institute* and there found that none of these were matches, being darker than "prime white" and lighter than "Off. summer yellow." All of the "Co-Cr-Cu" blends were much more green than the oil samples but the "Co-Fe-Cu" blends gave promise of matches on proper dilution and we, therefore, made several hundred dilutions of these fluids and present in Table II some data showing the possibilities of color matching with the fluids.

TABLE II—PRIME WHITE OIL APPROXIMATELY MATCHED IN 1-OZ. ROUND BOTTLES THE BLENDS SHOWN

	<i>N</i> /2 Acidulated Ferric Chloride Cc.	<i>N</i> /2 Acidulated Cobalt Chloride Cc.	Water Sufficient to Make Cc.
Ia.....	15.5	0.8	50
Ib.....	15.5	0.9	50
Ila.....	15.5	1.0	50
IIVa.....	15.7	1.0	50
Va.....	15.9	1.0	50
Vla.....	15.9	0.8	50
VIIa.....	15.9	1.1	50
VIIla.....	16.0	1.0	50
IXa.....	16.1	1.0	50
Xa.....	16.3	1.0	60
XIa.....	16.3	1.1	60
XIIa.....	16.4	1.0	60
XIIIa.....	16.5	1.0	60
XIVa.....	16.5	1.0	65
XVa.....	16.0	1.4	60
*XVla.....	16.0	1.5	60
XVlla.....	16.0	1.2	60
XIXa.....	16.2	1.2	60
XXa.....	16.3	1.4	60
*XXla.....	16.0	1.3	60

The best matches in Blake bottles (indicated by asterisks in Table II) were XVa, XVIa, and XXla, and these were submitted to a Lovibond reading with results given in Table III.

TABLE III—LOVIBOND READINGS OF MATCHING FLUIDS

	Red	Yellow	Blue
XVa.....	0.1	1.0 + 0.4 + 0.2 + 0.1	....
XVla.....	0.2	1.0 + 0.4 + 0.1	....
XXla.....	0.09	1.0 + 0.4 + 0.2 + 0.1	....

Compared with the oil reading in Table I, it will be seen that all of these are good matches.

It must be also specially noted that *N*/2 acidulated ferric chloride solution was not sufficiently yellow to match the color of the oil, so a *N* acidulated solution (18.616 g. iron (Fe) per l.) had to be employed.

TABLE IV—CHOICE SUMMER YELLOW APPROXIMATELY MATCHED IN 1-OZ. ROUND BOTTLES THE BLENDS SHOWN

	N Acidulated Ferric Chloride Cc.	N/2 Acidulated Cobalt Chloride Cc.	Water Enough to Make Cc.
Ib.....	33.3	3.3	50
IIb.....	33.3	3.3	50
IIIb.....	33.0	3.6	50
IVb.....	34.0	3.4	50
Vb.....	33.0	3.8	50
*VIIb.....	32.4	4.0	50
*XIb.....	31.5	4.0	45
*XIIb.....	31.0	4.4	45

The best matches in Blake bottles (indicated by asterisks in Table IV) were VIIb, XIb, and XIIb, which give, in $\frac{1}{2}$ -in. cells, the Lovibond readings shown in Table V.

TABLE V—LOVIBOND READINGS OF THE MATCHING FLUIDS

	Red	Yellow	Blue
VIIb.....	0.9	5.0 + 4.0 + 2.0 + 0.4	—0.1
XIb.....	1.0	5.0 + 4.0 + 2.0 + 1.0 + 0.2	—0.1
XIIb.....	1.0	5.0 + 4.0 + 2.0 + 0.3	—0.1

Again, comparison of these figures with the Lovibond reading of the oil sample in Table I shows a fairly good match.

TABLE VI—OFF. SUMMER YELLOW APPROXIMATELY MATCHED IN 1-OZ. ROUND BOTTLES THE BLENDS SHOWN

	N Acidulated Ferric Chloride Cc.	N/2 Acidulated Cobalt Chloride Cc.	Water Enough to Make Cc.
Ic.....	5.0	5.0	55
IIc.....	38.0	5.0	50
IIIc.....	37.0	4.2	50
IVc.....	45.0	6.1	60
*VIC.....	42.0	5.7	60
*VIIc.....	42.0	6.0	60
*VIIIc.....	42.0	6.2	60
IXc.....	40.0	6.0	60
IXc.....	41.0	5.5	60
Xc.....	41.5	6.0	60

The best matches in round bottles (indicated by the asterisks in Table VI) were Vc, VIc, and VIIc, and Table VII shows the Lovibond readings of these.

TABLE VII—LOVIBOND READINGS OF THE MATCHING FLUIDS

	Red	Yellow	Blue
Vc.....	1.0 + 0.5	5 + 4 + 3 + 2 + 1.8 + 1.2	—0.45
VIc.....	1.0 + 0.6 + 0.08	5 + 4 + 3 + 2 + 1.8 + 1.5 + 0.3	—0.4
VIIc.....	1.0 + 0.5 + 0.3	5 + 4 + 3 + 2 + 1.8 + 1.5	—0.4

Comparison with the Lovibond readings of the sample of oil found in Table I will show that all of these are fairly good matches.

This work was checked up in the cases of all three samples of the oil and of the matching fluids in the Lovibond tintometer, the oil sample being placed in one $\frac{1}{2}$ -in. cell and the matching fluid in another at its side. The results obtained coincided with those obtained with 1-oz. round bottles. More exact matching was then tried in the Kober colorimeter but the results were unsatisfactory, due primarily to the color changes occurring in the oil.

TABLE VIII—COTTONSEED OIL SAMPLES, No. 2. LOVIBOND READINGS IN $\frac{1}{2}$ -IN. CELL

	Red	Yellow	Blue
Prime White.....	0.4	1.9	.....
Choice Summer Yellow.....	1.0	5 + 4 + 2 + 1.9 + 0.2	.....
Off. Summer Yellow.....	1.3	5 + 4 + 3 + 1.6	.....

TABLE IX—COTTONSEED OIL SAMPLES, No. 3. LOVIBOND READINGS IN $\frac{1}{2}$ -IN. CELL

	Red	Yellow	Blue
Prime White.....	0.1	0.4 + 0.2	.....
Choice Summer Yellow.....	0.7 + 0.2	5 + 3	.....
Off. Summer Yellow.....	2.2	5 + 4 + 3 + 2 + 1	.....

This preliminary work proved, however, the practicability of matching the color of cottonseed oil with the colored fluids; so two new sets of oil samples were obtained, and with the experience gained in the pre-

liminary work, the finding of entirely satisfactory matches became a simple matter.

Of the fluids prepared for comparison with these oils those given in Table X were approximate matches and for the sake of uniformity (not obtaining in the original fluids given in Table II) all were prepared on the basis of 50 cc. of finished product. In Table X both proportions of blend and Lovibond readings are given.

TABLE X PRIME WHITE				
	N/2 Acidulated Ferric Chloride Cc.	N/2 Acidulated Cobalt Chloride Cc.	Water Enough to Make Cc.	Lovibond Readings $\frac{1}{2}$ -In. Cells
				Red Yellow Blue
24a.....	14.0	1.5	50	0.2 + 0.1 1.9
27a.....	11.2	1.4	50	0.2 1.0 + 0.4 + 0.2
28a.....	15.0	0.8	50	0.2 1.8
29a.....	15.0	0.7	50	0.2 1.9
31a.....	15.0	1.5	50	0.2 + 0.1 0.4 + 0.2
39a.....	14.5	1.5	50	0.2 + 0.1 2.0
41a.....	8.0	0.4	50	0.2 1.0
42a.....	6.0	0.4	50	0.1 0.7

CHOICE SUMMER YELLOW				
	N/2 Acidulated Ferric Chloride Cc.	N/2 Acidulated Cobalt Chloride Cc.	Water Enough to Make Cc.	Lovibond Readings $\frac{1}{2}$ -In. Cells
				Red Yellow Blue
2c.....	33.3	3.3	50	0.7 + 0.1 5 + 4 + 3
3c.....	33.0	3.6	50	0.7 + 0.2 5 + 4 + 3
4c.....	34.0	3.4	50	0.7 + 0.1 5 + 4 + 3
19c.....	33.5	4.0	50	1.0 5 + 4 + 3 +
20c.....	33.5	4.2	50	0.7 + 0.2 5 + 4 + 3 +
21c.....	33.3	4.4	50	1.0 + 0.1 5 + 4 + 3 +
22c.....	30.0	2.6	50	0.4 + 0.1 5 + 4 + 2
23c.....	28.0	2.8	50	0.4 + 0.1 5 + 4 + 1
24c.....	26.0	3.0	50	0.4 + 0.2 5 + 4
25c.....	24.0	3.0	50	0.4 + 0.1 5 + 3
26c.....	23.0	3.2	50	0.7 + 0.06 5 + 2
27c.....	22.0	3.4	50	0.7 + 0.1 5 + 1.6
28c.....	21.5	3.6	50	0.7 + 0.2 5 + 1.3 + 0.1
29c.....	21.0	4.0	50	1.0 + 0.1 5 + 1.3
30c.....	20.5	4.0	50	1.0 + 0.1 5 + 1 + 0.2
31c.....	20.5	3.8	50	1.0 5 + 1
32c.....	21.5	3.4	50	0.7 + 0.2 5 + 1.3 + 0.1
33c.....	25.5	3.0	50	0.7 5 + 3 + 0.2
34c.....	25.0	3.0	50	0.7 5 + 3 + 0.2

OFF. SUMMER YELLOW				
	N Acidu- lated Ferric Chloride Cc.	N/2 Acidu- lated Cobalt Chloride Cc.	N/2 Acidu- lated Copper Sulfate Cc.	Water Enough to Make Cc.
11b....	39.0	4.5	...	50
14b....	38.0	6.0	...	50
16b....	38.0	7.0	...	50
17b....	38.0	6.0	2.0	50
19b....	38.5	6.0	3.0	50
20b....	39.0	8.0	...	50
21b....	39.0	7.2	...	50

Comparison of the Lovibond figures in Table X with the Lovibond readings of Samples 2 and 3 in Tables VIII and IX show that the readings of Prime White Oil No. 2 approximate the readings of Fluids 27a and 39a; that Choice Summer Yellow Oil No. 2 is in fair agreement with Fluids 2c, 3c, and 4c; that Off. Summer Yellow Oil No. 2 checks up with Fluids 11b, 14b, and 19b; that Prime White Oil No. 3 resembles Fluid 42a; that Choice Summer Yellow Oil No. 3 was like Fluids 27c and 28c; that Off. Summer Yellow Oil No. 3 was matched by Fluids 20b and 21b. The six oil samples were then subjected to critical comparison with the resembling fluids, as well as a number of the others enumerated above, (a) in round 1-oz. bottles, (b) in two $\frac{1}{2}$ -in. cells in the Lovibond instrument, (c) in the Kober

colorimeter. The results of this critical comparison are tabulated below.

TABLE XI
PRIME WHITE No. 2

In 1-oz. round bottles matched 39a
In Lovibond apparatus matched 39a
In Kober colorimeter matched (30 mm. layer against 30 mm. layer) 39a

CHOICE SUMMER YELLOW No. 2

In 1-oz. round bottles matched 2c and 4c
In Lovibond apparatus matched 2c
In Kober colorimeter matched 2c (30 mm. layer against 30 mm. layer) and 4c (30 mm. layer against 28 mm. layer)

OFF. SUMMER YELLOW No. 2

In 1-oz. round bottles matched 11b and 14b
In Lovibond apparatus matched 14b
In Kober colorimeter matched 19b (30 mm. layer against 30 mm. layer)

PRIME WHITE No. 3

In 1-oz. round bottles matched 42a
In Lovibond apparatus matched 42a
In Kober colorimeter matched 42a (30 mm. layer against 30 mm. layer)

CHOICE SUMMER YELLOW No. 3

In 1-oz. round bottles matched 27c
In Lovibond apparatus matched 27c
In Kober colorimeter matched 27c (30 mm. layer against 30 mm. layer) and 28c (30 mm. layer against 28 mm. layer)

OFF. SUMMER YELLOW No. 3

In 1-oz. round bottles matched 20b and 21b
In Lovibond apparatus matched 21b
In Kober colorimeter matched 21b (30 mm. layer against 30 mm. layer)

In most of the Kober readings matching of 40 mm. layers gave same results as 30 mm. layers.

SUMMARY AND CONCLUSIONS

I—The greatest difficulty in standardizing the color of cottonseed oil is the variation of the tint of commercial samples. This is shown by the matched difference in the Lovibond readings (using the same Lovibond glasses in each case) of Samples 1, 2, and 3 as given in Tables I, VIII, and IX, which is all the more surprising as the color values (expressed in the now accepted Lovibond units) given by those kindly furnishing the samples are in practical agreement as far as Prime White and Choice Summer Yellow are concerned.

II—This discrepancy may be due to the variation in the tint of the supposed standard Lovibond glasses (as pointed out by Mr. Priest) or to alteration of the color of the oil samples (see Table I) or to both causes.

III—Further study of the "Co-Fe-Cu" standardized colored fluids confirms the stability of the tints obtained on blending.

IV—The facts that they can be prepared by anyone competent to conduct quantitative analysis, that when made of proper strength their color values are uniform, and that their employment saves the cost of expensive appliances commend them to the practical men.

V—In matching cottonseed oil with these standardized fluids (as shown in Table XI) approximately good matches are obtained when the oil samples and the fluids are compared in 1-oz. round bottles, while practically perfect results are secured by comparing the oil samples with the fluids in 1/2-in. cells placed side by side in the Lovibond instrument. In fact, in our work we found such matches not only more easily secured, but in some respects even more satisfactorily obtained, than when the more expensive colorimeter was used.

VI—As shown in Tables III, V, VII, and XI, the Prime White samples were matched by blends ranging from 6 cc. *N/2* acidulated ferric chloride solution, 0.4 cc. *N/2* acidulated cobalt chloride solution, and water enough to make 50 cc. to 16 cc. *N/2* acidulated ferric chloride solution, 1.4 cc. *N/2* acidulated cobalt chloride solution, and water enough to make 60 cc.; Choice Summer Yellow samples were matched by blends ranging from 22 cc. *N* acidulated ferric chloride solution, 3.4 cc. *N/2* acidulated cobalt chloride solution, and water enough to make 50 cc. to 33.3 cc. *N* acidulated ferric chloride solution, 3.3 cc. *N/2* acidulated cobalt chloride solution, and water enough to make 50 cc., while Off. Summer Yellow samples were matched by blends ranging from 42 cc. *N* acidulated ferric chloride solution, 6.2 cc. *N/2* acidulated cobalt chloride solution, and water enough to make 60 cc. to 39 cc. *N* acidulated ferric chloride solution, 7.2 cc. *N/2* acidulated cobalt chloride solution, and water enough to make 50 cc. Whether the limits of color should be fixed between narrower boundaries is a problem to be decided by the standards committee of the Society of Cotton Products Analysts.

In closing, the authors wish to extend their thanks to Messrs. David Wesson, F. N. Smalley, and G. Worthen Agee for samples of oil and for suggestions kindly given.

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THE TINCTURE OF VANILLA OF THE NATIONAL FORMULARY

By BERNARD H. SMITH
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Tincture of vanilla was discontinued in the 9th Edition of the Pharmacopoeia, being transferred to the 4th Edition of the National Formulary. The method of the 8th Edition of the Pharmacopoeia called for the use of 65 per cent alcohol, which is generally recognized as being higher than is necessary to produce the best vanilla extract, but otherwise the procedure was practicable and workable. The same cannot be said of the substituted method, which is as follows:

TINCTURE OF VANILLA

(U. S. P. VIII)

Tr. Vanill.

Vanilla, cut into small pieces, one hundred grams.....	100 g.
Sugar, in coarse granules, two hundred grams.....	200 g.
Alcohol.....	.....
Diluted Alcohol.....	.....
Water, each, a sufficient quantity.....	.....

To make one thousand milliliters..... 1000 mils.

Macerate the vanilla with five hundred milliliters of alcohol in a stoppered container, in a moderately warm place, for two days with frequent agitation; then transfer it to a plain filter and reserve the filtered liquid. Spread out the drug on the filter and expose it to the air until all of the alcohol has evaporated. Then grind the vanilla and sugar to a uniform powder, pack this in a percolator and slowly percolate it with a mixture of the reserved filtrate and an equal volume of water. When the liquid ceases to drop, continue the percolation slowly, gradually

adding the remainder of the prepared menstruum and then sufficient diluted alcohol to make the product measure one thousand milliliters.

It will be noticed that the new method calls for a preliminary extraction with alcohol which contains not less than 94.9 per cent of alcohol by volume; in other words, "Cologne spirits" of commerce. Alcohol of this strength removes a resinous extractive from the beans which is precipitated in the form of a persistent cloud when the menstruum is diluted and which is not subsequently removed by percolation or by any ordinary method of filtration. This colloidal material adds nothing to the flavor of the extract, but on the other hand renders it unsightly and unsalable.

Another obvious disadvantage of the proposed method is the loss of alcohol which its use entails. Vanilla beans of average moisture content will retain 10 per cent of the alcohol used when placed upon a filter to drain, which is lost if the directions are followed to expose the drug "to the air until all of the alcohol has evaporated."

The method would seem to be of greater academic interest than of practical value, which is unfortunate, inasmuch as the authorities having the enforcement of the food and drug laws in charge naturally attach great importance to official methods of procedure.

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THE DETERMINATION OF BROMIDE IN MINERAL WATERS AND BRINES¹

By W. F. BAUGHMAN AND W. W. SKINNER

The chief sources of bromine in the United States are natural and artificial brines in which it is present as bromide associated frequently with small amounts of iodide. Bromine is obtained by appropriate treatment of the mother liquor, or "bittern," obtained as a by-product in the manufacture of common salt. Owing to the increased demand for bromine resulting in a greatly increased market value during the period of the war, search has been made for new supplies of brine rich in bromide. The authors had occasion to examine a number of samples of brines and desired to determine their bromide content.

The colorimetric methods have been studied by the Association of Official Agricultural Chemists² and by Sweeney and Withrow,³ but are not entirely satisfactory. In these methods the bromide solution is treated with chlorine water or some other oxidizing agent and the liberated bromine absorbed in carbon disulfide, chloroform, carbon tetrachloride, etc., and compared with suitable standards. Where the bromine present in the sample taken for the determination is greater than 5 mg., however, only approximate results can be obtained by these methods.

A search of the literature revealed no method which could confidently be relied upon to give correct results for bromine associated with the other constitu-

ents usually found in brines, and it was necessary to attempt the development of a satisfactory method.

The literature contains many methods for the selective oxidation of bromides in the presence of chlorides and the subsequent removal of the liberated bromine by steam distillation or by aspiration. Vortman¹ recommended the use of lead peroxide (PbO_2) and acetic acid, the liberated bromine being removed by distillation. Cavazzi² recommended barium dioxide (BaO_2) and dilute sulfuric acid. Engel³ made the assertion that ammonium persulfate ($(NH_4)_2S_2O_8$) and sodium acetate ($NaC_2H_3O_2$) will liberate bromine and not chlorine at a temperature of 70–80° C. Berglund⁴ used a mixture of potassium bisulfate ($KHSO_4$) and potassium permanganate ($KMnO_4$) in the cold, and removed the bromine by aspiration. He found, however, that if sodium chloride were present in excess of 1 g., a small amount of chlorine would be set free along with the bromine. To overcome this difficulty he recommended two aspirations, the first to concentrate the bromine content in a suitable absorbing solution from which the bromine is again liberated by potassium bisulfate and potassium permanganate and removed by aspiration, resulting in pure bromine being obtained. Baubigny and Rivals⁵ stated that copper sulfate ($CuSO_4$) and potassium permanganate ($KMnO_4$) will liberate at room temperature bromine and not chlorine unless chlorine is present in too large amount. Wyss⁶ used ferric sulfate ($Fe_2(SO_4)_3$) and potassium permanganate ($KMnO_4$). White⁷ used aluminum sulfate ($Al_2(SO_4)_3$) and potassium permanganate ($KMnO_4$). Jannasch and Aschoff⁸ used acetic acid and potassium permanganate ($KMnO_4$). Bugarsky,⁹ Benedict and Snell,¹⁰ and Andrews¹¹ suggested the use of iodic acid. Gooch and Blumenthal¹² used selenic acid, and Gooch and Cole¹³ telluric acid.

The possibility of obtaining a clean separation of bromine and chlorine by the use of most of these methods is dependent upon the concentration of the chloride or of the oxidizing agent, or of the acidity of the solution. They are effective, therefore, only within narrow limits of concentration of the reacting solution and the possibility always exists that either owing to the addition of too much acid or oxidizing agent, or from the solution becoming too concentrated during distillation, some chlorine will be set free, or, the contrary conditions prevailing, all of the bromine will not be liberated.

The double aspiration recommended by Berglund disposes of the possibility of bromine being contaminated with chlorine, but it seems to have been overlooked or not approved by later investigators who

¹ *Z. anal. Chem.*, **26** (1886), 172.

² *Gazz. chim. ital.*, **13**, 174.

³ *Compt. rend.*, **118** (1894), 1263.

⁴ *Z. anal. Chem.*, **24** (1885), 184.

⁵ *Compt. rend.*, **136** (1897), 527, 607.

⁶ *Repert. anal. chem.*, **6** (1885), 238.

⁷ *Chem. News*, **67** (1888), 233.

⁸ *Z. anorg. Chem.*, **1** (1892), 144.

⁹ *Ibid.*, **10** (1895), 387.

¹⁰ *J. Am. Chem. Soc.*, **26** (1903), 809.

¹¹ *Ibid.*, **29** (1907), 275.

¹² *Am. J. Sci.*, **36** (1913), 54.

¹³ *Ibid.*, **37** (1914), 257. See also Cole, *Ibid.*, **38** (1914), 265.

¹ Read before the Division of Water, Sewage, and Sanitation of the American Chemical Society, at the 57th Meeting, Buffalo, April 7 to 11, 1919.

² *J. A. O. A. C.*, [I] **1** (1915), 97.

³ *THIS JOURNAL*, **9** (1917), 671.

by the methods proposed seem to have sacrificed accuracy and reliability of results to rapidity of procedure.

Bugarsky¹ has pointed out another possible source of error in case the bromide is removed by distillation caused by the formation of a small amount of hydrobromic acid (HBr) from steam and bromine. Consequently, if the liberated bromine is driven out by distillation, it should be determined gravimetrically and not iodimetrically.

Wyss,² recognizing the uncertainty of results obtained by methods already recommended, suggested a method which he thought would dispose of the possibility, theoretical or practical, of results being vitiated by the liberation of chlorine. He makes the statement that in the presence of free chromic acid in excess, "chlorine in the native state will be found as chromyl chloride which at room temperature is not volatile and not dissociated," and asserts that if any chlorine is set free it will combine with the chromic acid.

His procedure is substantially as follows:

Chlorides and bromides, which should be contained in a minimum of solution, are treated with an excess of chromic anhydride (CrO_3) (about 15 g.) and a few cubic centimeters of hydrogen peroxide (H_2O_2), and the liberated bromine removed by aspiration at room temperature, absorbed in a potassium iodide (KI) solution, and titrated with thiosulfate. His recommendation, however, is supported by only seven experiments which are considered not sufficiently comprehensive to substantiate it. It was, therefore, decided to subject this proposed method to a more thorough investigation.

REAGENTS

SODIUM CHLORIDE (NaCl)—This was purified as described in a previous paper on the determination of iodide.³

POTASSIUM BROMIDE (KBr)—A quantity of potassium bromide (C. P. reagent) was recrystallized several times from distilled water and carefully dried. A solution was prepared by dissolving an accurately weighed amount in distilled water. Upon standardizing gravimetrically by precipitating and weighing as silver bromide, a figure for the bromine content was obtained which agreed within a few tenths of a milligram with that calculated from the quantity of potassium bromide weighed out.

CHROMIC ANHYDRIDE (CrO_3)—This was a C. P. reagent which contained a small quantity of sulfuric acid. Check analyses were made and it was determined that the small quantity of sulfuric acid usually found in chromic anhydride does not affect the accuracy of the result.

HYDROGEN PEROXIDE (H_2O_2)—The ordinary 3 per cent U. S. P. article of commerce was used (free of acetanilide).

POTASSIUM IODIDE—The salt used for the absorption solution was also a C. P. reagent which was tested and found to be free from iodate.

THIOSULFATE SOLUTION—This was standardized against pure iodine which had been resublimed twice from a small quantity of potassium iodide.

APPARATUS

Three tall-form, 250 cc. glass-stoppered, Drechsel gas washing bottles or cylinders were joined together in series, the first two by welding together the outlet tube of the first and the intake tube of the second, and the second and third by rubber tubing, bringing the ends of the two glass tubes as close together as possible. (The third bottle need not be a Drechsel wash bottle, but may be constructed from any kind of a suitable bottle at hand.) In the first, the bromine is liberated and its removal by aspiration is facilitated by filling the cylinder to about half its capacity with glass beads. It was found convenient in order to easily force the

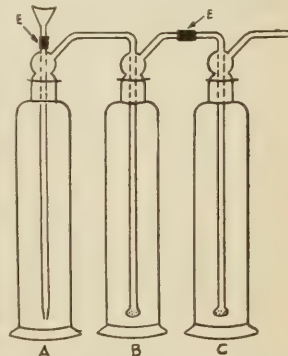


FIG. 1—APPARATUS
A—Reaction Cylinder. B and C—Absorption Cylinders. E—Rubber Connections.

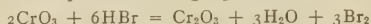
intake tube down through the beads to make the end of the tube somewhat pointed. A small funnel was joined by a rubber connection to the outside vertical end of the intake tube so as to make possible the introduction of liquids after the cylinder was closed.

The other two cylinders contain the liquid for absorbing the bromine. The lower end of the intake tube of each cylinder was blown into a little ball, the horizontal circumference of which was pierced by fine holes in order to break up the bubbles. It was found that only a very small part of the bromine escapes from the first absorption cylinder, so it is safe to connect it with the second only by a rubber tube, provided the edges of the two tubes are close fitting.

In a former paper¹ concerning the determination of iodide in mineral waters and brines, the authors suggested a method for removing iodide from the sample to be used for the bromide determination. In the present paper it is assumed that iodide has either been removed, as previously indicated, or that it is not present in amounts sufficient to interfere with the bromide determination. The latter assumption often proves to be a fact in the case of brines.

EXPERIMENTAL WORK

The action of chromic anhydride on a bromide in solution was investigated first. This reaction is represented by the following equation:



The reaction cylinder was charged first with a layer of glass beads about 1 in. in thickness, then

¹ Loc. cit.

² Med Klinik, 24 (1910), 288.

³ THIS JOURNAL, 11 (1919), 563.

¹ Loc. cit.

with 15 g. of dry chromic anhydride, and finally enough glass beads to half fill the cylinder. The first absorption cylinder contained 10 g. of potassium iodide dissolved in 200 cc. of water, and the second, 3 or 4 g. potassium iodide in a like volume. After charging, the cylinders were joined together and a slow current of air drawn through. A measured volume of the standard potassium bromide solution was then added to the reaction cylinder through the small funnel mentioned and the funnel washed with a small amount of water until the total volume added (including the potassium bromide solution) was about 25 cc. The velocity of the air current was then increased to from $\frac{1}{2}$ to $\frac{3}{4}$ l. per min. and the aspiration continued for about 1 hr. The absorption cylinders were then emptied and the contents titrated with thiosulfate. By aspirating into a fresh potassium iodide solution, it was determined whether or not all the bromine had been removed.

TABLE I

EXPT. No.	CrO ₃ G.	Vol. of Soln. Cc.	NaCl Present G.	Br Present as KBr G.	Time Aspiration Hrs.	Standard ² Na ₂ S ₂ O ₃ Soln. Cc.	Bromine Found G.	Error G.
1	15	25	None	0.1003	2	12.62	0.1000	-0.0003
2	15	25	None	0.2006	1	25.33	0.2012	+0.0006
3	15	25	None	0.0602	1	0.07	0.0602	0.0000
					2	7.50	0.0602	0.0000
4	15	25	None	0.0602	$\frac{3}{4}$	0.10	0.0602	0.0000
					1	7.50	0.0602	0.0000
5	15	25	None	0.0802	$\frac{3}{4}$	10.12	0.0802	0.0000
					1	0.00	0.0802	0.0000
6	15	25	2.0	0.0000	3	Faint trace	Faint trace	
7	15	25	3.0	0.0000	3	Faint trace	Faint trace	
8	15	25	10.0	0.0000	3	Faint trace	Faint trace	
9	15	25	0.5	0.0602	1	7.60	0.0602	0.0000
10	15	25	0.6	0.0602	2	0.00	0.0602	0.0000
					3	7.60	0.0602	0.0000
11	15	25	0.6	0.0602	1	0.00	0.0603	+0.0001
					3	7.62	0.0603	+0.0001
12	15	25	1.0	0.0602	1	0.00	0.0604	+0.0004
					3	7.63	0.0607	+0.0005
13	15	25	2.0	0.0602	1	0.00	0.0607	+0.0005
					2	7.65	0.0607	+0.0005
14	15	25	3.0	0.0602	2	0.01	0.0612	+0.0010
					1	7.68	0.0612	+0.0010
15	15	25	4.0	0.0602	2	0.05	0.0612	+0.0010
					1	7.55	0.0612	+0.0010
16	15	25	5.0	0.0602	2	0.18	0.0611	+0.0009
					1	5.75	0.0611	+0.0009
17	15	25	6.0	0.0602	1	1.60	0.0634	+0.0032
					2	0.36	0.0634	+0.0032
18	15	25	8.0	0.0602	1	0.00	0.0630	+0.0028
					2	3.32	0.0630	+0.0028
19	15	25	10.0	0.0602	1	2.40	0.0602	0.0000
					2	1.08	0.0602	0.0000
20	15	25	5.0	0.0201	1	1.10	0.0201	0.0000
					2	4.40	0.0201	0.0000
21	15	25	5.0	0.0281	$\frac{1}{2}$	1.40	0.0281	+0.0003
					2	2.24	0.0281	+0.0003
22	15	25	5.0	0.0401	2	0.03	0.0404	+0.0003
					2	3.00	0.0404	+0.0003
23	15	25	5.0	0.0080	$\frac{1}{2}$	1.05	0.0082	+0.0002
					2	1.05	0.0082	+0.0002
24	15	25	5.0	0.0160	2	3.30	0.0160	+0.0000
					2	0.15	0.0160	+0.0000
25	15	25	5.0	0.0160	2	0.10	0.0160	+0.0000
					2	0.10	0.0160	+0.0000

¹ Stood over night before this aspiration.

² 1 cc = 0.00792 g. bromine.

The results obtained are the first five in Table I. It will be noted that they are very satisfactory, those of Expts. 3, 4, and 5 agreeing exactly with the theory. The bromine was usually removed completely by aspirating for about 1 hr.

Expts. 6, 7, and 8 show the action of chromic anhydride on a solution of sodium chloride. A very

faint trace of iodine was liberated in the potassium iodide solution which, after 3 hrs. aspiration, was equivalent to not more than 0.1 mg. of bromine. When, however, the solution of sodium chloride and chromic anhydride was allowed to stand over night and then aspirated, using a fresh potassium iodide solution, slightly more iodine was liberated, an amount equivalent to about 1 mg. of bromine. That this was due to the action of chromic anhydride on sodium chloride and not to chromic acid carried over mechanically was proven by aspirating a solution containing only chromic anhydride. Not a trace of iodine was liberated. Therefore, if the sodium chloride were free from bromine, and it is believed from the precautions taken it can be assumed that it contained no trace of bromine, then chromic anhydride will, at room temperature, liberate a trace of chlorine from chloride, especially if allowed to act for a considerable length of time.

In Expts. 9 to 24, mixtures of sodium chloride and potassium bromide were used. A measured volume of the potassium bromide solution was added to a weighed quantity of sodium chloride in a small dish, water added if necessary to dissolve the sodium chloride, and the solution then evaporated nearly to dryness. A few glass beads were added to the reaction cylinder, then the mixture of sodium chloride and potassium bromide scraped in as completely as possible, and then beads added until the cylinder was half full. After connecting the cylinders and starting the aspiration, 15 g. chromic anhydride dissolved in 10 to 12 cc. water were added to the reaction cylinder, followed by washings from the evaporating dish which had contained the mixed chloride and bromide sufficient to bring the total volume added to about 25 cc. as before.

Bromine was determined in the presence of 0.5 or 0.6 g. sodium chloride with very satisfactory results. But when the quantity of sodium chloride was increased to 1 g. or more, the results for bromine were too high, showing that some chlorine was liberated. The results show that more chlorine is liberated from a mixture of chloride and bromide than from solutions of pure sodium chloride, that is, the presence of bromide decreases the stability of sodium chloride toward chromic anhydride. This is similar to the observation of Berglund¹ concerning the action of potassium bisulfate and potassium permanganate on solutions of mixtures of chloride and bromide and to our experience concerning the action of ferric sulfate on solutions of mixtures of iodide and bromide.¹ In the latter case we showed that while ferric sulfate would not liberate bromine from a pure bromide solution below a certain concentration, yet if free iodine were present, bromine would be liberated and that free iodine decreased the stability of bromide toward ferric sulfate. Berglund explained his results by assuming that some chlorbromide was formed and this seems plausible, but is difficult to prove experimentally.

With increasing concentration of chloride, the rate of evolution of bromine decreases. In the absence

¹ Loc. cit.

of a chloride, it is possible to remove all the bromine in 1 hr. or less. In Expt. 17 only about 89 per cent of the bromine was removed by 3 hrs. aspiration from a solution containing 6 g. of sodium chloride, assuming that all the halogen evolved was bromine, although it is probable that some of it was chlorine; in Expt. 18, about 87 per cent after $3\frac{1}{2}$ hrs. aspiration from a solution containing 8 g. of sodium chloride; and in Expt. 19, about 81 per cent after $3\frac{1}{2}$ hrs. aspiration from a solution containing 10 g. sodium chloride.

If the mixture of chromic acid, bromide, and chloride is allowed to react without aspirating for a considerable length of time, as over night, and then aspirated, the bromine comes over more rapidly. This is shown in Expts. 25 to 31, Table II. Also, more chlorine is liberated.

TABLE II.—MIXTURE ALLOWED TO STAND OVER NIGHT BEFORE ASPIRATION

Expt. No.	CrO ₃ G.	Vol. of Soln. G.	NaCl Present G.	Br Present G.	Time of Aspiration Hrs.	Standard Na ₂ S ₂ O ₃ Soln. Cc.	Bromine Found G.	Error G.
25	15	25	10	0.0802	3	9.45	0.0816	+0.0014
					$\frac{1}{4}$	0.6		
26	20	20	10	0.0802	$\frac{1}{4}$	0.25	0.0824	+0.0022
					$\frac{1}{4}$	11.62		
27	15	20	5	0.0602	$\frac{1}{4}$	0.05	0.0684	+0.0082
28	20	20	10	0.0602	$\frac{1}{4}$	8.54	0.0676	+0.0074
29	15	20	10	0.0000	1	Trace		
30	20	16	10	0.0000	3	0.05	0.0004	+0.0004
31	15	25	8	0.0602	$\frac{1}{4}$	8.18	0.0649	+0.0047
					1	0.02		

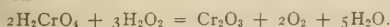
1 cc. = 0.00792 g. bromine.

It is evident from these last experiments that free bromine can be readily removed by aspiration from a concentrated sodium chloride solution and that after the bromine is once set free, sodium chloride does not have a retarding influence on its removal. It is more likely that the decrease in the rate of evolution with increasing amounts of chloride present is due to the sodium chloride removing some of the chromic anhydride from the sphere of action, possibly by the formation of chromyl chloride (CrO₂Cl₂). Thus, due to the decreased concentration of the chromic anhydride, the bromide would be oxidized less readily. From a solution containing in 25 cc. 5 g. chromic anhydride and 0.0600 g. bromine as potassium bromide, only 22 per cent of the bromine was evolved after $3\frac{1}{2}$ hrs. aspiration. However, after standing over night, the remainder of the bromine was removed in about 2 hrs.

It is, therefore, clear that the use of chromic acid alone does not solve the problem of separating bromine and chlorine.

The influence of hydrogen peroxide as recommended by Wyss was next studied.

Upon the addition of hydrogen peroxide to a solution of chromic anhydride, a rapid evolution of oxygen takes place and the chromic anhydride is reduced to the insoluble chromic oxide (Cr₂O₃) according to the equation



When hydrogen peroxide is added to a solution of chloride, bromide, and chromic anhydride which is being aspirated into a potassium iodide solution, an effervescence occurs due to the oxygen formed and in a few seconds the iodine color in the potassium iodide

solution begins to deepen rapidly. That this is due to bromine (or chlorine) liberated by the chromic anhydride and hydrogen peroxide was proven by treating a solution of chromic anhydride which contained no bromide or chloride with hydrogen peroxide in a similar manner. No iodine was liberated in the absorbing solution. The strong oxidizing influence is evidently due to the nascent oxygen.

An inspection of the records of Expts. 32 to 38, inclusive, will show that the addition of hydrogen peroxide increases the rate of evolution of bromine and also the amount of chlorine liberated.

EXPT. 32—8 G. NaCl, 0.0602 G. Br as KBr, 15 G. CrO₃, 18 Cc. H₂O
Aspirated 1 hr., two 2-cc. portions H₂O₂ added at 20 min. intervals

Standard Na₂S₂O₃ soln. required = 7.55 cc.

Added 2 cc. H₂O₂, aspirated 2 hrs.

Standard Na₂S₂O₃ soln. required = 0.15

Added 2 cc. H₂O₂, aspirated 1 hr.

Standard Na₂S₂O₃ soln. required = 0.05

Bromine found = 0.0614 g. Total = 7.75 cc.
Error = +0.0012 g.

EXPT. 33—10 G. NaCl, 0.0602 G. Br as KBr, 15 G. CrO₃, 18 Cc. H₂O
Aspirated 1 hr., two 2-cc. portions H₂O₂ added at 20 min. intervals

Standard Na₂S₂O₃ soln. required = 7.60 cc.

Added 2 cc. H₂O₂, aspirated 2 hrs.

Standard Na₂S₂O₃ soln. required = 0.23

Added 2 cc. H₂O₂, aspirated 1 hr.

Standard Na₂S₂O₃ soln. required = 0.15

Bromine found = 0.0632 g. Total = 7.98 cc.
Error = +0.0030 g.

EXPT. 34—10 G. NaCl, 0.0602 G. Br as KBr, 15 G. CrO₃, 20 Cc. H₂O
Mixed and allowed to stand over night in reaction cylinder

Aspirated 2 hrs., three 2-cc. portions H₂O₂ added at 20 min. intervals

Standard Na₂S₂O₃ soln. required = 8.40 cc.

Aspirated 1 hr.

Standard Na₂S₂O₃ soln. required = 0.05

Added 2 cc. H₂O₂, aspirated $\frac{1}{2}$ hr.

Standard Na₂S₂O₃ soln. required = 0.10

Bromine found = 0.0677 g. Total = 8.55 cc.
Error = +0.0075 g.

EXPT. 35—10 G. NaCl, 0.0802 G. Br as KBr, 15 G. CrO₃, 20 Cc. H₂O
Mixed and allowed to stand over night in reaction cylinder

Aspirated 2 hrs., three 2-cc. portions H₂O₂ added at 20 min. intervals

Standard Na₂S₂O₃ soln. required = 11.85 cc.

Aspirated 1 hr.

Standard Na₂S₂O₃ soln. required = 0.00

Added 2 cc. H₂O₂ and aspirated $\frac{1}{2}$ hr.

Standard Na₂S₂O₃ soln. required = 0.10

Bromine found = 0.0946 g. Total = 11.95 cc.
Error = +0.0144 g.

EXPT. 36—10 G. NaCl, 0.0602 G. Br as KBr, 15 G. CrO₃, 20 Cc. H₂O, 2 Cc. H₂O₂

Mixed and allowed to stand over night in reaction cylinder

Aspirated 2 hrs., two 2-cc. portions H₂O₂ added at 20 min. intervals

Standard Na₂S₂O₃ soln. required = 7.99 cc.

Aspirated 1 hr.

Standard Na₂S₂O₃ soln. required = 0.00

Added 2 cc. H₂O₂, aspirated 1 hr.

Standard Na₂S₂O₃ soln. required = 0.10

Bromine found = 0.0641 g. Total = 8.09 cc.
Error = +0.0039 g.

EXPT. 37—10 G. NaCl, 0.0802 G. Br as KBr, 15 G. CrO₃, 20 Cc. H₂O, 2 Cc. H₂O₂

Mixed and allowed to stand over night in reaction cylinder

Aspirated 2 hrs., two 2-cc. portions H₂O₂ added at 20 min. intervals

Standard Na₂S₂O₃ soln. required = 10.60 cc.

Aspirated 1 hr.

Standard Na₂S₂O₃ soln. required = 0.00

Added 2 cc. H₂O₂, aspirated 1 hr.

Standard Na₂S₂O₃ soln. required = 0.10

Bromine found = 0.0847 g. Total = 10.70 cc.
Error = +0.0045 g.

EXPT. 38—10 G. NaCl, No KBr, 20 G. CrO₃, 16 Cc. H₂O

Mixed and allowed to stand over night in reaction cylinder

Aspirated 3 hrs.

Standard Na₂S₂O₃ soln. required = 0.05 cc.

3 cc. H₂O added, aspirated 1/2 hr.

Standard Na₂S₂O₃ soln. required = 0.10

Aspirated 1/2 hr.

Standard Na₂S₂O₃ soln. required = 0.00

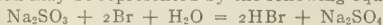
3 cc. H₂O added, aspirated 1/2 hr.

Standard Na₂S₂O₃ soln. required = 0.10

The assertion of Wyss that free chlorine in a solution of chromic anhydride will form chromyl chloride, which at room temperature is not dissociated and not volatile, and that, consequently, this principle may be used for separating chlorine and bromine, is not according to the experimental facts as we have found them. The method published by Wyss, therefore, is wholly unreliable.

The difficulties pointed out, however, can be overcome by using the double aspiration principle first suggested by Berglund in his bisulfate and permanganate method. The first aspiration serves to concentrate the bromine content in an absorbing solution which will change the free halogen to halide, the absorbing solution being subjected to a second treatment with chromic anhydride, resulting, on account of the small amount of chloride present, in pure bromine being evolved.

The results in Table III were obtained by employing double aspiration. The reaction cylinder was charged as before with glass beads, the sample to be examined, 15 g. chromic anhydride, and 25 cc. water. To the first absorption cylinder were added 20 cc. and to the second 5 cc. of a solution which contained in 25 cc. 1 g. sodium sulfite (Na₂SO₃) and 0.2 g. sodium carbonate (Na₂CO₃). Sufficient water was then added to each cylinder to bring the volume to about 200 cc. The sulfite reduces the bromine to bromide and the reaction may be represented by the following equation:



The carbonate neutralizes the hydrobromic acid and prevents it from being volatilized during the subsequent evaporation. After connecting, the cylinders were aspirated for a short time until the contents of the reaction cylinder were thoroughly mixed. The small funnel on the reaction cylinder was then removed and the inlet tube of the cylinder closed by clamping a rubber tube over the end. In order to guard against a possible escape of bromine at the ground glass stopper of the reaction cylinder, the pressure in the apparatus was reduced by sucking out a little air after closing. The apparatus was then allowed to stand over night. In the morning, it was aspirated for about 3 hrs. and four portions of 2 cc. each of hydrogen peroxide added at half-hour intervals. The absorbing solution was then evaporated nearly to dryness, the residue dissolved in about 5 cc. of water and added, using 20 cc. water to wash the evaporating dish, to the reaction cylinder which had been previously charged with glass beads and chromic anhydride and connected with the absorption cylinders filled with potassium iodide solution. Aspiration was continued until all the bromine had been evolved (about 1 hr.), and the potassium iodide solution titrated with thiosulfate.

The results are considered very satisfactory and indicate that bromine may be determined in the presence of as much as 10 g. sodium chloride with a negative error of less than 1 mg. and no possibility of the results being vitiated by the liberation of chlorine.

TABLE III—DOUBLE ASPIRATION

EXPT. No.	NaCl Present G.	Br Present as KBr G.	Standard Na ₂ S ₂ O ₃ Soln. ¹ Cc.	Bromine Found G.	Error G.
39	None	0.0602	7.60	0.0602	0.0000
40	3	0.0642	8.00	0.0634	—0.0008
41	6	0.0602	7.52	0.0596	—0.0006
42	10	0.0602	7.52	0.0596	—0.0006
43	10	0.0802	10.10	0.0800	—0.0002
44	10	0.0802	10.00	0.0792	—0.0010
45	5	0.0591	7.42	0.0588	—0.0003
46	10	0.0591	7.40	0.0586	—0.0005
47	10	0.0985	12.40	0.0982	—0.0003
48	10	0.0788	9.94	0.0787	—0.0001

¹ 1 cc. = 0.00792 g. Br.

The procedure recommended for the determination of bromine in a mixture of bromide and chloride, using the apparatus already described, is as follows:

Evaporate the sample of water or brine, which should not be acid (if necessary, add small amount of sodium carbonate), to dryness or nearly so. Charge the reaction cylinder by introducing first glass beads to a depth of about 1 in., then as much of the sample as can be scraped in, and finally enough glass beads to fill the cylinder half full. Make a solution of sodium sulfite and sodium carbonate of such a concentration that 25 cc. will contain 1 g. of sulfite and 0.2 g. of carbonate. Add 20 cc. of this solution to the first absorption cylinder, 5 cc. to the second, and dilute each to approximately 200 cc. Connect the three cylinders and draw through a slow current of air. Add 15 g. chromic anhydride dissolved in 10 to 12 cc. water to the reaction cylinder, followed by washings from the evaporating dish which contained the sample, sufficient to bring the total volume added to about 25 cc. Aspirate until the contents of the reaction cylinder are in solution and thoroughly mixed, then discontinue, close the inlet tube with a small piece of rubber tubing and a clamp, and reduce the pressure in the apparatus slightly by sucking out some air in order to guard against any possible escape of bromine at the ground glass stopper. Allow to stand over night, then aspirate with a rather strong current of air (about 1/2 to 3/4 l. per min.) for 3 hrs., adding four 2-cc. portions of 3 per cent hydrogen peroxide at 30 min. intervals. Stop the aspiration and evaporate the contents of the two absorption cylinders nearly to dryness. Clean out the reaction cylinder and freshly charge with glass beads and 15 g. chromic anhydride. Into the first absorption cylinder, put 10 g. potassium iodide dissolved in 200 cc. of water, and into the second 3 or 4 g. in a like amount of water. Connect the apparatus, draw through a slow current of air, and transfer the contents of the evaporating dish to the reaction cylinder by means of the small funnel, using 25 cc. of water. Aspirate with a rather strong current of air until all the bromine is evolved (about 1 hr.) and titrate the potassium iodide solution with thiosulfate.

SUMMARY

Chromic acid in concentrated solution liberates bromine from bromides quantitatively at room temperature, and the bromine may be removed by aspiration. It liberates only a trace of chlorine from chlorides and forms probably chromyl chloride which remains in solution.

When chromic acid acts on a solution of chlorides and bromides, some chlorobromide is formed which is removed with the bromine by aspirating.

Details of a method making use of the principle of double aspiration are given for the determination of bromine in the presence of large amounts of chlorides.

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THE COMPOSITION OF THE FRUIT OF THE VIRGINIA CREEPER, *AMPELOPSIS QUINQUEFOLIA*

By GEORGE D. BEAL and EDWARD A. GLENZ

Received February 28, 1919

Ampelopsis quinquefolia, family *Vitaceae*, is a climbing woody vine found in woods and thickets throughout the central portion of the United States and from Quebec to Manitoba in Canada. It is known variously as the Virginia creeper, American ivy, five-leaved ivy, woodbine, and false grape. The fruit consists of small, blue, one- to four-seeded berries, and is not edible. Some few cases of poisoning have been ascribed to it, but proof of its poisonous nature is lacking. The fluid extract of the leaves has been used medicinally.

The various methods for the extraction of the proximate constituents were carried out according to Parsons.¹ The solvents used were benzene, methyl alcohol, water, and sulfuric acid. After each extraction the residue was dried and weighed to determine the amount of material extracted.

BENZENE EXTRACT—100.6 g. of the air-dried fruit were extracted with benzene for 8 hrs. in a Soxhlet extractor. After evaporation of the benzene an oily extract remained, having a greenish brown color and possessing a somewhat aromatic odor. The extract amounted to 28.91 per cent. This contained a yellow oil and 0.394 per cent of a waxy substance insoluble in low boiling petroleum ether. The extract yielded 0.14 per cent of neutral ash.

METHYL ALCOHOL EXTRACT—The residue from the benzene extraction was extracted with methyl alcohol, sp. gr. 0.848, for 8 hrs. in a Soxhlet extractor. This extract had a purplish red color similar to that of grape juice, and after standing for some time deposited some green, solid matter. The total material extracted by the alcohol amounted to 21.1 per cent and was used in qualitative tests for the sugars and organic acids present.

COLD WATER EXTRACT—The residue after the alcohol extraction was macerated with cold water for 16 hrs., filtered, and after thorough washing with cold water was expressed. A neutral red solution was obtained, the water-soluble extractives amounting to 1.8 per cent.

SULFURIC ACID EXTRACT—After the water treatment, the residue was boiled under a reflux condenser for 1 hr. with 1 per cent sulfuric acid, and then macerated in the cold for 2 days. The mixture at no time gave a reaction for starch with iodine. A reddish purple, syrupy extract was obtained, containing 14.7 per cent of solids.

SUGARS—To avoid any discrepancies due to chemical change, the sugars were determined in a portion of the fresh fruit. At the time of gathering the sam-

ple 100 g. of the fresh berries were placed in a flask and covered with 300 cc. of 95 per cent alcohol, then allowed to stand until needed, being shaken two or three times per week. At the end of 5 mos. the mixture was boiled for 2 hrs. under a reflux condenser, filtered, and the treatment repeated two or three times with fresh portions of solvent, the last extract obtained being colorless. The combined extracts were evaporated *in vacuo* to a thick syrup and taken up with water. The solution was washed three times with ether to remove the green oily matter and the resulting cherry-red solution was clarified with lead subacetate and alumina cream. The filtrate was then made up to a volume of 2000 cc. and used for the various sugar determinations, while the precipitated lead compounds were a second source of material for the study of the organic acids.

The total reducing sugars were determined by the method of Defren-O'Sullivan both before and after inversion, and calculated as dextrose. The reducing sugar before inversion amounted to 9.97 per cent and after inversion to 12.29 per cent of the fresh fruit. The sucrose calculated from the increase in reducing power after inversion amounted to 2.26 per cent of the fresh fruit, while that determined by direct and invert polarization in another portion of the same extract by the Clerget method was found to be 2.22 per cent.

The amount of levulose as determined from polariscope readings at 20° and 60°, according to Wiley's formula,¹ was found to be 7.00 per cent, and the dextrose to be 3.67 per cent. Only one osazone could be obtained from the solution. When heated rapidly so that a temperature of 200° was reached in 3 min. it melted at 204° and was evidently glucosazone. This would indicate the absence of other osazone-forming sugars than dextrose and levulose.

ORGANIC ACIDS—In all, three different samples were used for the identification of the organic acids. The methyl alcohol extract was evaporated to a syrup, taken up with water, and the acids precipitated with lead subacetate and alumina cream. This precipitate and the precipitate used in the clarification of the sugar solution were used for the qualitative tests, reactions being obtained indicative of oxalic, malic, tartaric, citric, and tannic acids. For the quantitative determination a weighed quantity of the dried fruit was digested with 2 per cent hydrochloric acid for 1 hr. at the boiling temperature, and after filtering, clarified with boneblack. After concentrating the solution the method of Barfoed² was used for the separation. The results, calculated to the air-dry fruits, were oxalic acid 1.21 per cent, and citric acid 0.58 per cent.

OIL—The oil was the most interesting part of the whole fruit. As the plant belonged to the same family as the grape, we expected to find an oil similar to grape oil. The air-dried fruit was crushed between two boards and 100 g. of clean seeds picked out. These

¹ Wiley's "Agricultural Analysis," p. 272.

² *Z. anal. Chem.*, 7 (1868), 403.

¹ *Am. Chem. J.*, 1 (1880), 377

were washed with low-boiling petroleum ether, the washings afterwards being used in the extraction, and carefully crushed in a mortar. They were extracted in a Soxhlet extractor with petroleum ether (b. p. 25°-40°) for 8 hrs., then ground to a fine powder and again extracted for 8 hrs. About half of the solvent was evaporated on the water bath and the evaporation completed in a current of carbon dioxide. The final traces of solvent were removed in a vacuum desiccator. Treated in this way the seeds yielded 25.6 per cent of oil.

The oil has the appearance of olive oil, perhaps slightly yellower, is odorless, and has only a slight taste, which reminds one of castor oil. After standing for a week a small amount of solid fat separated. At 0° C. the oil formed a pasty mass and solidified below that point. It responded to the elaidin test, forming a white solid and a brown liquid. A film of the oil dried in 14 days, although it had not even become tacky in 7 days. The absorption of oxygen, as measured by the increase in weight, was as follows:

First 70 hrs.	0.99 per cent
Second 70 hrs.	3.34 per cent

The oil gave the following analytical constants:

Saponification number	193
Iodine number, Hanus	90
Acid value	0
Unsaponifiable matter, per cent.	1.67
Specific gravity, 15.5°	0.9239
Index of refraction, 15°	1.4761
Liquid fatty acids, Gussow, per cent.	84.0
Solid fatty acids, per cent.	1.60
Iodine value of liquid acids	103.2
Iodine value of solid acids	53.4
Iodine value of mixed acids	96
Neutralization value of mixed acids	203
Mean molecular weight of mixed acids	275
Acetyl value of mixed acids	42.85
Neutralization value of liquid acids	170
Mean molecular weight of liquid acids	330

Making use of the scheme for the study of the mixed fatty acids given by Lewkowitsch,¹ it appears that the following solid acids are present: stearic, palmitic, lauric or myristic, and probably dihydroxystearic and isooleic, while the liquid acids are oleic, ricinoleic, and linolic.

These properties of the oil which have been enumerated place it in the castor oil group of fatty oils, as will be seen by the following table:

	CASTOR	GRAPE	CROTON	AMPELOPSIS
Specific gravity	0.96	0.935	0.95	0.924
Refractive index	1.4799	1.4713		1.4762
Saponification number	183-186	178	210-215	186-194
Iodine number	83-86	96	102-104	86-90
Mixed fatty acids:				
Neutralization value	192	187	201	203
Iodine number	87-93	99	111	96
Molecular weight	293	299	279	275
Acids present:				
Tiglic	+		+	
Dihydroxystearic	+			+
Stearic	+		+	+
Palmitic		+	+	+
Myristic			+	
Lauric				+
Ricinoleic	+	+	+	+
Linolic	+	+		+
Oleic	+	+		+

UNIVERSITY OF ILLINOIS
URBANA, ILLINOIS

THE U. S. P. ASSAY OF MERCURIAL OINTMENT

By L. F. GABEL

Received April 21, 1919

The method as given in the U. S. P. IX for the assay of mercurial ointment has proven unsatisfactory in that results by this method are variable and low. In the official assay the fats are extracted by the solvent action of purified petroleum benzene. The mercury is incorporated in the fats in a finely divided state and is separated by repeated washings with benzene. The mercury is so finely divided that it does not settle quickly in the benzene and the numerous decantations make it almost impossible to prevent the loss of part of the mercury. The manipulation required is also a factor to be considered.

With the view of replacing the official assay by a more accurate and expeditious method, comparative experimental determinations were made using three methods: (1) The U. S. P. assay; (2) the determination of mercury as mercury sulfide; (3) the proposed continuous extraction method.

In carrying out the sulfide method, the sample of ointment was treated with dilute nitric acid (1 : 2), digested, filtered, washed, and evaporated to dryness. After redissolving in hydrochloric acid (1 : 8), the general procedure of the U. S. P. sulfide method for the assay of mercuric chloride was followed.

The proposed method as given below is accurate and calls for the minimum amount of manipulation.

THE EXTRACTION METHOD

Extract several 11 cm. hardened filter papers (similar to Whatman's No. 5) with ether to remove fats, dry, and fold. Weigh a 5 to 10 g. sample of the ointment on one of these filter papers which has been previously tared. Place in a Soxhlet apparatus so that the top of the paper extends just above the arm of the out-flow tube. This is easily adjusted by placing glass wool or absorbent cotton in the lower part of the Soxhlet apparatus. Extract with petroleum ether from 2 to 4 hrs. Dry and weigh.

Two samples of mercury ointment (U. S. P.) containing 30 per cent and 50 per cent of mercury were assayed by the three methods and the comparative results obtained are given in Table I.

SAMPLE Per cent Hg	U. S. P. Assay		Sulfide Method		Extraction Method	
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
30		27.2		29.6		29.6
		29.2		30.0		30.3
		28.7		30.2		30.1
		26.5		...		30.5
		48.9		49.6		49.8
50		48.4		49.8		49.5
		48.0		...		49.6

It will be seen that the U. S. P. method gives results which are variably low, while the sulfide method and the extraction method both give results which are fairly accurate. Because of the ease of manipulation, the extraction method is preferable and it is recommended that this method be seriously considered for the next revision of the U. S. P.

It should be noted that the mercury left on the filter paper in the extraction method is readily collected into a globule and is easily examined for the presence of any appreciable amount of foreign material.

ANALYTICAL DEPARTMENT, PARKE, DAVIS & COMPANY
DETROIT, MICHIGAN

¹ "Technology of Oils, Fats and Waxes," Ed. 5, Vol. 1.

LABORATORY AND PLANT

PREPARATION AND TESTING OF HYDROGEN OF HIGH PURITY

By JUNIUS DAVID EDWARDS

Received February 28, 1919

In the course of a study of the properties of pure gases, the preparation of pure hydrogen by several different methods was undertaken. W. A. Noyes has already shown¹ in his work on the atomic weight of hydrogen, that hydrogen of exceptional purity could be prepared by the electrolysis of a solution of barium hydroxide. His work leaves little further to be said regarding the purity of hydrogen, which can be produced in that manner if the proper precautions are adopted. Where the highest purity is not essential, other methods may offer certain advantages. Chief of these is the greater speed with which hydrogen can be generated by such means as the reaction between zinc and acid or of hydron (sodium-lead alloy) and water. For example, the maximum rate of generation from a small electrolytic cell taking 10 amp. is about 4.4 l. per hr., whereas 10 to 20 times that rate can be easily attained with a small-sized Kipp generator for relatively short periods of time.

The Kipp generator, however, has two disadvantages where purity of the product is the first requisite. The residual air must be swept out (which consumes time and material), and the acid is in contact with air in the upper reservoir; this air dissolving in the acid may slowly diffuse into and contaminate the hydrogen. To obviate these difficulties, the generator shown in Fig. 1 was designed by the author in coöperation with Mr. E. R. Weaver.

The operation of the generator is apparent from the figure. The chief advantages claimed for this generator are:

- 1—The sweeping-out period of generation is eliminated.
- 2—An atmosphere of pure hydrogen is maintained in all parts of the apparatus at all times.
- 3—Pure hydrogen can be obtained from the generator at any time—immediately after filling or after standing for long periods.
- 4—Fresh acid can be introduced without admitting air.

The manipulation by which this is accomplished is as follows: Before filling the apparatus it is first evacuated through *a*. The residual pressure in the generator is indicated by the height of the mercury in the tube *d* which serves as a manometer and also as a blow-off. Any leak can thus be detected by the indications of this manometer. If the generator contains any liquid, the pressure cannot, of course, be reduced below its vapor pressure. Continued pumping will, however, sweep out the generator with a stream of water vapor. The acid to be introduced (sulfuric, 1 : 8) is contained in and nearly fills the flask *f* which is connected to the generator by a delivery tube as shown. Several pieces of zinc are introduced into the flask, in order to sweep all the air out of the acid and saturate it with hydrogen. When this has been accomplished, the vent *e* is closed until the pressure

increases sufficiently in *f*, from the generation of hydrogen, to force the acid through the delivery tube and out the end of the Geissler stopcock; all air is thus removed from the connections. On turning the cock to connect with the generator, the acid will then run into the evacuated generator. Before the acid has reached the level of the zinc, the hydrogen dissolved in it can be removed by pumping in order to further ensure complete absence of air. The proper amount of acid is then allowed to enter and hydrogen generated until it bubbles out through *d*, which shows that the generator is under pressure. The rate of generation is regulated by the cock *c*.

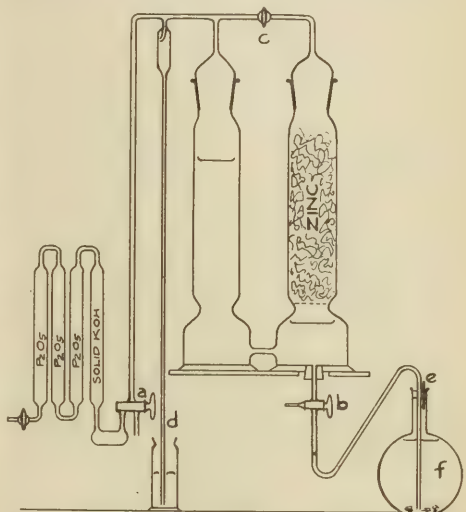


FIG. 1—GENERATOR OF EDWARDS AND WEAVER FOR PURE GASES

The generator illustrated was made from two large calcium chloride towers with glass stoppers. The stopcock at *b* entered through a rubber stopper which was always under liquid. All parts are rigidly mounted on a stand to prevent breakage of the glass connections. The size, shape and arrangement of parts can of course, be modified as occasion demands.

PURITY OF HYDROGEN FROM ZINC AND ACID

Although the purity of the gas may vary with the purity of the materials employed, the present tests are of interest as showing the possibilities of the method. The zinc used was a very pure sample from an English source; the acid was J. T. Baker's "C. P." sulfuric acid. The possibility of the hydrogen containing the following impurities should be considered: Oxygen and nitrogen, sulfur dioxide, hydrogen sulfide, acetylene, methane or other hydrocarbons, carbon monoxide, carbon dioxide, arsine, phosphine, stibine, and water vapor.

¹ Bureau of Standards, Bulletin 4 (1908), 345.

Of these impurities, oxygen and nitrogen which might come from air leaks, had to be rigidly excluded because there is no satisfactory method of removing traces of nitrogen. Sulfur dioxide, hydrogen sulfide, and carbon dioxide were removed by passing the gas over solid potassium hydroxide. The gas was thoroughly dried by passing through three tubes of sublimed phosphorus pentoxide. All connections were glass to glass sealed with de Khotinsky cement where necessary. The following tests for impurities were applied to the gas.

REFRACTIVITY—The refractivity of a sample of hydrogen is a delicate criterion of its purity because all gases which are likely to be present have much higher refractive indices than hydrogen; helium and neon are the only gases having lower refractive indices. The gas interferometer,¹ which measures the difference in refractivity of two samples of gas, may thus be used for detecting impurities in hydrogen. The interferometer was calibrated by the method of Edwards.² For the standard of comparison, hydrogen was generated by electrolysis of barium hydroxide in an all-glass electrolytic cell³ and purified by passage over hot platinized quartz, solid potassium hydroxide, and sublimed phosphorus pentoxide. Every precaution was taken to secure the requisite purity of the materials and to exclude leaks in the apparatus. The hydrogen so generated was considered to have considerably less than 1 part in 10,000 of impurity present.

When compared with this gas in the interferometer, the hydrogen from zinc showed a total impurity, calculated as air, of less than 0.01 per cent. The interferometer was of such sensitivity that 0.005 per cent air in hydrogen could be detected. If gases other than air were present, the actual percentage would be still lower because their higher refractive index gives a greater sensitivity in the reading of the interferometer.

TESTS FOR CARBON COMPOUNDS—To test for carbon compounds, the hydrogen was burned with carbon-free air in a hard glass tube filled with copper oxide. The residual air was then passed through a solution of barium hydroxide contained in the spiral wash bottle⁴ of Weaver and Edwards. The precipitated barium carbonate was filtered off and washed free from barium hydroxide without removing it from the wash bottle or allowing it to come into contact with air containing carbon dioxide. The small precipitate of barium carbonate which was formed yielded 4.4 mg. of barium sulfate, equivalent to 0.83 mg. of carbon dioxide. If this came from the oxidation of acetylene it would have corresponded to 8 p. p. m. by volume in the 25 l. of hydrogen from which it came.

Acetylene was determined directly in the gas by the colorimetric method of Weaver⁵ using an absorbing solution of cuprous chloride containing gelatin, hy-

droxylamine hydrochloride, alcohol, and ammonia in the proportions recommended in the article cited. The limit of visibility was about 0.02 mg. of acetylene. Only the faintest coloration was secured which indicated not more than 1 or 2 p. p. m. of acetylene. The remainder of the carbon found in the previous test may have come from traces of carbon monoxide, methane, or other hydrocarbons.

Hydrogen generated from a sample of hydron generated 4 p. p. m. of acetylene as determined in the same manner.

TESTS FOR ARSINE AND STIBINE—Arsine and stibine were absent as indicated by the lack of any deposit on the passage of the gas through a heated tube. Arsenic and antimony were not detected in the chemical analysis of the zinc.

All of these results confirm the conclusions arrived at from the indications of the interferometer, namely, that hydrogen containing not more than 1 part in 10,000 of impurity can be prepared from zinc with the generator described.

It was of interest to determine the purity of gas obtained from an ordinary Kipp. The gas was compared with the hydrogen from the generator shown in Fig. 1, by means of the interferometer. The gas from the Kipp was purified by passage through soda lime and anhydrous, granular calcium chloride. There was a short piece of rubber tubing leading to the drying tower and three rubber stoppers in the line. No leaks were detected in the system upon evacuation. The purity of the hydrogen and the amount generated by the Kipp were determined every 5 min. The results are shown in Table I.

TABLE I—COMPARISON OF PURITY AND YIELD OF HYDROGEN FROM KIPP GENERATOR

Time from Start of Generation Min.	Purity of Hydrogen Per cent	Total Volume of Gas Generated Liters	Calculated Volume of Gas Required to Reach Indicated Purity Liters
17	83.86	3.96	4.00
22	93.59	6.02	6.03
27	87.86	8.50	8.45
32	99.51	11.58	11.70
37	99.92	15.00	15.69
42	99.97	18.35	17.84
57	99.974	28.4	18.17
77	99.973	41.7	...
112	99.976	74.3	18.3

The results given in Column 4 of the table were calculated from the following equation:¹

$$\frac{\text{Total Gas Evolved}}{\text{Total Gas Space}} = \log_e \left(\frac{1}{1 - \frac{a}{100}} \right)$$

In this equation a is the purity of the hydrogen expressed as a percentage. The gas space in the case of the generator tested was 2.2 l. It is assumed in this equation that there is perfect mixing at all times of the hydrogen with the air in the generator. The agreement between the experimental and the calculated values is quite satisfactory and shows that the equation can be used in calculating the sweeping-out period for any similar generator when gas of any required purity is desired.

¹ Weaver, "Generation of Hydrogen from Ferrosilicon," 4th Annual Report Nat. Adv. Comm. for Aeronautics, 1918.

¹ For a description of the gas interferometer, see L. H. Adams, *J. Am. Chem. Soc.*, **37** (1915), 1181.

² *Ibid.*, **39** (1917), 2382.

³ Similar in design to that of Weber, Bureau of Standards, *Bulletin* **9** (1913), 135.

⁴ *This Journal*, **7** (1915), 534.

⁵ *J. Am. Chem. Soc.*, **38** (1916), 352.

Hydrogen of approximately the same purity (99.97 per cent hydrogen) was prepared in the same Kipp from J. T. Baker's "C. P." zinc said to contain a trace of arsenic and antimony.

SUMMARY

A generator is described with which hydrogen containing not more than 1 part in 10,000 of impurities can be prepared from zinc and acid. Methods of testing for contaminating gases are described. The relation between the volume of gas generated and purity of the product is given by an equation which was verified experimentally.

BUREAU OF STANDARDS
WASHINGTON, D. C.

AN APPARATUS FOR RAPID GASTRIC ANALYSIS TOGETHER WITH A METHOD FOR THE PRESERVATION OF STARCH SOLUTION

By RAYMOND J. MILLER
Received November 29, 1918

Considerable of the success accomplished along the line of gastric investigation conducted at the Jefferson Medical College recently is due to an apparatus designed by one of the members of the research staff, the author of this contribution. With the aid of this apparatus the manipulation of different solutions used in the several analyses has been shortened. The apparatus demonstrates its real value not in the handling of one case for analysis but rather when three or more are to be run.

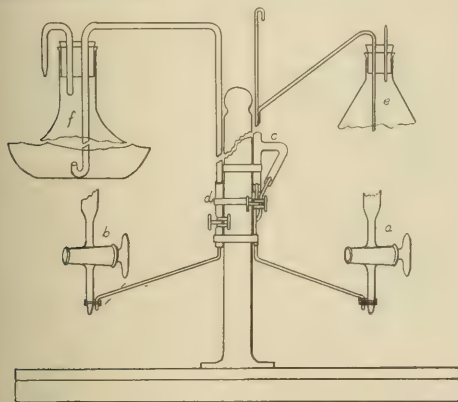


FIG. 1

a—Alkali Burette
b—Thiosulfate Burette
c—Automatic Pipette
d—Syrphon Device (Starch)
e—Formation Reservoir
f—Starch Solution

In gastric analysis as conducted in this laboratory the following determinations are considered of most importance:

- 1—Total Acidity: Titration with $N/100$ potassium hydroxide.
- 2—Free Acidity (Sahlb Method): Titration with $N/100$ sodium thiosulfate, finishing with starch solution.
- 3—Formol Titration or Amino Acid Nitrogen Complex: Addition of neutral formalin and titrating with $N/100$ potassium hydroxide.

The apparatus is designed to meet the requirements for these three determinations.

APPARATUS

To set up the apparatus the following material is necessary:

- 1—Double burette stand.
- 2—Two certified burettes, 30 cc. capacity, graduated to 0.05 cc.
- 3—Capillary glass tubing, 1 to 2 mm. inner diameter.
- 4—Four glass T tubes: Three, inner diameter 3 mm. One, inner diameter 4 mm.
- 5—Red rubber tubing, inner diameters of 1 to 2 mm. and also 4 mm.
- 6—Pinchcocks, three plain and one special two-way cock.
- 7—Adhesive tape.

Fig. 1 shows the apparatus as completed and in running order in the laboratory. The burette on the right is connected to the alkali reservoir, that on the left to the thiosulfate. At the top of the burettes is placed an arrangement which is shown in detail in Fig. 2. Near the base of the burette stand two devices will be observed. The one on the right leading to the tip of the alkali burette is an automatic pipette used in the formol titration, and is shown in detail in Fig. 3. The attachment on the left leading to the tip of the thiosulfate burette is an ordinary gravity device for the rapid addition of starch solution.

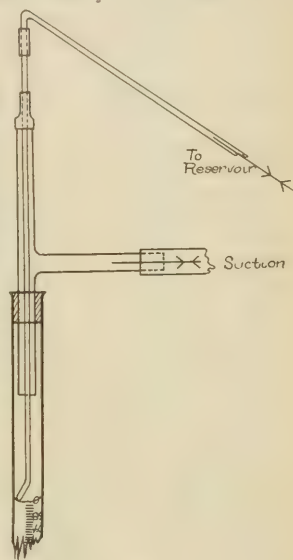


FIG. 2

Fig. 2 illustrates the overhead arrangement whereby the burette can be filled by suction and when the same is released any excess solution drawn over is immediately withdrawn back into the reservoir, leaving the burette reading 0.00 cc.

Fig. 3 shows the automatic pipette which, as soon as its charge is delivered, automatically fills up to approximately its former level and is again ready to be discharged. The principle upon which this device depends is a two-way pinchcock as illustrated at A, Fig. 3. This type pinchcock was designed by another author and reported some time since.

Very little has been said in regard to the assembling of material for the several devices as it has been taken for granted that the figures are self-explanatory. Perhaps but one thing needs an explanation and that is the purpose of the adhesive tape. It will be observed in Fig. 1 that the automatic pipette *c* and the starch

dropping device *d* are attached directly to the up-right support of the burette stand. Adhesive tape was found to be the best means of fastening these devices to the support.

STARCH SOLUTION

The delicacy of starch solution as an indicator for iodimetric and thiosulfate titrations is well known. Its rapid deterioration, mainly due to the presence of molds, has thus far required the observation of the following precautions in its preparation:

- 1—That the starch solution be made up fresh each day.
- 2—That the cold starch solution be placed in small bottles, sterilized for 2 hrs. on a water bath at 100°, closing with soft sterilized stoppers and keeping the individual bottles to be opened as the occasion required (Stokes).
- 3—That preservatives be added. Of these the following have been used: Mercuric iodide (Gastine); potassium chloride, saturated (Bang); potassium iodide; zinc chloride; chloroform; etc.

In pursuance of gastric investigations in the department of physiological chemistry of the Jefferson

Medical College, the problem of preparing a starch solution which would remain intact over a considerable period of time with as little addition of foreign material as possible was studied by the author. As a result the following procedure was developed for use in the laboratory in connection with the determination of free acidity of gastric juice by the Sahli method.

Rub up in a mortar, with sufficient cold distilled water to form a paste, 10 g. of soluble starch (Lintner). Boil 2 l. of distilled water for 15 min. To approxi-

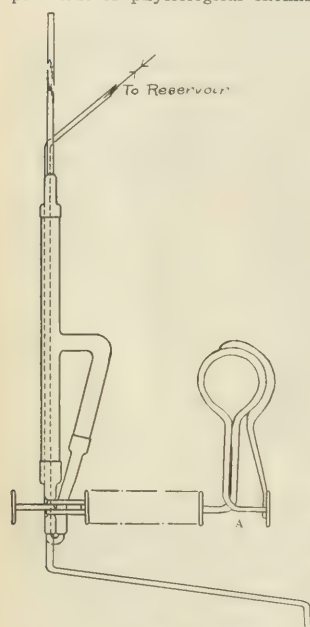


FIG. 3

mately 750 cc. of the boiling water add the starch paste and stir thoroughly. Continue heating for 10 min. Place the hot solution in a clean graduated cylinder and make up to a liter with the remainder of the boiling water.

Rinse the flask to be used as a reservoir with scalding water as well as the siphon device (see Fig. 1).

Immediately place the hot starch solution in the reservoir, 1 cc. of toluol may or may not be added. If it is added, it is well to shake or stir the solution throughout. Immediately float a layer of liquid

petrolatum, $\frac{1}{4}$ in. deep, over the surface of the hot solution. Place the short leg of the siphon device in position within the reservoir. Carefully charge the siphon with the pinchcock open. When so charged the siphon is in running order until the reservoir becomes practically "dry."

The addition of toluol to the solution, it is believed, can readily be omitted and is added only to ensure a preservation of the solution in the siphon during the first usage of the starch solution.

In Fig. 1 it will be noticed that the end of the short leg of the siphon is bent upward. The object of this is to avoid disturbance of the layer of residual dextrin (Blake) which generally sediments at the end of 24 hrs. standing.

This starch solution used in this apparatus has been found to give no trace of reddish coloration with iodine for a period of 6 mos. A further study of the solution was rendered impossible because of the exhaustion of the reservoir supply. Aside from the saving of valuable time by using the above procedure, the fact that starch solution having practically the same properties as a freshly prepared one with little or no addition of foreign material, was always at hand, was of great importance.

JEFFERSON MEDICAL COLLEGE
PHILADELPHIA, PA.

RAPID AND CONVENIENT METHOD FOR THE PREPARATION OF CONDUCTIVITY WATER¹

By C. B. CLEVINGER
Received April 5, 1919

The frequent and increasing need for good conductivity water makes it highly desirable to have a convenient method for its preparation. A description of such a method is especially important because some of the procedures in use are unsatisfactory in one or more respects.

The apparatus used in this laboratory is a modification of the one first described by Bourdillon.² It was originally used here by Dr. S. F. Acree but without all of the present features. The improvements and the non-acquaintance of many chemists with this still give occasion for this publication.

According to Kendall,³ with the exception of some high dilution experiments noted by himself⁴ and Washburn,⁵ the purest distilled water, after exposure to the atmosphere, has a conductivity which is practically accounted for by the carbon dioxide that is absorbed under atmospheric conditions. Kendall found that the conductivity values of water in equilibrium with the air ranged from 0.75×10^{-6} to 0.90×10^{-6} reciprocal ohms at 25° C. It is, therefore, futile to prepare and use water having lower values than the above unless it is carefully protected from the carbon dioxide of the air at all times. It is only for conductivity measurements of the greatest precision that

¹ Published by permission of the Director of the Wisconsin Agricultural Experiment Station.

² *Trans. J. Chem. Soc.*, **103** (1913), 791.

³ *J. Am. Chem. Soc.*, **38** (1916), 1480, 2460.

⁴ *Ibid.*, **39** (1917), 7.

⁵ *Ibid.*, **40** (1918), 106.

this protection is advisable and necessary. For measurements of this kind the water produced by the method here described may be redistilled and appropriately protected.

PRINCIPLE OF THE BOURDILLON STILL

The basic principle on which the Bourdillon still¹ operates and in which it is different from others is that the water is purified largely while in the vapor condition by means of a current of pure air. This is accomplished as follows: Steam, from water to which phosphoric acid or potassium acid sulfate is added, first passes through a trap where substances less volatile than steam are condensed and eliminated. The steam then passes up into a specially constructed condenser through which a rapid stream of purified air is forced. This stream of air, moving through the steam, sweeps out the impurities.

DETAILS OF CONSTRUCTION

The accompanying figure shows the construction of the modified still. Its main parts are a copper boiler, A, a copper trap, F, and a special condenser, K, in which the purification and condensation of the steam take place. The boiler A of about 15 l. capacity is fitted with a glass gauge and a screw cap, *b*, for filling. It is connected to the trap F by the block-tin spiral D. The spiral is joined to the boiler by means of the metal collar *c* and to the trap F by means of the slip joint *e* made tight with tin foil. This spiral stops spray and condenses the less volatile substances which pass off through the outlet *h*. The cylindrical trap is provided with a removable lid, *g*, made tight with tin foil, and to the trap are soldered the $\frac{1}{4}$ -in. tubes *e* and *i*. The tube *e* extends within the trap near the side to about $\frac{1}{2}$ in. of the bottom. The inside of the trap and the parts of *e* and *i* which are in contact with the steam are lined with tin. The spiral and trap are insulated with asbestos paper. The trap is connected to the special condenser K by a block-tin pipe *t* soldered to K and forming with *i* another slip joint made tight with tin foil. The special upright condenser K consists of a block-tin tube $1\frac{1}{4}$ in. in diameter and 6 ft. long, around which are soldered, at the ends, the copper cooling jackets *l* and *m* which are connected by the glass tube *o*. To the tube K are also soldered the $\frac{5}{8}$ -in., block-tin tubes P, *n*, and *w*. The loop in P, by remaining filled with water, serves as a guard preventing to a large extent the passage of air from the still into the container Q. The glass or block-tin container is attached to the end of P by means of a rubber stopper. It is fitted with a siphon or water cock and a guard tube of soda lime. To P is soldered an independent outlet *r* consisting of a $\frac{1}{2}$ -in. block-tin tube, the end of which is provided with a solid block-tin stopper. This outlet furnishes a convenient means for obtaining small portions of water to be tested and for discarding the first of the distillate. The measurements of all tubes are outside diameters.

Connected to *n* but not shown in the figure is a train for the purification of the air stream which is preferably produced by means of an electrically driven rotary

¹ Loc. cit.

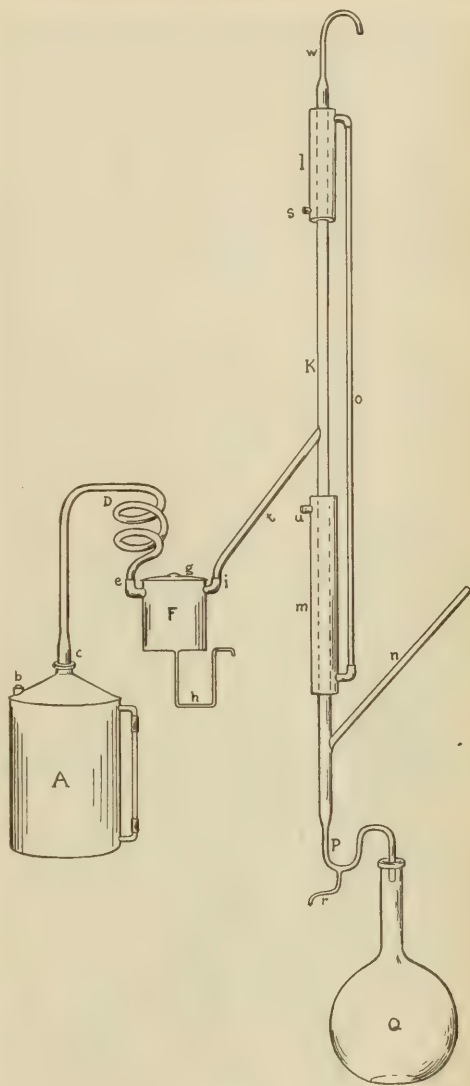


FIG. 1

pump. An ordinary water filter pump arranged for producing pressure may be used, but this requires more attention and often does not give uniform pressure which is essential. Air may also be drawn through by suction, but this results in the danger of impure air coming through the joints. The air stream is purified by passing through 2 l. bottles, filled two-thirds full of concentrated sulfuric acid and broken glass, and then through two similar bottles containing a solution of concentrated sodium hydroxide. An empty bottle should be placed between the acid and alkali.

The air then passes through a vertical column of glass beads to remove spray and finally through an empty bottle serving as a trap. The alkali should follow the sulfuric acid because this acid is appreciably volatile in a rapid stream of air. To the tube *w* at the top of the condenser is connected a bottle containing sulfuric acid which collects the moisture carried over from *K*. To this bottle is attached, when the operation of the still is stopped, a guard train to prevent back entrance of carbon dioxide and ammonia. This guard consists of two absorbing towers, one filled with porous pumice saturated with sulfuric acid, and the other filled with soda lime.

OPERATION

The water is first boiled a short time to expel gases and then a few cubic centimeters of phosphoric acid are added. About one-fourth of the steam condenses in the trap and carries away impurities. The steam entering *K* is purified by the upward air stream and is cooled just to condensation by the upper jacket *l*. As the hot water runs down the sides of *K* it continually meets air which is less and less contaminated by washing and is thus further purified. The water is finally cooled by the jacket *m*. The cooling water enters the upper condenser *l* at *s* and passes from the other opening into the lower condenser through *o* and then away through *u*. The size of the air stream is limited only by the efficiency of the purification train. A continuous stream of small bubbles in the train producing a rapid but gentle movement of the air from the top of *K* is sufficient.

During the operation of the still the guard train attached to *w* to prevent back entrance of carbon dioxide and ammonia into the condenser is disconnected.

ADVANTAGES OF THIS STILL

This modification differs from the original Bourdillon still mainly in that the parts are connected into a permanent unit and in that there are the additions of the loop *P* and the separate outlet *r*. The chief merits of the still as described are that large amounts of good water can be secured easily by a single distillation, and that very little attention is required for its operation. With the size described about 1 l. per hr. is the usual rate of distillation. Starting with about 12 l. of ordinary distilled water in the boiler, 8 l. of water can be obtained having a conductivity value of 0.8×10^{-6} reciprocal ohms. Without the use of phosphoric acid or any chemicals in the boiler a value of about 1.0×10^{-6} is secured. These values are of the water after exposure to the air and the former agrees well with the average value of those reported by Kendall.

Should small quantities of water of a better quality be desired these may be obtained directly from the still through *r* during the middle of a distillation period. Where there is need for considerable conductivity water of good quality this type of still has many advantages.

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A METHOD FOR DETERMINING THE PERMEABILITY OF BALLOON FABRICS

By JUNIUS DAVID EDWARDS AND S. F. PICKERING

Received March 25, 1919

The rapid development of lighter-than-air craft in the past few years has stimulated the development of fabrics which are relatively impervious to gases, especially to hydrogen. Concurrent with the development of fabrics has been the development of apparatus and methods for determining their permeability to gases. The Bureau of Standards has already given¹ a description of the methods commonly used for determining permeability together with the results of an investigation of the effect of experimental conditions upon the real and apparent permeability.

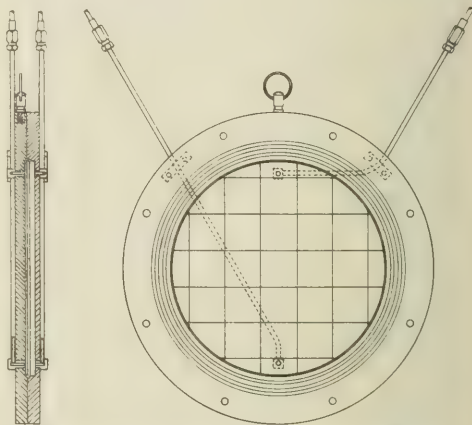


FIG. 1—CELL FOR HOLDING FABRIC FOR PERMEABILITY TEST

The method adopted by the Bureau for most of its work may be briefly described as follows: The fabric which is to be tested is firmly held between the two halves of a circular metal cell (Fig. 1) which is divided thereby into two chambers. A current of pure, dry hydrogen is passed through one chamber so that one surface of the fabric is maintained in an atmosphere of hydrogen under a pressure of 30 mm. of water above the pressure on the opposite side. A current of dry air is passed through the other chamber and the hydrogen which penetrates the fabric diffuses into the air. The resultant mixture of air and hydrogen is passed through a gas interferometer, where the percentage of hydrogen is determined, and through a precision gas meter which measures the rate of air flow. From these factors and the area of fabric exposed, the permeability is calculated. This method is precise and rapid but requires a gas interferometer, which is an expensive instrument and one not readily available at the present time. An alternative method which is extensively used is to determine the amount of hydrogen by combustion, with subsequent weighing as water after absorption in some suitable medium. This procedure, however, is tedious and time-consuming, and leaves much to be desired in many respects.

¹ J. D. Edwards, "Determination of Permeability of Balloon Fabrics," Bureau of Standards, *Technologic Paper* 113, 1919.

DESCRIPTION OF NEW METHOD

We have devised another method based upon a different system of operation which permits the volumetric determination of the hydrogen and which dispenses with both the interferometer and gas meter. While it has not superseded at the Bureau the standard method just described, it offers certain advantages which make it of interest and value to other experimenters in this field.

The novel feature of the method lies in the use of carbon dioxide instead of air for sweeping the hydrogen out of the cell. The mixture of carbon dioxide and hydrogen is then passed into a bulb containing a solution of sodium hydroxide; this solution absorbs the carbon dioxide and leaves as a residue the hydrogen which diffused through the fabric, together with traces of air originally present in the carbon dioxide.

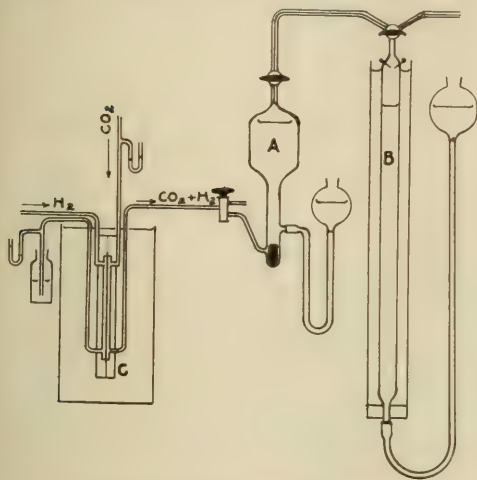


FIG. 2—DIAGRAM OF PERMEABILITY APPARATUS

A diagram (not drawn to scale) of the apparatus as used is shown in Fig. 2. The fabric is held in the cell C which is suspended in a constant temperature bath maintained at a temperature of 25° C.¹ The stream of hydrogen passes out through a water seal which maintains an excess pressure equivalent to 30 mm. of water in the cell. The carbon dioxide and hydrogen from the other chamber pass into the base of the absorption bulb A through a small mercury seal as indicated. The height of the leveling bulb is adjusted so that the gas enters in a steady stream at the proper pressure. This latter condition also requires careful adjustment of the depth of the mercury seal. The bulb A is made wide so that the levels of the liquid will change as little as possible, thus making frequent adjustment of the leveling bulb unnecessary. For this reason it is also desirable to start the test with a small volume of air in the more constricted upper part of the bulb where the volume of the apparatus and consequently the level of the

¹ For data on the large variation of permeability with temperature see *Technologic Paper* 113, 12.

liquid change most rapidly. When the hydrogen penetrating the fabric in a suitable interval of time has been collected, the stream of gas is diverted through the three-way cock either to a duplicate bulb (not shown) or to the air. The hydrogen and air in the bulb A are then transferred to the graduated gas burette B, mixed with the proper amount of air and exploded by sparking. The volume of hydrogen present is then calculated from the contraction in volume in the usual manner. It would be possible, of course, to measure directly the volume of hydrogen collected, but it requires the taking of extreme precautions to ensure the absence of all traces of air in the carbon dioxide. Practically, it is simpler to analyze the collected gas by the explosion method, which is a very simple procedure. It also removes any doubts as to the actual volume of hydrogen present. In running check tests the sample collected in A can be transferred to the burette and analyzed at leisure, the bulb A meanwhile being used for the collection of another sample with a minimum loss of time.

RESULTS OF TESTS

The validity of results obtained by this method depends upon the assumption that the permeability of the fabric to hydrogen remains unchanged when it is in contact with carbon dioxide instead of air. This assumption was tested by determining the permeability of a number of different samples of balloon fabric by the method just described and also by the interferometer method. The results of these tests are given in Table I. The permeability is expressed in the customary manner as liters of hydrogen penetrating the fabric per square meter per 24 hrs., the hydrogen being measured at 0° C. and 760 mm. of mercury pressure. The permeability is determined with the fabric at a temperature of 25° C. and at a pressure on one side of 760 mm. of mercury with an excess pressure of hydrogen equivalent to 30 mm. of water.

TABLE I—COMPARISON OF NEW METHOD WITH BUREAU'S STANDARD METHOD

Test No.	Fabric No.	Permeability by New Method Using CO ₂ Instead of Air L. per Sq. M. per 24 Hrs.	Permeability by Bureau's Standard Method L. per Sq. M. per 24 Hrs.	Difference (Col 3 Minus Col. 4)
1412	24579	6.7	6.7	0.0
1416	36827	9.5	8.8	+0.7
1454	36827	9.8	9.8	0.0
1467	36827	11.1	11.1	0.0
1474	26293	12.0	11.8	+0.2
1504	26293	13.0	13.2	-0.2
1535	24674	17.2	17.5	-0.3
1541	24674	15.5	15.5	0.0

AVERAGE DIFFERENCE... 0.18

The agreement of the results obtained by the two methods is very satisfactory. The effect of carbon dioxide upon the permeability to hydrogen was also tested by running a sample by the standard method, using carbon dioxide in place of air and determining the hydrogen with the interferometer; carbon dioxide of the same purity was used as a comparison gas in the interferometer. These latter data are relatively few in number but corroborate our conclusion that within the limit of experimental error the carbon dioxide does not influence the permeability to hydrogen.

EDGE EFFECT IN TESTING BALLOON FABRICS

It may be well to call attention again to a source of error¹ common to all permeability methods and which has not, perhaps, been sufficiently emphasized. This error is due to imperfect delimitation of the area of fabric under test. The great majority of fabrics in use contain at least two plies of cloth with a layer of rubber in between and usually a thinner layer of rubber on one or both sides. The rubber seldom penetrates the interstices between the threads very thoroughly and, as a result, hydrogen is able to diffuse laterally along the textile as well as directly through the rubber film. Under these circumstances hydrogen which has diffused through the textile can pass through the main layer of rubber, where it is clamped between the edges of the cell, and back through the textile on the other side into the air chamber. The exposed or "active" area of fabric is then larger than the area defined by the edges of the cell and the results are correspondingly high. If there is no rubber on either side or on only one side, the fabric can be satisfactorily sealed with vaseline or soft wax applied hot, which fills up the space between the threads and prevents lateral diffusion of the hydrogen. However, if the fabric is rubber-coated on both sides, which is the general practice in this country for envelope fabrics, the vaseline cannot penetrate the rubber coating into the cloth underneath; no satisfactory method of sealing such fabrics is known. The best procedure is to reduce the margin of the fabric to as small an area as possible and put hot wax on the edge. The possible error if the whole margin is active can be easily calculated. The Bureau's practice is to run such fabrics with a margin not over 4 mm. in width in a cell having an area of 250 sq. cm. The error can then not be over 9 per cent, or 1 liter on an "11 liter" fabric, and this correction can be applied if desired.

NOTES ON NEW METHOD

Aside from the simplicity and availability of the necessary apparatus, the new method possesses a number of advantages which may be pointed out. The permeability over the whole testing interval is averaged; this tends towards uniformity of results. The permeability may be estimated roughly during the course of a test by observing the rate at which the gas collects in A. This is of value with a fabric having a high permeability. The method eliminates the danger from explosions which frequently occur with the combustion method when a fabric of high permeability is tested. If two or three cells are being used only one gas burette need be employed since it can be connected to the absorption bulbs in turn.

With a fabric having a permeability of 10 l. per sq. m. per 24 hrs., about 5.5 cc. of hydrogen are collected in 30 min. with a cell having an area of 250 sq. cm. This gives a contraction of 8.2 cc. upon explosion. A gas burette graduated to 0.1 cc. thus enables the hydrogen to be determined with an accuracy of about 0.1 l. under the assumed conditions. This is ample accuracy for most purposes. It is rather

difficult to manufacture a roll of balloon fabric which will not show differences of 0.5 to 1.0 l. from place to place in the roll. Differences of 2 and 3 liters are not unusual in the ordinary run of fabric.

SUMMARY

We have described a method of determining the permeability of balloon fabrics to hydrogen in which the hydrogen penetrating a given area of fabric is collected in a stream of carbon dioxide. The carbon dioxide is absorbed in alkali as in a nitrometer; the hydrogen remaining is then determined volumetrically by explosion with air in a gas burette. Simplicity and availability of apparatus combined with a satisfactory precision of results make the method of value to experimenters not desiring to install a more elaborate set-up. The reader is referred to *Technologic Paper 113* of the Bureau of Standards for supplementary details regarding the determination of permeability.

BUREAU OF STANDARDS
WASHINGTON, D. C.

THE ESTIMATION OF FIBERS IN PAPER

By ROGER C. GRIFFIN

Received April 24, 1919

The estimation of the percentages of different fibers in paper, after the paper has been reduced to pulp in the usual way and a representative portion of the fibers properly stained and prepared for microscopic examination, is conducted by one of two methods, either the so-called Count Method or the Estimation Method. In the former method the actual numbers of the different fibers in a given field are counted and from the average counts of several fields the percentages are calculated. This method is doubtless capable of accurate results if properly carried out. Its accuracy, however, is influenced by the condition and the kind of fibers. In the case of ground wood-sulfite mixtures, for instance, there is considerable difference in the size and physical characteristics of the fibers and they cannot all be given equal weight in counting. The same is true of paper where the pulp has been much beaten.

By the estimation method the observer visualizes the field as a whole under the microscope and estimates the proportions of the field occupied by the different kinds of fibers, in his final report, of course, averaging his estimates of several fields. It is hardly necessary to say that the observer should train his eye by examining slides made up from papers of known fiber composition, and that such slides should be frequently examined in comparison with the papers whose fiber composition is to be ascertained.

The Committee on Paper Testing of the Technical Association of the Pulp and Paper Industry in its 1917 report¹ recommends the estimation method, believing it to have the following advantages: "(1) It is more accurate under certain conditions, namely, in making ground wood determinations, and of equal accuracy under all other conditions; (2) it is much quicker; (3) it is easier to teach an individual to estimate

¹ Edwards, *Aviation and Aeron. Eng.*, 4 (1918), 104.

¹ Paper, October 17 and 24, 1917.

correctly than to count correctly; (4) it is possible to make up standard mixtures for ready comparison."

The estimation method of fiber analysis has been used in this laboratory for many years with satisfactory results. The well-known Herzberg zinc chloride-iodine stain is used for staining the fibers. Two slides of each paper sample are prepared and they are marked with key numbers so that the individual analysts do not know which slides are duplicates. Frequent standard slides are included with the unknowns and these are also marked with numbers only. The estimates of each individual are turned in to the chief analyst who tabulates and averages them. In comparatively rare instances, where the agreement between different estimators is not satisfactory, two more slides are made up and given different numbers, and often a different standard is included with them. This procedure is at times varied by making up three slides of one paper, two of another, and a single standard. It may be safely assumed that the estimators are in ignorance of the identity of the slides, and that their estimates are unbiased.

TABLE I

Actual Composition	Number of Estimates	ESTIMATES			
		Highest	Lowest	Av.	Report
GROUND WOOD-SULFITE MIXTURES					
30 G. W.	21	35	15	26	25
50 G. W.	13	70	40	50	50
60 G. W.	42	75	40	59	60
80 G. W.	24	95	60	76.5	75
RAG-SULFITE MIXTURES					
10 Rag	17	25	5	13	15
40 Rag	23	60	30	43	45
60 Rag	59	75	45	63	65
65 Rag	62	80	40	66.5	65
70 Rag	50	90	50	69	70
80 Rag	16	90	75	83	85
SODA-SULFITE MIXTURES					
30 Soda	13	40	15	30	30
40 Soda	42	65	10	35	35
50 Soda	22	65	25	44	45

TABLE II—INDIVIDUAL ESTIMATES ON RAG-SULFITE STANDARDS

Actual Composition Percent Rag	Estimated by	Number of Estimates	ESTIMATES			
			Highest	Lowest	Average	Report
90	A	8	95	90	93	95
	B	7	100	95	96	95
80	A	12	90	60	81	80
	B	13	90	55	79	80
70	A	15	90	60	72	70
	B	17	75	50	68	70
65	A	13	80	50	67	65
	B	15	75	50	66	65
60	A	14	85	45	64.5	65
	B	13	75	50	66.5	65
40 ¹	A	13	75	35	48	50
	B	12	65	40	55	55
30	A	12	40	25	32	30
	B	7	50	25	37	35
10	A	3	20	5	10	10
	B	3	15	5	10	10

RECAPITULATION

Chemist A

Chemist B

Total estimates.....	90	87
Correct.....	24 = 27%	20 = 23%
Within 5 per cent.....	57 = 63%	51 = 59%
Within 10 per cent.....	76 = 84%	72 = 83%
More than 10 per cent variation.....	14 = 16%	15 = 17%

OMITTING THE 40 PER CENT STANDARD

Total estimates.....	77	75
Correct.....	21 = 27%	19 = 25%
Within 5 per cent.....	51 = 66%	50 = 67%
Within 10 per cent.....	66 = 84%	67 = 89%
More than 10 per cent variation.....	11 = 16%	8 = 11%

¹ The original 40 Rag-60 Sulfite standard was not properly made up. When this was discovered a new standard was prepared. The results in Tables I and III are on the new standard but in Table II results are on both standards as it was impossible to separate the figures.

The standard papers were very carefully prepared in this laboratory from pure stock, making correction for moisture content.

TABLE III

Per cent Ground Wood	Individuals	GROUND WOOD-SULFITE MIXTURES				Av. Report	Deviation
		Highest	Lowest	Av.	Report		
30	6	35	20	26	25	— 5	
	6	30	15	21	20	—10	
	5	30	20	26	25	— 5	
	5	50	30	36	35	— 5	
	8	70	40	52	50	— 2	
40	5	50	40	47	45	— 2	
	5	70	50	59	60	— 1	
	5	60	50	52	50	—10	
	6	75	50	65	65	— 5	
	6	75	50	64	65	— 5	
60	5	70	50	61	60	— 1	
	8	80	60	67	65	—15	
	5	85	70	76	75	— 5	
	6	95	80	90	90	+10	
	5	75	70	73	75	— 5	
MANILA-SULFITE MIXTURES							
Per cent Manila	5	55	15	36	35	+ 5	
	4	50	35	45	45	+ 5	
	7	55	40	49	50	— 1	
	7	65	30	51	50	— 1	
RAG-SODA MIXTURE							
Per cent Rag	7	85	65	74	75	+ 5	
RAG-SULFITE MIXTURES							
Per cent Rag	6	10	5	8	10	— 2	
	5	20	10	14	15	+ 5	
	6	25	10	16	15	+ 5	
	20	25	15	21	20	— 1	
	30	7	35	43	45	+15	
40	8	45	25	34	35	+ 5	
	7	60	35	44	45	+15	
	7	50	35	41	45	+15	
	8	65	35	49	50	+10	
	6	45	35	39	40	— 1	
60	5	60	30	43	45	+ 5	
	6	70	45	54	55	— 5	
	6	50	50	59	60	— 1	
	7	60	60	65	65	— 5	
	6	70	60	67	65	+ 5	
65	5	65	50	59	60	+ 5	
	7	70	40	67	65	+ 5	
	8	70	60	66	65	+ 5	
	5	75	60	66	65	+ 5	
	5	75	50	67	65	+ 5	
Per cent Rag	6	80	60	69	70	+ 5	
	5	80	70	73	75	+10	
	6	70	55	64	65	— 1	
	6	80	65	69	70	+ 5	
RAG-SULFITE MIXTURES							
65	10	75	50	65	65	— 5	
	10	70	30	62	60	— 5	
	7	70	70	70	70	+ 5	
	8	70	60	61	60	— 1	
	6	80	65	72	70	+ 5	
70	7	75	50	64	65	— 1	
	10	80	60	70	70	— 5	
	5	90	50	70	70	— 5	
	7	80	60	74	75	+ 5	
	7	85	65	74	75	+ 5	
80	6	90	80	85	85	+ 5	
	5	90	75	83	85	+ 5	
	5	85	75	80	80	— 5	
SODA-SULFITE MIXTURES							
Per-cent Soda	6	20	15	19	20	+10	
	5	40	15	32	30	— 2	
	8	35	15	28	30	— 2	
	9	55	10	30	30	—10	
	7	65	20	38	40	+ 2	
40	6	30	45	45	45	+ 5	
	6	45	10	30	30	— 10	
	5	45	20	33	35	— 5	
	7	50	30	34	35	— 5	
	7	40	65	40	51	+10	
60	6	50	35	46	45	— 5	
	6	50	30	44	45	—15	
	7	75	65	68	70	— 2	
	9	100	85	95	95	+ 5	
	5	95	90	92	90	— 2	
95	8	100	80	96	95	— 5	

A record has been kept for some time of the individual estimates on certain of the standard slides and sufficient data has been accumulated to give some idea of the degree of accuracy that may be expected. It is our custom to report fiber estimations to the nearest even 5 per cent. In Table I is given a résumé of the results on those standards which have been most in use. All figures except the second column are percentages.

The maximum and minimum figures vary in some cases considerably from the true composition. We have made no attempt, however, to cut out the poor ones, but have taken them just as they come. In many cases the highest and lowest figures are accounted for by new and inexperienced estimators. In making reports on unknown papers this is, of course, taken into consideration. Notwithstanding the individual variations, the averages are satisfactory.

In Table II we have arranged the estimates of two individual chemists, A and B, on the rag-sulfite series. Each estimate was made on a different slide and on different days. They extend over a period of about five years.

These figures would indicate that only about one estimate out of 6 or 8 made by an individual on rag-sulfite mixtures is more than 10 per cent from the true composition and where from 5 to 10 people estimate on a single slide it may be expected that the average will be within 5 per cent of the actual composition. In rare cases there may be a variation of 10 per cent, but this should not be exceeded if five or more individuals make independent estimations which are within reasonable accord and if their estimates are frequently checked up by standard slides. Ground wood-sulfite and soda-sulfite mixtures are more difficult and in rare cases there may be 15 per cent variation but ordinarily the results may be expected to be within 5 or 10 per cent of the actual composition.

Table III shows that the above statements are borne out by results in this laboratory on standard slides. In this table are given the actual results, taken just as they come, on various standards where five or more individuals have estimated on them at one time.

It is to be remembered that the above figures are all on single slides. On unknown papers where duplicate slides are employed probably still greater accuracy may be expected.

SUMMARY

The estimation method of fiber analysis as applied to papers has been thoroughly tested out and has given satisfactory results in this laboratory for considerably more than 15 years. When carried out as above described it may be expected to give results accurate to within 5 per cent or better on rag-sulfite mixtures and within about 10 per cent or better on ground wood-sulfite and soda-sulfite mixtures.

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DATA OF INTEREST IN THE BARIUM INDUSTRY

By LOUIS S. POTSDAMER

Received February 19, 1919

Since September 1914, when the barium industry in the United States sprang into being, there has been a tremendous growth. Starting with one firm at that time, at least two dozen are active now and rapidly growing. Of course, some have fallen by the wayside, but they represent a very small minority.

Very little data of use in this industry have been published and we therefore offer the tables attached, for what they may be worth.

Table I was compiled by the writer in collaboration with Alexander Strobl, and it has recently been corrected. It gives at a glance equivalents of chemicals frequently used in this industry.

TABLE I

	1.18	1.12	0.96	3.19	0.81	1.00
BaSO ₄	0.86	0.82	0.70	2.32	0.59	0.73
BaS.....	1.00	0.95	0.81	2.70	0.69	0.85
BaCO ₃	0.86	0.82	0.70	2.32	0.59	0.73
BaO.....	0.78	0.74	0.63	2.10	0.54	0.66
BaCl ₂	1.06	1.00	0.86	2.86	0.73	0.90
BaCl ₂ ·2H ₂ O.....	1.24	1.17	1.00	3.35	0.86	1.05
Ba·N ₂ O ₁₀	1.41	1.33	1.14	3.81	0.97	1.19
HCl, 100 per cent.....	0.37	0.35	0.30	1.00	0.25	0.31
HCl, 18%.....	1.33	1.26	1.07	3.59	0.92	1.13
HCl, 20%.....	1.18	1.12	0.96	3.19	0.81	1.00
HCl, 22%.....	1.05	0.99	0.85	2.83	0.73	0.89
H ₂ SO ₄ , 100 per cent.....	0.50	0.47	0.41	1.35	0.34	0.42
HNO ₃ , 100 per cent.....	0.62	0.58	0.50	1.67	0.43	0.53
ZnSO ₄ ·7H ₂ O.....	1.46	1.36	1.18	3.95	1.00	1.24
ZnS·BaSO ₄	1.68	1.57	1.36	4.53	1.16	1.43

Example—One pound of BaSO₄ is equivalent to 0.73 lb. BaS or can be produced from 0.42 lb. 100 per cent H₂SO₄ and 0.90 lb. BaCl₂.

Table II contains data from the 1918 Van Nostrand Annual and is of value to the lithopone manufacturers.

TABLE II

~ZnSO ₄ ·7H ₂ O at 15° C.— ZnSO ₄ ·7H ₂ O Deg. Bé. Per cent			~ZnCl ₂ at 19.5° C.— ZnCl ₂ Deg. Bé. Per cent		
4.1	5		6.3	5	
8.1	10		12.1	10	
12.1	15		17.5	15	
16.0	20		22.7	20	
20.7	25		27.9	25	
23.5	30		32.7	30	
27.2	35		37.7	35	
29.9	40		42.9	40	
34.3	45		47.5	45	
37.8	50		52.4	50	
41.3	55		57.1	55	
44.6	60		61.7	60	

Table III is of use to the manufacturers using barium sulfide, black ash, and was compiled by the writer in collaboration with A. Lusskin.

TABLE III

Deg. Bé. at 60° F.	BaS Lbs. per Gal.	BaS Per cent
2	8.486	2.67
4	8.571	4.10
6	8.700	6.21
8	8.827	8.21
10	8.945	10.29
11	9.013	11.40
12	9.082	12.46
13	9.151	13.58
22	9.810	24.42
23	9.890	25.72
24	9.970	27.28
25	10.046	28.38
26	10.135	29.91
27	10.171	31.26
28	10.256	32.64

CHEMICAL PIGMENTS CORPORATION
PHILADELPHIA, PENNSYLVANIA

SOME CHEMICAL NEEDS OF THE VEGETABLE OIL INDUSTRY¹

By DAVID WESSON

A large corporation engaged in crushing cottonseed and refining vegetable oils was recently asked by the War Department what were the effects of the war on its manufacturing methods. A request was made at the same time for photographs showing improved plant and machinery as illustrating improvements brought about by the war conditions. The answer that was sent back conveyed the information that in handling the seed the amount of lint cut off was about doubled, and to do this the linting capacity of the mills had to be increased. This called for more power, which,

¹ Read before the Division of Industrial Chemists and Chemical Engineers, 57th Meeting, American Chemical Society, Buffalo, April 7 to 11, 1919.

with the difficulty in increasing power plants and the scarcity and poor quality of coal furnished, had a tendency to cut down the normal capacity of the mills.

In the refineries, owing to the drafting of many of the chemists and skilled labor, the work was in many instances done at low efficiency, while in the lard-substitute plants the same methods were carried on through the war as before, though attempts were made to induce the Government to use, in both the Army and the Navy, a form of lard substitute which would have saved them from 12 to 14 per cent of cost on packages, with a corresponding saving in freight space.

In the handling of by-products the manufacture of glycerin was stimulated by high prices, which have now faded away, leaving the product uninteresting to manufacture.

On account of the shortage of chemists, research work in many cases had to be dropped, so peace finds the industry very much where it was before the war started.

With the increased cost of living and high prices of the necessities of life there seems to be a wide field for chemical development of the cheaper materials of the industry. When the armistice came the country had on hand half a million bales of cotton linters, which, during the war, were worth $4\frac{1}{2}$ cents per pound, but in normal times are not worth over 2 cents. This material can be made at the rate of 150 lbs. per ton of seed, as in the past, and it is up to the chemist to work this very valuable raw material into useful products.

The cottonseed cake carries 35 to 40 per cent of protein. Some method should be worked out to put this in a digestible form suitable for human food.

In the manufacture of the oil through its various processes there is still room for improvement. This country is far behind in the use of solvents for extraction, and now with benzol cheap and plentiful it would seem that extraction processes are going to play a big part in the future of the industry. There is a need at the present time for their development.

As is well known, the chief chemical used in the vegetable oil industry is caustic soda. Before the war this was almost universally sold on the basis of 60 per cent Na_2O by the New York and Liverpool test. During the war caustic soda was sold all kinds of ways, mostly, however, flat. Most of the large producers adhered to the old-fashioned way of quoting as above

stated, while the speculators and others who did not care to go into the intricacies of alkali mathematics sold caustic for so much a pound for certain brands of certain strengths. This, of course, led to a great deal of confusion.

When the writer first left school he was given some caustic soda to analyze and made a report but found it was very different from the bill. It was then that he ran up against the time-honored New York and Liverpool test for testing alkali. Apparently very few young chemists know much about this test, and I venture to say there are a good many old ones, not in the habit of handling caustic soda in large quantities who are no better posted. This test has been in use for the last seventy years and is based on the incorrect chemical equivalent of sodium oxide in which it is assumed the atomic weight of sodium is 24 instead of 23. By this method pure carbonate of soda would show 60.377 per cent, whereas actual Na_2O would be 58.491 per cent. In other words, the New York and Liverpool test shows 3.226 per cent more Na_2O based on the total actual Na_2O present. When this test is applied to caustic soda the buyer has to pay for Na_2O present whether it is there as sodium hydroxide or sodium carbonate.

The only defense brought forward for the New York and Liverpool test is "trade custom," and this is because some conservative firms still like to make the ignorant buyer think he is getting more for his money than he receives.

When a chemist buys caustic soda he wants sodium hydroxide because that is what he uses in his work. It would be a considerable saving in time and trouble to those engaged in the industry if all using caustic soda would specify a definite percentage of sodium hydroxide in their contracts and settle on that basis, allowing nothing for Na_2O as carbonate which, in oil refining, is of no use when mixed with the hydroxide.

With the large capacity of alkali plants brought about by the war and the natural competition for business which is bound to result, it would seem that the time is ripe for relegating an obsolete and worse than useless trade custom to the scrap heap, and it is hoped that the members of the AMERICAN CHEMICAL SOCIETY will do what they can to bring about this result.

SOUTHERN COTTON OIL COMPANY
120 BROADWAY, NEW YORK CITY

FOREIGN INDUSTRIAL NEWS

By A. McMILLAN, 24 Westend Park St., Glasgow, Scotland

MANUFACTURE OF COKE

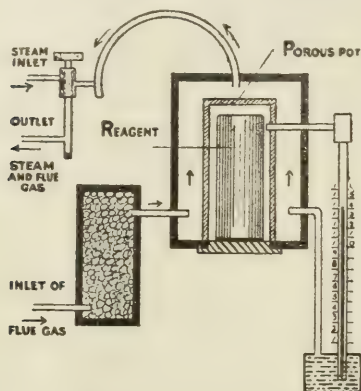
According to an English patent, carbonaceous material, for example, anthracite, peat, lignite, etc., is mixed with the calculated quantity of tar, pitch, petroleum residues or other hydrocarbon required to produce a mixture analytically similar to natural coking coal. The mass is crushed, mixed into a slightly pasty mass and pressed into briquettes in a cold state. The blocks are exposed to the air for about 24 hrs. and are subsequently coked, the volatile constituents being collected as tar, which may be employed for mixing with other material to be coked. The coke obtained has the special properties of metallurgical coke.

STEEL WORKS IN NORWAY

The *Anglo-Norwegian Trade Journal* states that the Minister of Norwegian Industrial Supplies has announced that the government purposes to subsidize new steel works and rolling mills planned in Norway. Loans will be granted and premiums given on production. The latest project is a steel works to be established at Eidjiford, Hardanger. A company with a capital of several million kroner has secured water power and sites for the works and will use a new electric process which is said to be much cheaper than methods used hitherto. The water power amounts to 50,000 h. p., of which 10,000 h. p. will be utilized as a beginning.

COMBUSTION INDICATOR

An instrument made by the "W. R." Patents, Ltd., 8 Old Jewry, London, and called a combustion indicator, is designed to give a continuous indication of the percentage of carbon dioxide present in the flue gases of a steam boiler, and thus to enable the fireman to adjust the air supply to the furnace in such a way as to get as complete combustion of the fuel as possible. The essential part of the device consists of a porous pot in which is placed a dry absorbing reagent in the form of a cartridge. A sample of the gases it is desired to keep under observation is continuously sucked from the flue by an aspirator worked by a small jet of steam (in cases where forced or induced draught is not employed) and is passed through a filter into a closed chamber containing the porous pot. Some of the gases in the chamber penetrate the porous walls into the interior of the pot and are there



absorbed by the reagent, and the partial vacuum thereby produced inside the pot is measured by means of a water gauge connected between the interior of the pot and the chamber, the scale being so graduated as to permit the percentage of carbon dioxide to be read off directly at any time. The instrument which can be used not only with steam boilers but also for the exhaust gases of gas and oil engines and with gas producer plants is stated to be accurate within 1 per cent and to respond quickly to variations in the carbon dioxide content of the gases. No adjustments are required and the only supervision it needs is the renewal of the absorbent cartridge every other day.

PAPER MATERIAL

Experiments, says a contemporary, carried out at the Imperial Institute, London, show that the husks of Burma rice are not, as was at first hoped, suitable for making paper. The fibers from the husks had an average length of from 0.5 mm. to 0.7 mm. and the pulp contained a large proportion of gelatinous material which could not be satisfactorily removed by heating and washing; the pulp might be used as a filler in admixture with longer fibered pulps for the manufacture of low-grade paper or strawboard.

ALUMINUM

According to the *Revue générale de l'électricité*, the surfaces of two pieces of aluminum if they are to be soldered together should be rubbed down with emery paper with a small quantity of vaseline. The fluid may be made up as follows, according to a prescription given by the soldering association: lithium chloride, 15 per cent; potassium chloride, 45 per cent; sodium chloride, 30 per cent; potassium fluoride, 7 per cent; sodium bisulfate, 3 per cent. The joint should be carefully brushed and washed in hot water to remove all traces of flux.

TESTING FOR SIZING WITH IODINE

Albuminous bodies which include animal glues give with iodine solution, on addition of acetic acid, yellow or brown colors. The reaction must be obtained with an aqueous extract of the paper as well as with the sized fibers. The iodine solution is made by dissolving as much iodine as possible in a 1 per cent solution of potassium iodide. If some of the paper teased out with a needle on the slide is dabbed with the solution, a brown color is produced, whether the size is animal or rosin. If, however, the paper is heated on the slide with a little water and then removed, the dried residue on the slide shows characteristic appearances under the microscope. Animal-sized paper leaves behind a considerable formless residue extending over the whole surface formerly occupied by the water. The iodine solution gradually dissolves it with a rusty red color. If the paper be rosin-sized, it leaves but little residue which shows a grainy structure with an uneven dented edge round the space formerly taken up on the slide by the watery solution. This residue also gives a brown color with the iodine solution. It consists of fine resinic acid, according to an article in *Paper-Maker*, 55 (1919), 43, melted out by the hot water and forming an irregular deposit against the dry part of the glass.

IMPORTATION OF CHEMICALS

A proclamation dated June 25 has been issued by the British government of which the following is the operative part: As from and after the date hereof, subject as hereinafter provided, the importation into the United Kingdom of the following articles is hereby prohibited, *viz.*, chemicals of all descriptions; scientific, mathematical, and optical instruments; tungsten powder and ferro-tungsten; provided always that this prohibition shall not apply to any such goods which are imported under license given by or on behalf of the British Board of Trade and subject to the provisions and conditions of such license. The Board of Trade give notice that whereas the above proclamation prohibits, *inter alio*, the terms of the prohibition have been thus widely drawn solely for convenience of a demonstration and that it is not the intention at present to do more than to control the entry into the United Kingdom of certain classes of chemicals of a high degree of purity. The Department of Restrictions will, therefore, almost immediately issue general licenses for a large number of chemicals which are not of this description and they will also issue licenses in suitable cases and for limited quantities of the chemicals which are retained under control. For this purpose, the Department will be assisted by a committee which is now in process of formation and which will contain representatives of official, scientific, and trade bodies connected with chemical industry.

CARBON DEPOSITS

According to *Motor News*, 20 (1919), 1095, Messrs. Shippey Bros., 13 and 14 King St., Cheapside, London, have provided a chemical decarbonizer for preventing deposits on the pistons of motor car and cycle engines, valves, radiators, etc. Its effectiveness results in improved lubrication and more mileage. It gets over the expense and trouble of dismantling and scraping the carbon from the cylinder heads. It is only necessary to put from two to four tablespoonfuls of the liquid into the cylinder every twenty or thirty days, according to the amount of mileage done. This it is claimed keeps the engine in prime order, and lubricating oil may be used as a mixing agent. The makers suggest that about two tablespoonfuls should be put into every quart of cylinder oil used in the crank case or other oil reservoir. The liquid quickly combines with the carbon and by the aid of the combustion in the cylinders volatilizes the same and so removes the carbon.

FIFTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES

THE SPIRIT OF THE EXPOSITION

By R. S. McBride

About ten years ago when one said he was a chemist this meant something to anyone acquainted with this science. The Fifth National Chemical Exposition has proven a change from this former condition. Chemistry has permeated all industry, and now when one says he is a chemist, it seems to mean nothing, for it really means so much. This extension of chemistry is the first and most striking of all the impressions received at the Exposition. Every line of industry, every material of commerce, every principle of science, seems to find here effective presentation, in some form or other.

To tell the story of the Exposition in any short space would, of course, be wholly out of the question. But the spirit of this occasion is clear and easy to set forth: Progress, Efficiency, Service. These three stand out above all other items.

As a "mirror of progress" the occasion was a tremendous success: new materials, new products, new processes, new apparatus and new machinery—to tell of it all would be the full story of American success, not only in its declaration, but more still in its accomplishment of industrial independence. This progress too is not set forth so much as a fully accomplished thing, but rather as a splendid start with wonderful promise for the future.

The success of industries obviously depends upon a recognition of sound principles in the building of machinery and a practice of sound business methods. For all of these the chemist and the chemical engineer are in part responsible. Their duty is to fix upon a proper scientific basis, making for efficiency in the whole structure which the industrial man is to build with his trade or manufacture. In the Exposition this efficiency was made a practical affair, not a mere theory or fetish. The means for its realization and the demonstration that the realization is practical were set forth, both in the process and the product. It is clear that the exhibitors realized that efficiency is to be our industrial yardstick.

Moreover, the Exposition was of interest not only to the chemical and related industries, but also to the entire country. By this is not meant that the demonstration would appeal to popular visitors or attract the non-technical public; but to all of the country it had a real significance. In the last analysis the whole motive was that of service. This is really a logical outcome of the effort for efficiency and it is clear that chemistry, both as a science and as a profession, is on the straight road to reach its deserved position among the greatest of all industries. And it is safe to say that it will never lose its position, as long as it remains as now, the servant of all.

CHARACTER OF EXHIBITS

To accomplish so large a function as set for it, obviously needed great care in preparation, and the results of this thought, taste and careful expenditure resulted in a most attractive and instructive set of exhibits. The thanks of the chemical profession are certainly due to those who made the effort to produce this gratifying result.

The exhibits were prepared for the chemist and the engineer, not for the casual sightseer. The exhibitors had carefully prepared material demonstrative of their processes and products in a way that appealed heartily to both the technical men and the business man associated with them in the industry. Those in charge of the booths not only knew what they had there, but better still knew its real significance. They were able to emphasize the improvement in the art to which their exhibit related and to demonstrate the sound relation of their claims to the economics of the business. In this way a great many found

valuable instruction for their own line where before they had had only casual interest. Apparently for the first time many appreciated the value to themselves of much of the material shown which seemed at first to lie wholly outside their own field.

Genuine in appreciation of the spirit shown by the exhibitors was the response of those attending the show. In many cases those in charge of the booths remarked upon the striking contrast between this and previous occasions, in respect to the very limited number of persons who came and asked for information without an appreciation of the need or the value which this might have for them. As one exhibitor said, "We are blessed with an absence of 'rubber-necks.'"

Many new materials and machinery appeared here for the first time, with many older exhibits, well worthy of a second showing. A striking development was the more frequent use of charts with samples of material and models of apparatus to demonstrate the relation of raw material, process, and product. Many new exhibits in actual operation were also shown, adding greatly to the interest as well as to the real value of the occasion. By means of charts a very surprising perspective as to the scope of new and little appreciated fields was given. One striking example of this, in a field probably not fully grasped by many, was the chart of cyanamide, which is reproduced as one of our illustrations. The Barrett Company added renewed interest in their popular chart of coal-tar products, replacing names by samples. The United States Industrial Alcohol Company's chart demonstrated many substitute uses for the late John Barleycorn.

The only part of chemical industry which was not covered by the Exposition related to foods and drugs. It was really an industrial man's show, planned to appeal to the business man and financier as much as to the chemist and engineer. The emphasis on the economic side of the subject was strong, and this was supplemented in many of the points made in the addresses delivered before the various sessions. The need of good business methods in order to prevent error and loss, which was made clear so effectively by Mr. Dow in his address, had evidently guided much of the preparation. This indeed was one of the most hopeful aspects of the occasion as a permanent institution.

One of the remarkable features was the change in attitude of many of the visitors during their stay. Nearly all came with the expectation of not taking home any pamphlets or literature given out by the exhibitors, but this attitude quickly changed when the genuine value of such was noted, for data and principles of processes were clearly set forth in an attractive way and even those most objecting to carrying a bunch of pamphlets could not resist the appeal. The pamphlets were not at all "popular" in nature. They were built to show that the subject demonstrated really could "deliver the goods." It was a very satisfying evidence that the chemist is now practicing what he has long preached, buying upon specification, analysis, or guaranteed performance. No longer is the skill of the salesman sufficient to sell; real merit is taking its deserved place.

The scope of the exhibits extended from the test tube (yes, there really were test tubes there) to full-size industrial equipment even as large as nitrating kettles of a capacity to circulate five thousand gallons of liquid per minute. Apparatus of the finest sort to give specific gravity to the fourth decimal place and balances that were sensitive to one hundredth of a milligram vied with large-scale measuring equipment, even up to that of two million cubic feet of gas per hour. Delicate physical apparatus on the one hand and laboratory furniture on the other also were there to show that the research man could find any type of equipment which might be of interest in his line as well



as others. Our American independence of foreign manufacturers was most encouraging.

As a reward for their effort the exhibitors were shown by all present an enthusiasm and optimism which was most satisfying. The attendance, at all times, was good, showing that the estimate of twenty thousand interested people in Chicago for this Exposition and the five conventions held simultaneously was probably conservative.

All in all, the first National Chemical Exposition to be held in the middlewest should be acclaimed a great success. This section of the country has fully appreciated the occasion and has made the most of it. They have set a high standard which the next exposition will have difficulty in excelling.

WASHINGTON, D. C.

THE CHEMICAL INDEPENDENCE OF AMERICA AS SHOWN AT THE EXPOSITION

By PROCTER THOMSON

The chemical independence of America is often thought of in terms of those industries that have been developed during the war. These represent only a part of our independence. The Fifth Exposition of Chemical Industries was impressive in its showing of the completeness of the development of American chemical industry.

Those industries whose development has completed our independence were well represented. The by-products coke in-

dustry has reached the point where plentiful supplies of organic raw material are assured, so plentiful that benzol, toluol, xylol mixtures are offered as a motor fuel at a price that competes with gasoline. The production of naphthalene is so great that we now have a surplus for export. Paracoumarone resin of American origin is now available at a low price. A number of well organized companies with the proper financial backing are offering intermediates. These make it possible for the American manufacturer to consider the production of synthetic organic products with an assurance of regular supply.

The number of firms offering dyestuffs was slightly greater than last year, and the lines of dyes available are more nearly complete. With some few exceptions, American dyes are ready to meet all demands. The dyes not now produced are being developed and the time is not far off when complete independence will be attained.

The Exposition was notable for the number of synthetic pharmaceuticals, flavoring extracts, and similar products offered. It is to be hoped that protection will be given American manufacturers in this line, so that our independence can be maintained.

In another line—rare metal products—the growth was noticeable. American-made tungsten, molybdenum, cerium, vanadium, uranium, and titanium, as metals and as salts, are available for commercial and research use.

For research use also there were exhibits by firms which are producing rare bacteriological sugars, bacteriological stains, organic chemicals, and other materials that have formerly made

American research laboratories dependent on foreign sources. Chemical independence is dependent upon these American manufacturers in a way that is not generally recognized. Laboratories, both research and educational, in their search through the literature find references to various reagents under foreign trade names. The people supplying American research chemicals should get proper recognition in order that the ordering of foreign stuff—merely because the literature mentions it—may be discontinued. Then our students and our research men will be extending the science of chemistry with American materials and American ideals.

American-made glassware, porcelain, and filter paper were shown by manufacturers and dealers. These products are of considerable merit and were developed to meet war time needs. The future of American-made laboratory supplies is in the hands of the American chemist. We believe that he realizes the importance of complete independence so strongly that this future will bring great development.

But the products developed in the last few years do not represent all of American independence, although the spirit which has guided this development is the principle feature of our independence. Before the war we were producing inorganic chemicals in large quantity. Our electrochemical development was well advanced. Our ferrous and nonferrous metallurgy was such as to make the American mining engineer and the American steel producer the envy of the world. The exhibits at the Fifth Exposition of Chemical Industries showed American chemical independence not only in those lines which have rounded out our freedom but in those lines which are the foundation of industrial liberty and in which we have been independent for many years.

CHICAGO, ILLINOIS

SESSIONS OF THE EXPOSITION¹

THE WELCOME

Speaking for Chicago and the Central States, Dr. L. V. Redman, chairman of the Chicago Advisory Committee of the Exposition, expressed a welcome to the Exposition to Chicago which was made genuine throughout the whole week. It was with obvious pride in Chicago as a center of chemical industry, that he spoke of the confidence of growth here of all lines of technology. Conspicuous in the whole Exposition was the fact that so many of the exhibitors represented this district of the country.

Citing the spirit of progress in arts and sciences, Dr. Redman set forth the conclusion that during the war period each year had represented as great an advance as would ordinarily be accomplished in a generation, and defied those who viewed the Exposition to deny this. He also pointed out that the increase in activity of chemists, bringing greater demands, has augmented chemists' wages.

This Exposition referred largely to the result of the application of research upon basic principles as a means for successful advance. In this connection Dr. Redman found much to rejoice in the recent resolution adopted by the American Federation of Labor at its national convention, at which time research by the Government was recommended. He found much satisfaction in this first recognition by labor of the basic significance of efficiency in production, and the acknowledgment that distribution is not the sole factor in determining living conditions.

FOR THE MANAGEMENT

Speaking on behalf of the exposition authorities, Charles F. Roth one of the managers, set forth the principles which have guided the work needed to make so great a display of chemical success. He pointed out that the business which is not founded and conducted on a sound chemical basis with modern, efficient chemical equipment will be a laggard in the commercial race. The effort of the Exposition is to serve a great American commercial need through the members of the chemical profession.

¹ We are indebted to Dr. R. S. McBride for the preparation of this and the following material from the Exposition

In pointing to the ever-increasing part chemistry is playing in the great industries of the world, he said:

American chemical engineering has shown during the past four years its ability to meet all emergencies and the competition of its enemies. There are many manufacturers who do not realize that their organizations are founded upon some chemical reaction, for the chemical industries are those founded upon the basic principle of transforming some raw substance or material by a change in its constituents to some material useful for the comfort of man.

After enumerating a long list of chemical industries, many of them not generally connected by the public with chemical arts, Mr. Roth continued:

Did all business men sense the value of a chemical study of their industries and place them upon a scientific basis, the result would place our domestic industries in an unassailable position, incomparable with the rest of the world, for the efficiency of so enlightened a procedure would reduce costs of production by elimination of wastes, obsolete machinery, long and tedious methods, the employment of unnecessary materials and a hundred and one other causes. Competition by any other country would be impossible until they had reached a similar stage of development.



CHARLES F. ROTH, Manager National Exposition of Chemical Industries

Inquire of the leading firms in every industry for the reason of their leadership. They know that the application of the imperative laws of chemistry to their operation has brought it about. The greatness of Chicago's packing houses lies more in the chemical utilization of the waste than the shipping of the prime product. The greatness of the gas house is not in the gas, but in the dyes and pharmaceuticals made from the tars it recovers.

FROM TEST TUBE TO DIVIDEND

Meeting the general interest in the chemists' problems as a commercial project, Herbert H. Dow spoke at length from his experience, taking as the subject of his address the vital question, "How Long Does It Take to Develop a Laboratory Process into a Dividend?" In his treatment he drew telling examples from the problems that occupied the six years from the summer of 1888 during the development of the bromine process of the Dow Chemical Company and the ten years spent in perfection of methods which fortunately matured to fruition within thirty days of the opening of the European war, when magnesium chloride was sent out in carload lots.

That all the promising efforts were not ever perfected to the plant stage was made clear by citing the experience with a brombenzol method for phenol production. Paralleling this, however, was the unusual success with an old method described as follows:

The first plant built had an estimated capacity of one ton per day. It turned out its first product on the first day of November 1915 and in this 30-day month produced 59,000 lbs., which was only 1000 lbs. short of the capacity which had been estimated from the small scale plant. This was the first time in our history that we had gone from a semi-manufacturing plant to a real manufacturing plant without experiencing troubles and months of delays. We attributed our success to a much larger and more mature development organization, and the further fact that after an organization once learns how to develop one chemical manufacturing process, it is much easier to develop another. In this case, the laboratory process and the dividend were less than one year apart, but we must take into consideration that the very abnormal war prices made a profit much more quickly obtainable. * * *

A high official of one of our largest electrical companies once stated to me that they had to figure on five years from the drafting room to the dividend on any product which was materially different from their normal line. The fact that the United States Government during the war could actually accomplish in six months or a year what an old experienced organization could not accomplish in a much greater length of time can only be explained on the ground that men of very unusual ability, and in much greater numbers than any commercial enterprise could command, were giving their services and the utmost energy which they possessed to the rapid development of these products so urgently needed by the allies. Aside from this fact, in the case of the Government, it was not necessary that costs be reduced to a point which would be essential for a dividend in a private enterprise. * * *

In all radical inventions, where public prejudice is a factor and a general campaign of education is necessary, it would appear probable that 10 years, more or less, would be consumed in making a new process profitable. While there are a great many statements in regard to the great length of time required to perfect the first indigo process, there are no data that tell when the earlier small plants began to be profitable. It is now more than ten years since the first indigo was made in one of the laboratories of the Dow Chemical Company, but no serious effort was made to commercialize this process until after the war started, and about three and one-half years after it was decided to build a commercial plant the process became profitable. However, we had the advantage of much of the previous work done by others, which very much shortened the time required. Future development organizations will have the aid of better laboratory equipment, more perfect organization and greater experience, but to offset this, processes in future must be more highly developed in order to meet the prices of competitors who are continuously making their plants more efficient.

We, therefore, leave it to yourselves to judge, but we trust that the few examples given may act as sign posts along the way.

Another point of much interest as a guide from the experience of this speaker was his review of the stages in process perfecting:

It is our experience that the method of evolving a successful process is somewhat as follows: The laboratory works out the process and compares it with the state of the art as shown in the literature, and if results would seem to justify the effort to make the process commercial, some further laboratory investigations are carried out, and then the laboratory force, without an exhaustive study of the subject, tests it out in a semi-manufacturing plant, made of commercial materials instead of glass and porcelain. Here a number of new problems will present themselves and will have to be worked out by the research men. After this plant is in successful operation, the draftsman start their work for a large plant. In the meantime, any uncertain points are still being investigated by the research organization, but an exhaustive study of the subject is not made in the research plant, as we have found by experience that there is no limit to the investigations that may be made at this stage, and many of the points which might be worked on would take months of valuable time which could better be employed at other work, even if we take some chances on a process not thoroughly developed. Finally, when the commercial plant begins to turn out a product, it is inevitable that certain details will have again to be worked upon by the development organization and the troubles remedied. Of course, in developing any new process, it is necessary to carry the laboratory work to a point where both the purity of the product and the yields are sufficiently satisfactory to make a commercial success; and a few hours spent with beakers and test tubes in the laboratory may be the means of saving days in the semi-manufacturing plant; and in a similar way, it is much cheaper to perfect a

process in this semi-commercial plant than in the ultimate commercial plant.

In all this another important warning entered, the need for the business sense in chemical developments and marketing. Not a few got on the rocks for lack of this and needlessly so.

INDUSTRIAL RELATIONS

John W. O'Leary, president of the National Metal Trades Association, added much of inspiration to the evening's proceedings. His entire address is worthy of careful thought.

INDUSTRIAL PATRIOTISM

By JOHN W. O'LEARY, President National Metal Trades Association

No invitation to meet the men of any profession or branch of industry has appealed to me as much as yours, and I am happy that the privilege has been accorded me to participate in the proceedings of this meeting of the National Exposition of Chemical Industries.

I have always tried when thinking in terms of the Great War to dwell not so much on its cost in money, in health, sacrifice or supreme loss of life, but more on the gain to the world through the war. It would be unfortunate if we forgot the debt we, as survivors of the awful struggle, owe to those who fought the good fight and won for us world liberty. None can do them too much honor, and we would be ingrates indeed if we failed in our daily life and expression to give thanks to God and them for the victory.

It seems to me, however, that we would be showing small appreciation and little reverence if we now only devote ourselves to acknowledgment of our debt by erection of monuments, memorials to those who won the war. The cost was too great, the struggle too long, to be content with such expression. We should rather feel the duty ours, to honor them by accepting as our task the rebuilding of the world resources destroyed, the conservation of the resources remaining, and the preservation of the lessons taught by experience.

To you men of the chemical industries comes the opportunity to lead in these tasks. The war brought to all of us a realization of your value in almost every branch of industry. One of the oldest of professions has come into its proper sphere of importance. For, during the war, whether the need was a greater destructive explosive, a more dangerous gas, a more brittle steel, or a more ductile, the science of chemistry was the agency to which we looked. Or if the demands of armies called for more cloth, or wood, or paper, or leather, or silk, or anything which natural resource or productive capacity could not supply, the chemist was called on to create the substitute.

And now that we are realizing the effect of interrupted production, and of wholesale destruction, when we are realizing the economic cost, and the difficulty of supplying even our current needs, when we know that it is essential that we also restore the lack in these years of war before equilibrium can again exist, what an opportunity is yours—to serve the world!

The awakening of industry in general to its need for your assistance was marked during the years immediately preceding the war. The twentieth century began with such an appreciation.

I have been interested all of my life in the steel industry. I have heard my father speak so often of the shipment of steel rails to the United States from England during his early manhood, and of the excitement over the discovery of the Bessemer process. I have watched with interest the later development of the open hearth, and the impetus which that development gave to the industry. But it was not until the chemical engineers developed the use of alloys in steel, and the wonderful magic effects of heat treatment, that the full possibilities of the steel industry became apparent. To-day the chemistry of steel makes us feel that no matter what phenomenal results have been

demonstrated recently, more phenomenal results will occur, and that there is no more important factor in the further development of the steel industry than chemistry. But it is not sufficient that you have improved materially the quality and uses of steel. You have been developing at the same time the by-products, which for so many years were wasted. In so doing, you are making us independent of Germany and her tar compounds and adding materially to the wealth of the United States. It is noticeable that while almost every commodity has increased in price since the armistice, that steel has been reduced, and that in spite of higher costs in actual production of the steel itself. This has been made possible largely through the utilization of the by-products. It is entirely within the realm of possibility that the by-products of steel manufacture may bring profits equal to those of producing steel. Whatever the gain, it will mean much to the future prosperity of the United States. To-day, we are the only great producing nation in position to carry on normal industry through finance, natural resource and comparative immunity from destruction of life from the war. While we are not taking full advantage of our position, because of industrial strikes, we will recover quicker than others. Eventually, however, we must meet competition which will demand the keenest efforts. The farther we advance in utilization of our by-products to carry the cost of manufacture, the better we will meet whatever the balance of the world offers in competition. What has been accomplished in the steel industry is indicative only of the importance of chemistry in almost every basic line. The extravagant, wasteful methods which we employed in the use of our forest resources is forcing attention now. Through the use of preservatives we must conserve what we have left; and it is your province to develop those preservatives.

The importance of the growth of your industry in the basic field of chemicals, drugs and dyes, is clearly shown in the comparison of our export figures for those articles in 1913 and 1917. Our imports from Germany in 1913 amounted to \$21,000,000, our exports in 1913 to all countries \$30,000,000; while in 1917, partly due to higher prices, but still representing large increase in volume, our exports amounted to \$188,000,000. Surely no other American industry can show such a ratio of increase. The war gave both impetus and protection permitting this vast expansion. American initiative, courage, and legislative protection must be forthcoming to continue onward progress.

And so I might continue if time permitted to enlarge upon the importance of the relationship of chemistry to industry. You know, better than I can tell, how vital your field is to industry. But what of the preservation of industry itself? It seems to me that our industrial progress has for the past year been backward rather than forward, and no gathering of business men at this time should fail to recognize the seriousness of our present trend, and seek for the cause and cure.

During the war, and more particularly since the armistice, we have been passing through successive stages of higher wage demands, higher profit demands; less hours, less work; more leisure, more extravagance; less responsibility; less patriotism; of course, the result is bringing higher costs, and a progress toward disaster. Economic truths have been discarded for theories which sound well but won't work. We are confused by a plethora of general terms, undefined in our own minds or in the minds of those who utter them. Living wage, collective bargaining, profiteering, labor as a commodity, partnership of capital and labor, the right to organize, shop representation, combination, a new era, democracy in industry, socialization of industry, are some of the terms used each day in every publication, in every forum. No one attempts to define what is meant, because every one has his own interpretation, and they nearly all differ.

The great mass of American workingmen just want to work; the great mass of American employers just want to produce.

They both recognize that they are interdependent and have cooperative interests, and if permitted to carry on, other conditions will correct themselves. But they too are confused by what is after all nothing more nor less than an insidious Socialistic propaganda. Not that all who are striving to express their understanding of the multitude of new thoughts are Socialists. Many are honest, well meaning folk who have assumed a paternal interest in industry but are in no way responsible for its continuance, nor have they any practical knowledge of its conduct. Others are selfishly interested in the propaganda because it furnishes them their daily bread. Others are employers who either through conscientious belief or pressure have adopted new plans of relationship and are anxious that they not conduct their experiment alone. And industry suffers! Five months of honest productive effort of American industry will supply all of our own needs, and permit of seven months' effort toward replenishment of the world. Yet at our present rate of progress, we are unable to supply our own needs.



JOHN W. O'LEARY, President National Metal Trades Association

Until recently, all Europe was pursuing similar tactics. Each nation's industry was striving to emulate the progress of Russia under Lenine, who has put into force all of the theories which we are talking about, as he understands them. I do not know whether his interpretation isn't likely to be as correct as any of ours. But to-day at least two of the nations who have been passing through this after-war orgy are recovering. Belgium is no longer striving to see how few hours she can work, but rather how many hours bodily strength and health will permit. Germany, under pre-war conditions, a wonderful industrial nation, has lost heavily in man power. But before the war 3,500,000 of her men were constantly removed from industry for military purposes, and millions more were engaged in supplying those 3,500,000. To-day there is no such drain on her industrial man power and the release of this burden more than offsets her losses during the war. They have stopped talking about the eight, seven, or six hour day, and are ready to devote ten, eleven and twelve hours a day to restoring her industrial position.

Frankly, men of American industry, it is time we woke up and undertook a larger influence in the guidance of our industrial program. Whether or not we are living in a new world, or a new era, the same sun shines, the same God rules. None of the formulas of chemical reaction have changed. We continue to progress in the discovery of new things, but they do not develop over night. Time and honest effort, not laws or theories, will

make the discoveries available for service. Progress must be step by step, and each step will succeed only as the proper reagents are used. I remember from my days in chemistry that it required hydrogen and oxygen to produce one of the necessities of life; that it required two parts of the hydrogen and one of oxygen to accomplish it; either a different element or different proportion meant failure. If we substituted sulfur for the oxygen we made an awful stench.

As I see it, industrial relations operate similarly to chemical relations. To reach proper results we must rely upon employer and employee, and in their proper proportion. Too much power on the part of either will not make the compound desired. The substitution of another element will make a stench, and the addition of another element will not produce the desired result.

Two weeks from to-day the Labor Conference called by the President of the United States will assemble in Washington. Its importance to industry is emphasized by the request of the President to union labor to await results of the Conference before inaugurating further strikes. The corollary is that if results of the Conference do not follow the desires of the Federation, strikes will follow, and we must continue the disastrous experience of the past year. It is important, therefore, to analyze from the President's speeches and trend his views on proper solution. He has expressed his belief that society sanctioned the eight hour day; he has approved collective bargaining, though not clearly defined as to method; he has said that he would offer a new basis for wages; he has indicated that workmen should be partners in industry; he has advocated placing employees on the Board of Directors; he has shown sympathetic approval of the organization of all workers.

As I indicated earlier, much depends on the interpretation we give to terms or words. Under any interpretation, a program based on immediate adoption by American industry of these principles would result in chaos. Unrest is too keen for the launching of any definite plan of development of theories which, whether good or bad, must be gradual in their presentation, adopted only after experiment in a small way has proven their success, and debated and studied when men are calm and their judgment keen, rather than under hysterical and restless conditions.

I hope, therefore, that all men of industry who meet together, whether employer or employee, will consider the seriousness of our industrial future, calmly and without passion, and I hope that as a result of such thought they will express to the President their hope that in this critical period of unrest no radical suggestions be inserted to further complicate conditions. Industry is in no position to absorb further departures from established practice than are now being tried. The general public cannot add to the burden being carried by them. Increased production is the only method which will make permanently possible improved standards of living or working conditions.

Our greatest need to-day is for a reawakening of the patriotic impulses created during the war. Now, the slogan should be "Industrial Patriotism."

AMERICA'S CASE IN CHEMISTRY—A SYMPOSIUM

Inspiring his hearers with a vision of the future and chiding them with their duty but partly done, the chairman, Ellwood Hendrick, developed his subject from the early history of American chemistry. Drawing telling contrasts between our technical and our political development in this country, the speaker set forth his appraisal of the situation and then made clear the duty of the chemist to industry, as follows:

The profession, I repeat, was out of focus. We did not have chemists enough because the subject was not talked about enough. Now the special bent of brilliant minds is not always disclosed in youth. They have to feel their way along until

they strike their *melior*; and it goes without saying that many a brilliant mind would have addressed itself to chemistry had the subject enjoyed the general consideration which is warranted by its importance. Chemistry was, in fact, a learned profession long before the tradition lost weight that law and divinity were the only suitable callings for a thoughtful man. When the Great War came upon us the eyes of the people were opened. Chemists were suddenly needed, needed as never before; and how ours responded, the world knows.

Industry has taken notice of chemistry, but it has not yet completely wedded itself to science by availing itself of its opportunities. There is need of many more general commercial laboratories than can find support. We need more industrial research. Again we have not yet learned the need of men with trained scientific minds on boards of directors of corporations engaged in chemical manufacture. This is a serious defect, and its results are frequently shown in the inertia of industry in failing to profit by improvements that would make for great economies as well as for advancement in well-being. Most of us are familiar with large industrial establishments, the processes of which are based on chemical reactions, and these corporations are operated from the standpoint of salesmanship, banking, and law. The company's legal adviser sits in council to pass upon contracts and procedure in dealings with men, but the chemical adviser who understands materials, and who, therefore, is responsible for the company's products and its good reputation, is generally left out in the cold. American industry at large, with only a moderate number of exceptions, is still deficient in its calls upon the man of science to its councils.

Whenever such calls are made the American chemist has responded and has set himself to work with diligence. That so many of his efforts have been crowned with success is pleasant to contemplate—but the way of progress does not lie in contemplation alone. We are in the race with the wide, wide world. In some respects we are ahead, and in others we are behind. We cannot lean back and fold our arms in the belief that a high protective tariff will assure us success. We must maintain the coordination between pure science and that which is applied. We must hold up the hands of our great teachers and encourage them in their arduous task. We must increase the honors and distinction of their offices, and make the post of teacher as desirable as possible. We must do what we can to discover the exceptional man, and to create opportunity for him, because often the exceptionally gifted in research lack the gift of finding places for themselves. We must preach the gospel of chemistry, and bear its evangel to spots where its light is still unknown. And we must, in one way or another, conjure up the "voice of authority" so that it may speak for us!

We need the voice of authority to put a stop to waste of power, waste of fuel, waste of wood, waste of materials, waste of labor—and waste of men. We need this voice to point out the ways of progress.

I believe that we can conjure it up, not as the utterance of one individual, nor in the shout of thousands of voices, crying in unison. It will come, but rather in the benediction of things done. I believe we can accomplish it if, as chemists, we interest ourselves intensely in public affairs, struggling with all our might, both individual and collective, for the public weal; by doing this daily, and without thought of personal reward. If we dig into public affairs with diligence, preaching the gospel of chemistry with all the ardor of insistence shown by the Ancient Mariner in telling his weird tale, then, in time, our message is bound to be heard and heeded. Indeed then, with God's help, we may advance toward a greater enlightenment with a better art of living and in a better ordered world, where justice and peace abide.

Dyestuffs

Dr. J. Merritt Matthews speaking of the dyestuff situation in this country first contrasted the present large exports with the imports of a few years ago, pointing out that now we send out dyes valued as highly as those which were imported in corresponding periods before the war. The number of products already available for the trade and the number of establishments connected with the business give assured success in this field if the protection needed for a time at least is afforded. The basic nature of this field and its interrelation to other industries was also made clear.

Following a brief review of some of the misconceptions as to dyes and as to the characteristics which are of commercial importance, Dr. Matthews seemed to find for all a most satisfying

sense of the availability of the colors needed when he pointed out that despite the practical cessation of the imports of dyes we do not find any lack of brightly colored fabrics and materials to serve the bulk of the commercial need. In contrasting the situation here and abroad he said, "It takes time to do all this, but the United States is no worse off than any other country in this particular."

Chemical Porcelain

Speaking of the history and the present status of the chemical porcelain industry, Herman S. Coors made clear some of the manufacturers' problems and interests. He said:

I am very glad of this opportunity of speaking to you regarding a subject which is of vital interest to me and which, I believe, is of interest to all of you. I am here to help secure the continued support and cooperation of you American chemists, asking your aid toward the perpetuation of all industries which in the space of four years have arisen from obscurity to a position of national importance. * * *

In conclusion, permit me to suggest that the art—as applied to chemical porcelain—is better than the article. The knowledge of how to produce is infinitely more important and valuable than the thing produced. The skill we now possess, which cannot be taken away from us, will continue to exert itself toward the production of chemical porcelain, provided you help to foster our interests and give us your material encouragement.

If we wish to preserve the strength and impregnability of American production, we must direct the growth, within our own country, of the wide and varied catalogues of our industries and sciences. We must develop and train the creative faculties of our own country instead of those of foreign lands.

Optical Glass

H. E. Howe, of the National Research Council, speaking in place of H. N. Ott, told the story of optical glass as a war-time development. Pointing out the fact that previous to the war there had been no incentive to make optical glass, he made clear why trade secrets had governed this industry in this country. But as the war demand arose it was quickly proven that science was more efficient than trade secrets, and the scientist, cooperating with the technologist, was able to produce all and more than the need of this country for optical glass. There was thus produced over 675,000 pounds, and at the end of the war period the production capacity had reached the astounding total of 105,000 pounds of glass per month.

The chronological development, whereby the six important kinds of glass needed in quantity were thus made available, despite tremendous difficulties, afforded a most interesting record in America's war achievements.

Laboratory Supplies

J. M. Roberts, secretary of the Apparatus Makers Association of the United States, spoke on the subject, "Laboratory Supplies; Instruments of Precision and Graduated Glassware." In this field Mr. Roberts pointed out as one of the most urgent needs the standardization of equipment, so that various makers' apparatus would precisely duplicate in every important characteristic with apparatus made by his competitors for the same particular purpose. He stated that, at the present time, many instruments of precision were being built in this country far superior to the types previously imported. With proper protection against importation this condition, in Mr. Roberts' opinion, assures complete success in supply of precision equipment for the laboratory.

Glassware

E. C. Sullivan presented a very interesting summary of the various types of commercial glassware which have been developed to establish our complete independence of foreign makers in this field.

He discussed not only laboratory ware and that which goes into general trade use, but many specialized types such as railway signal globes, lenses for signal lanterns, lamp-bulb glass, glass for protecting the eyes against ultra-violet, infra-red and

other rays that destroy the sight. It is unfortunate that the demonstration of these glasses, which had been prepared, was not possible under the circumstances of the presentation.

Inorganic Chemicals

W. D. Collins gave particular attention to the question of the need for more pure inorganic chemicals, especially from the standpoint of reagents. Many of the heavy chemicals and insoluble inorganic products can be made with full success, and Mr. Collins prophesied a rosy future in this field. He pointed out one difficulty, however, namely, that one could not, as is sometimes required on government purchases, base his order upon the lowest bid, since quality, of course, is often much more important than price.

Research Inorganic Chemicals

H. T. Clarke, telling the story of independence in the field of little used chemicals needed in research work, made the following comments:

At the opening of hostilities in 1914 the supply of imported research chemicals in this country was abruptly cut off. Research work continued for some time with the use of materials in the stock houses and in the storerooms of the universities, but by the middle of 1916 the condition was rapidly becoming serious and it looked as though research work was coming to a halt for lack of supplies.

During this period one attempt was made by a university laboratory to meet the shortage in its stock rooms. Dr. C. G. Derick, of the University of Illinois, initiated a system of vocation laboratory work for the senior students in the organic chemical department, in which the materials most urgently required for the work of the coming semester were prepared in quantities sufficient to meet the immediate requirements. * * *

In July 1918 a letter from Prof. R. A. Gortner was published in *Science*, appealing for an endowment of a laboratory in which this work could be carried out on a more extensive scale. It appeared in the Eastman Kodak Company that their laboratory was in a favorable position to undertake the preparation of synthetic organic chemicals, and approval of the AMERICAN CHEMICAL SOCIETY was obtained, while ample assurance of support was readily given by the large chemical manufacturing firms in the country. Owing to the scarcity of chemists at that time it was decided to staff the laboratory entirely with women, both as chemists and as assistants, and this plan has been adhered to throughout the progress of the work.

TECHNICAL SESSION

The technical session of the Exposition on Thursday afternoon under the chairmanship of Dr. Wm. D. Harkins, included several important papers. H. E. Howe described the organization and plans of the National Research Council, with special reference to industrial development; his report and that by E. W. Washburn on "The New International Union of Pure and Applied Chemistry" covered information already familiar to readers of THIS JOURNAL.

"Fields for Industrial Development; Canadian National Railways," was the subject of an address by C. Price Green, the industrial commissioner of these railways. Many of the industries already beginning work in this field were mentioned and attractive prospects shown for other lines of chemical industrial development.

Henry B. Faber spoke on "Filtration and Filters," his review of the field included a very interesting discussion of the principles in this line of technical operations.

WILLARD GIBBS MEDAL AWARD

On Friday evening, September 26, the Chicago Section of the AMERICAN CHEMICAL SOCIETY made the award of the Willard Gibbs medal to Professor William A. Noyes, of the University of Illinois. This medal is awarded annually for distinguished original research in some field of chemistry and this year this occasion was made part of the exposition week activities so that many more than usual were able to participate in the banquet and evening of addresses. Dr. Redman, chairman of the local

section was the toastmaster, and the award of the medal was made by Dr. Nichols, president of the Society.

Dr. Noyes is a leader in chemical thought in this country, known not only as an investigator but as a teacher of rare ability. He was born in Iowa, on November 11, 1857, and was educated at Grinnell College and Johns Hopkins University, receiving the Ph.D. degree from the latter in 1882. He later continued his studies at the University of Munich. His teaching experience commenced at Grinnell College in 1879; he then taught successively at the University of Tennessee and at Rose Polytechnic Institute. From 1903 to 1907 he was connected with the Bureau of Standards at Washington, and since 1907 has been Professor of Chemistry and Director of the Laboratories of Chemistry at the University of Illinois.



W. A. NOYES, WILLARD GIBBS MEDALIST

Dr. Noyes has held important offices in the AMERICAN CHEMICAL SOCIETY, including the secretaryship, 1903 to 1907, and as Editor of the *Journal of the American Chemical Society* from 1902 to 1917. To him also belongs the credit for the organization of *Chemical Abstracts*. He has himself published a large number of scientific papers representing research work covering a broad field of subjects. In 1908 he was awarded the Nichols Medal by the New York Section of the AMERICAN CHEMICAL SOCIETY for his work on the atomic weight of chlorine. His published works include several textbooks, which are recognized as authoritative in their respective fields, on qualitative analysis, organic chemistry and general chemistry.

Professor Noyes is a member of the National Academy of Science, the American Philosophical Society, and a Fellow of the American Academy of Arts and Sciences.

The customary address in acceptance of the award was made by the recipient, and will appear in a later issue of the *Journal of the American Chemical Society*.

POSITIVE AND NEGATIVE VALENCE

ABSTRACT OF MEDAL ADDRESS BY W. A. NOYES

During the first half of the nineteenth century chemistry was dominated by the old electrochemical theory of Davy and Berzelius. This was abandoned after the discovery of the chloro-acetic acids, in which positive hydrogen is replaced by the negative chlorine, and the theories of valence and of structure were developed without any reference to the thought of electrical forces. Since the introduction of Arrhenius' theory of ionization, and especially since the discovery of electrons and of the disintegration of atoms, new electrochemical hypotheses

have been proposed and chemists and physicists are now actively trying to decipher the structure of atoms and attempting to discover the nature of the electrical and magnetic forces which are almost certainly connected with chemical affinity. The supposition that atoms consist of electrons arranged within a sphere of positively charged matter seems to have been disproved by Rutherford and others and every one seems to assume that atoms consist of a positive nucleus, or of positive nuclei, around or between which electrons are in rotation or in a vibratory, nearly static condition. The hypothesis has been proposed that an electron from one of two electrically neutral atoms might hold these atoms in combination by rotation around two positive nuclei located in parts of the two atoms. It can be shown from a calculation of the known volume of sodium atoms that the kinetic theory would lead us to expect an orbital rotation of an electron during a period of the same order of magnitude as the vibrations which produce the sodium line in the spectrum. For this and other reasons it seems more probable that atoms contain rotating electrons than that the electrons are in a static condition. The evidence that halogen atoms are sometimes positive and sometimes negative and that the oxygen atom of the amine oxides is partly positive also points to a transfer of electrons which takes place in some other manner than that supposed by Irving Langmuir in his interpretation of the hypothesis of G. N. Lewis.

NOTES OF THE EXPOSITION

Laboratory apparatus companies at the Exposition told of a big rush of orders which is being received just now from those who are getting new laboratories and college equipment in order. Apparently every one is stocking up in order to fill the gaps which could not be cared for during the war period. Delays in deliveries due to this congestion of business are still further aggravated in some cases by strikes in the plants where glassware and other important fundamental materials are produced.

A very satisfactory spirit of service was made clear by the exhibits of laboratory equipment. This found a most cordial welcome among executives who have to plan equipment for research laboratories. The desire of the companies was clear, to build equipment well suited to the needs of the user and not to urge the user to fit his needs to apparatus listed in the catalogue. A real scientific attention to apparatus construction is at the root of this advance.

Several Canadian companies and the *Canadian Chemical Journal* were present, renewing acquaintances and making new friends among the American visitors. This Journal is taking great pride in announcing itself as recently appointed the official organ of the Canadian Institute of Chemists. Other exhibitors from Canada represented the department of mines and water-power, the Toronto harbor commissioners and the Shawinigan electrochemical developments.



It was clear that the moving exhibits were the ones that attracted most attention. Apparatus, large and small, was featured by this method, including devices for flotation, air-

conditioning, electrostatic and electromagnetic separation, pulverizing, grinding, separation by sedimentation, and many others. Compressors, vacuum pumps and other types of machinery, even including sprinkler-heads and fire extinguishers were demonstrated in this way. An interesting side-light on this sort of exhibits was shown by a statement from one of the firms which found it necessary to have two pipe-fitters assist on Sunday, the day before the opening. The bill for their services was only eighty dollars. However, it appeared that even these large costs were justified by the great increase in attention to this sort of display.

The coking of Illinois coal and production of by-products were demonstrated by one company, which showed samples and gave the results of official tests made recently at one of their plants by the United States Bureau of Standards and Bureau of Mines. This emphasis on the prospect of extending the coking of mid-continent coal attracted much attention. If it proves commercially feasible to do this, it will mean much for our industries of this field.

This by-product company also showed publicly for the first time a new sort of oven construction, using a double set of triangular flues. Some of the structural advantages were explained and it was pointed out that this system gives each oven a greater independence from the influence of the ovens adjoining it in a battery.

Porcelain exhibitors, including "Coors," "Guernsey," and "Ohio," were on the job, demonstrating that American-made ware is O. K. Great emphasis on American-made glassware was also given by exhibits from practically all firms in this field.

The Chicago Section of the AMERICAN CHEMICAL SOCIETY had a booth where they acted as hosts under the able leadership of the chairman of this section, Dr. L. V. Redman. The monthly bulletin of this section served as the first available guide to all features of the show. The cordial welcome afforded by this section was supplemented by that of the various technical periodicals where information offices were maintained.



The further adaptation by Spitzglass of the multiple contact for a pressure gauge enabled the Republic Flow Meters Company to demonstrate their devices as applied to gas, using the same principle which they have employed in their steam meters. This electrical recorder will serve with either an orifice or a pitot-type flow meter and the makers claim greatly increased convenience and accuracy with greatly decreased cost of installation for large capacities.

Governor Lowden of Illinois was called to Washington to testify before the Congressional committee on budget reform, so that they might have knowledge as to the results under the Illinois system. This made it impossible for the Governor to make the opening address at the Exposition. Dr. Charles H. Herty, editor of THIS JOURNAL, was also prevented from attending to participate as one of the speakers in the opening meeting by his absence in Europe.

That the Chairman of the Advisory Board of the Exposition had not forgotten this occasion was evidenced by a cablegram from him, dated from Paris on the opening day of the Exposition, as follows:

"All together for American independence; best wishes for successful exposition; regret exceedingly necessarily absent.—HERTY."

The Semet-Solvay Company and the Solvay Process Company departed from the usual line of products that one thinks of in connection with by-product coking and emphasized by a model farm some of the uses of chemical products in which they are interested.

The Chemical Warfare Service with smoke, smells and noise was very much in evidence. One would think that the very realistic gas alarms must have made all overseas veterans nervous because they did not have a gas mask within reach. The equipment shown by this branch of the service included samples of masks at all stages of production and a variety of gas, smoke and chemical shell and other material of ordnance which are specially applicable for trench warfare of this sort.



One of the speakers at the opening session made the surprising statement that in the entire United States there are only as many chemists as there are lawyers in the city of Chicago alone. If this is true one can well realize that we really need to have the very largest registration of students who expect to take chemistry in our colleges and universities, which is being experienced this year. Incidentally this is giving the faculties of every institution a serious problem, as not nearly enough men are available for instructors and assistants.

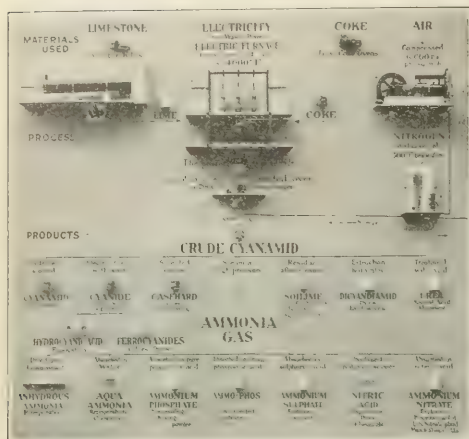
At least two professors of industrial chemistry took advantage of the Exposition to bring their classes of students to Chicago for a special course in connection with the Exposition and the industries which were open during this week. Prof. H. C. Peffer, of Purdue University, and Prof. E. P. Harding, of Minnesota, were thus very busy with their classes.

Four exhibitors, working jointly at a vantage point in the center of the main exposition hall, demonstrated that real art is one of the most effective means of presenting technical material. To eliminate the gaudy and substitute the artistic found increased appreciation at the Exposition.

One of the features which made the Exposition a great success to the firms represented was the fact that many buyers were present prepared to make important decisions regarding purchases.

The use of miniature apparatus representing plant equipment added greatly to the effectiveness of such displays as those for stoneware to be used in nitric acid plants, engineering equipment displays, etc.

A striking development of our war work was evidenced in the many suggestions which were presented for the peace-time use of equipment which had been developed for military uses or munition production. For example, the use of a nitrating kettle for the blending of oils was suggested in order that great saving of time should be accomplished and the influence of oxidation and darkening of the oil eliminated.



THE CYANAMIDE INDUSTRY

One subject of conversation that always brought out strong expression from the chemists in attendance was the thought that the Chemical Warfare Service must be continued as a separate branch of our army for complete success in this important field. One eminent chemist stated "If we are not to be helpless in any later war against an enemy who may easily break his word, we must be prepared fully in this particular." He pointed out that we must study at all times the art of gas offense in order to be ready to protect our own troops against this means of attack. In other words offense studies are an essential prerequisite to defense studies.

That a glass blower who is skilled at his trade is an effective attraction was evident from the crowded aisles about one of the booths where a workman was engaged in the production of blown glassware. Similar demonstrations of the method of preparation of cups, cigarette holders and other materials made from redmanol and bakelite attracted great attention.

It was with great regret that the members of the Electrochemical Society and Mining Engineering Institute learned that the trip to Gary could not be held because of the strike.

The industrial aspect of the chemist's problems was emphasized by numerous exhibits of safety devices including fire extinguishers, sprinkler heads, dust respirators, masks, resuscitation devices, special material for treating burns, etc. On the last day of the Exposition a symposium on safety methods particularly applicable in this field was conducted as a part of the general program.

The professional chemical fraternity, Alpha Chi Sigma, had a registration desk at the Chicago Section of the AMERICAN CHEMICAL SOCIETY. It was found that over two hundred members of this organization were in attendance and more than half of these joined in the dinner party on one of the evenings during the exposition week. Similar social functions innumerable were held by organizations in which chemists predominated.

One of the interesting features was the extensive use of the popular press, to which large numbers of "stories" were regularly issued by the publicity department of the Exposition.

Numerous distinguished visitors were present, including a large delegation from the Swiss Industrial Commission, which arranged its itinerary so that it would be present in Chicago during the week of the Chemical Exposition. Charles M. Schwab, of the Bethlehem Steel Corporation, and numerous other distinguished individuals also found the occasion of sufficient interest to give hours of their time to viewing the exhibits.

An unusual number of technical and trade journals were represented at the booths of the exposition.

A most amazing collection of motion picture films on technical subjects was shown at various times during the week. Every evening it was planned to have such a display, films of related sort being given on the same evening so that the visitors might attend exhibitions which were of most interest to them and gain all of the important information that was available from this effective means of publicity.

The exhibitors have learned how to exhibit.

War has been a great catalyst of chemical progress.

The buyers were there; the Exposition was a success.

The exhibits—a super-saturated solution of good material which is precipitating in every impressible mind.

MEETINGS OF SCIENTIFIC ORGANIZATIONS

AMERICAN ELECTROCHEMICAL SOCIETY

In connection with the Chemical Exposition, the American Electrochemical Society held its 36th General Meeting on September 23 to 26, inclusive. Many of the sessions were held jointly with the American Institute of Mining and Metallurgical Engineers, especially the sessions on iron and steel, ferrous and nonferrous metallurgy, and pyrometry. The many attractions led to a fine attendance and great interest in the society reports.

At the first session the committee report on a standard method for recording the potential data in electrochemical literature led to a spirited debate. The majority report of the committee was finally adopted and there is now to be a standard practice in the nomenclature (as to plus and minus signs) of the publications of this society.

Some of the numerous papers presented at the meetings, including those from this society for joint sessions, were as follows:

Manganese. M. A. HUNTER and J. W. BACON. The authors measure the effect of small variations in the percentages of manganese, nickel and iron on the electrical resistivity and on the temperature coefficient of resistivity. They also studied its thermo-electromotive force against copper. They conclude that small variations in manganese affect the resistivity but not its temperature coefficient; that small quantities of iron affect the temperature coefficient considerably. Care must be taken in annealing the wire to avoid oxidation of the manganese in it.

Depreciation in Small Dry Cells with Age. A. J. HELFRECHT. The author endeavors to show how closely the method of judging cell deterioration, called "flash test," approaches actual measurements of capacity through discharging the cells. Comparative curves for the different sizes of cells tested are given. From the data gained by this investigation a table has been compiled indicating reasonable depreciation of the four important sizes of small cells.

The Effect of Amalgamation upon the Single Potential of Aluminum. LOUIS KAHLBERG and JOHN A. MONTGOMERY. Measuring the single potential of aluminum in a $\frac{1}{2}$ molar solution of aluminum chloride at room temperature, by means of the calomel electrode, the writers obtained much higher values with amalgamated than with unamalgamated aluminum, due to the removal of the coat of resistant oxide by the mercury. They showed also that the measurements were actually the single potentials of the aluminum and not those of an aluminum amalgam.

The Effect of Amalgamation upon the Single Potentials of the Binary Alloys of Aluminum with Copper, Zinc, and Nickel. LOUIS KAHLBERG and JOHN A. MONTGOMERY. While an insufficient number of alloys have been prepared to draw any conclusions with regard to the form of the single potential curve for the entire series, nevertheless, from the data it is quite evident that by amalgamation the initial potentials of the alloys which contain less than 35 per cent of nickel are much higher than the potentials which are measured upon the unamalgamated specimens. Just as in the aluminum-copper series, there is a break in the curve for the readings made upon the amalgamated alloys of aluminum and nickel. The minimum occurs at 7 per cent of nickel, while the eutectic, according to Gwyer, corresponds to 6.5 per cent of nickel. It will be recalled that the break in the curve representing the readings taken upon the amalgamated alloys of the aluminum-copper series also occurred at about the eutectic for that series. The

potential of the 56 per cent nickel alloy of aluminum was not obtained, since it was not in a suitable condition to warrant any measurements being made.

The Activation of Carbon. N. K. CHANEY. The war has brought into existence, as an article of commerce, a new product known as "activated carbon." Originated as a means of defense against toxic gases in warfare this material is rapidly finding industrial applications, the extent and novelty of which are not as yet generally appreciated. The development of activated carbon represents something more than a mere improvement in older forms of adsorptive carbon, or in older processes. It stands for a new viewpoint as to the general nature of so-called amorphous carbon.

Electric Furnace for Experimental Work. F. A. J. FITZGERALD AND GRANT C. MOYER. The authors present description and detail drawings of a furnace built up to heat the charge in the crucible by radiation from the arc, which they usually operate at 50 volts with 500 to 1000 amperes. They state: "While there is nothing original in the general principles of the furnace it is believed that the detail design may be found as useful by others as it has by us, on account of its being so cheap and easy to construct."

A Square Deal for the Electric Furnace. H. G. WEIDENTHAL. A polemic defending the electric furnace for steel-making against prejudices of the trade. The user is urged to acquaint himself thoroughly with electric furnace practice and furnish the best that can be produced by the electric furnace. Thus "he will do justice to himself and his business, and at the same time give the electric furnace a square deal."

Radiant Resistor Furnace. F. A. J. FITZGERALD. The author describes a radiant resistor furnace for the distillation of low-grade or scrap zinc, which was built and operated at the FitzGerald Laboratories and produced several tons of refined zinc. The best results were obtained with a current of approximately 845 amperes at 65 volts or 55 kilowatts. With this power the output was about 50 kilograms refined zinc per hour.

Electric Heat in the Typewriter Industry. A. M. CLARK. An electrically heated oven is described for baking japan on various parts of typewriters. The method of use is explained and comparative tables show the better economy and larger capacity of the electrically heated oven, compared with gas or oil heated ovens.

Some Problems in Contact Catalysis. WILDER D. BANCROFT. The author states: "My attention has been drawn recently to several cases in which a reaction comes apparently to a standstill although no equilibrium has been reached. The experimental data are not as satisfactory as I should like; but I think that the results should be put on record for what they are worth."

Factors Governing the Structure of Electro-Deposited Metals. WILLIAM BLUM. Of the suggested generalizations in this field the most comprehensive are those contained in Bancroft's so-called "axioms of electroplating" first offered in 1904 and reiterated in 1913. One reason for the lack of discussion or application of these axioms by electroplaters is the fact, pointed out by Mr. C. B. Hogaboom in 1913, that few platers could even understand, much less employ them. In order, therefore, to translate these axioms into platers' language and to illustrate their application to electroplating, a number of simple experiments were recently conducted at the Bureau of Standards, the results of which were presented in an informal report to the American Electroplaters' Society. Even though the experiments were primarily pedagogical and in no sense conclusive or exhaustive, it is believed that the results may be of some interest to the Electrochemical Society and may serve to invite discussion of these axioms or other principles of electrodeposition. If some such principles can be definitely established and accepted as a working basis for research in this field, an economy of time and effort will be effected for both the investigator and the commercial operator. The author concludes: "Experiments have shown that Bancroft's 'axioms of electroplating' are applicable over a wide range of conditions and with a variety of metals. They may, therefore, serve as a valuable guide in plating research and in practical plating operations."

Lead Plating from Fluoborate Solutions. W. BLUM, F. J. LISCOMB, ZALIA JENKS AND W. E. BAILEY. Comparison of the fluosilicate and fluoborate baths showed that the fluoborate possessed certain advantages, among which were: (1) It may be prepared by any operator from chemicals easily obtainable; (2) it may be used to plate directly upon steel, whereas in the fluosilicate solution the steel must be first copper plated or receive other special treatment; (3) the fluoborate solution is

less readily decomposed and produces less sludge than does the fluosilicate; and (4) the deposits from the fluoborate solutions are more dense and more nearly impervious than those obtained under similar conditions from the fluosilicate solutions. The work as described in this paper represents therefore the result of a large amount of preliminary work and of a comparatively few well-defined experiments upon the effects of changes in the composition, concentration and current density, together with some data upon methods of testing and analyzing such solutions. No attempt was made to secure high accuracy in the various measurements, since only the more pronounced effects of the different variables were being investigated. While it is not possible to predict at this time the future scope or applications of lead plating, it seems desirable to place on record the results of these experiments, which it is not practicable to continue at this time. It is finally concluded, "lead plating is a practical operation, which can be conducted by an experienced plater with the usual facilities. There is a considerable field for its future application."

The Penetration of Iron by Hydrogen. T. S. FULLER. The results are given of experiments showing the effect of various conditions on the penetration of iron by nascent hydrogen at temperatures from 20° to 100° C. Hydrogen was generated on the outside of an iron tube by immersing the tube in a solution, and the volume of gas penetrating to the inside of the tube was measured. The rate was greater for a unit immersed without electrical connections than when the unit was used as a cathode, but in the latter case the greater the current the greater the penetration. The rate also increases with the temperature. Copper is not penetrated, but a coating of tin on the iron increases the rate. The effects of other conditions are shown.

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS

PYROMETRY SYMPOSIUM

Under the auspices of the American Institute of Mining and Metallurgical Engineers there was held on Thursday and Friday an extensive symposium on pyrometry. This was the result of the joint efforts of the National Research Council Committee on Pyrometry and the Divisions of Heat and Metallurgy of the National Bureau of Standards. Dr. G. K. Burgess, chief of the Metallurgical Division of the Bureau of Standards, presided, and Paul D. Foote, pyrometer specialist of the Bureau, was secretary of the sessions.

This symposium, including as it did, fifty-five papers on all phases of the general subject, was the most impressive symposium on this or similar subjects ever held. One of the reasons for its success was the splendid spirit of coöperation which the promoters found in every quarter when developing papers for the occasion.

The symposium was opened by a series of papers discussing the fundamental concepts of temperature and of methods for temperature measurement. A discussion of the standard scale of temperature and the thermodynamic scale in its relation to radiation and optical pyrometry was included.

A series of papers from representatives of the Bureau of Standards discussed fundamental methods and apparatus. This was followed by several reports from representatives of the Nela Laboratories of Cleveland, who discussed particularly optical methods and the status of our knowledge of means for controlling temperatures.

Representatives of several companies making pyrometric equipment made clear the status of the art of pyrometer construction. This was also the occasion for considerable attention to the subject of porcelain and other materials for pyrometer protection tubes. It was made clear that it was still practically impossible to get wholly satisfactory material for tubes to be used at temperatures of 1400° C. and above. Permeability to gases, melting point, and chemical characteristics, all came in for their share of the discussion.

The industrial application of pyrometers in glass-furnace control aroused one of the most interesting phases of the discussion. It is clearly evident that in this, as in many other cases, the technique of applying pyrometers is not yet fully de-

veloped. The application of pyrometry in cement burning, the ceramic industries, the manufacture of clay ware, the production of many other industrial materials showed the practical applications of this equipment. The teaching of pyrometry also came in for its deserved share of attention.

It is planned that the series of papers and the discussion which they aroused will be printed by the American Institute of Mining and Metallurgical Engineers as a resumé of this important series of meetings. That the subject is worthy of attention is clearly evident from the unexpectedly large attendance at sessions which more than taxed the capacity of the large meeting place. That a report of this proceeding will find a place as a technical classic in our libraries is certain.

TECHNICAL ASSOCIATION OF THE PAPER AND PULP INDUSTRY

The fall meeting of the Technical Association of the Paper and Pulp Industry was held in Chicago on September 24 to 27, in connection with the Fifth National Chemical Exposition. This proved to be one of the best attended and most successful of the quarterly sessions of the society. Many of the exhibits at the Exposition and several attractive side trips added greatly to the enthusiasm and value.

Especially attractive features were the luncheon and afternoon spent at Sears, Roebuck and Company, with visits to the paper mill, wallpaper plant, and other departments of special interest to the membership. The whole day Friday was spent in the visit of the society to the Forest Products Laboratories of the Department of Agriculture, located in Madison, Wis.

The report of the committee on soda pulp consisted of a review of the principles involved in the washing of unbleached soda pulp, by the chairman of the committee, M. L. Griffin. After discussing the advantages of deep and shallow tank washing, it was concluded as follows:

Thus we observe that there is a medium point between these extremes, depending upon local circumstances where the best results may be obtained. By all of these processes, large amounts of heat are lost and the washing requires large volumes of hot water. The movement of the pulp is intermittent, thus necessitating considerable tank storage capacity at different stages of the process.

Opposed to this old-time practice, I desire to present an entirely new view of washing soda pulp which I believe may become practical, and which I have referred to earlier in this paper.

With the rapid strides made during the last few years in mechanical continuous filtration, I believe it is quite within the range of possibility to filter and wash soda pulp with greater economy. The matter is so interesting to builders of such filters that I hope they will participate in the discussion of this prospect.

A report of the committee on testing methods gave a review of the present accepted practice for examinations through chemical, mechanical, and microscopic methods. Brief reports were presented on sulfite pulp and sulfate pulp, also. Another project which developed considerable discussion was the plan for publication of material to serve in vocational educational work. The medium to be used for this was an important consideration.

A paper by Otto Kress of the Forest Products Laboratory covered the question "Deterioration of Wood and Wood Pulp Due to Infection by Fungi." Suggestions for the control and the prevention of losses from this source were presented, including the possibilities of use of disinfecting fluids such as a solution of ammonium fluoride. This paper and the report on soda pulp both elicited lively discussions.

AMERICAN CERAMIC SOCIETY

Wednesday, September 24, was spoken of as Ceramic Day, for the American Ceramic Society held its meetings at this time. The program for the morning was opened by Charles F. Binns' paper entitled "The American Ceramic Society—Past, Present and Future."

Alexander Silverman, presenting data in connection with his

paper entitled "Buy on Analysis," made a very effective argument by contrasting the composition of materials from different sources. His paper dealt with the variations in composition of soda ash, pearl ash, limestone, quick lime, burnt lime, sand, litharge, nitre, salt cake, zinc oxide, alumina, china clay, feldspar, fluorspar, cryolite, and other minerals and chemicals used in the manufacture of glass. It illustrated the wide range of possibilities in composition and emphasized the necessity for purchasing one kind of material for a given manufacturing purpose. The author pointed out that there is not so much danger in the difference of composition as in substituting a material of one composition for that of another formerly employed in glass making at a given factory without making necessary corrections. The paper further emphasized the importance of the density of material such as soda ash and the mechanical analysis of sand, calling attention to variations in grain size which might produce different results in glass manufacture. The paper entitled "Superior Refractories," by Ross C. Purdy, discussed the various fused refractories, particularly those like silicon carbide and alundum, which are, in general, electric-furnace products. The history and the present status of artistic pottery was described by Frederick H. Rhead, who delivered a paper entitled "The Making of Pottery."

One of the most interesting bases of classification of optical glass which has been proposed was presented by Robert J. Montgomery in his article entitled "General Types of Optical Glass." He presented charts, in which he plotted index of refraction in comparison with the dispersion of the glass. Using this basis of classification he divided the field into 23 parts, representing the 23 types of glass which he named. Of these types 12 are now being successfully made in this country.

The article by Douglas F. Stevens entitled "Brick and Tile" referred particularly to the application of these materials in the construction of industrial chemical equipment. The article expected from Dr. A. V. Bleining on the application of scientific methods in ceramic research was not given because of the absence of the author on account of illness. As a substitute, Dr. E. W. Washburn spoke on "Some Aspects of Science and Research as Applied in Glass Manufacture." His remarks covered the following points: With the development of methods of producing, controlling and measuring high temperatures in the laboratory our knowledge of the chemistry and physics of high temperature processes has steadily increased and applications of that knowledge have naturally followed. The stimulus of the war has aided greatly in bringing together the practical man of the factory and the scientist of the laboratory. But in glass making we know *how* to-day much better than we know *why*. Progress demands that we know *why*. In industrial laboratories the work to be done may be roughly classified under three headings: (1) routine testing of raw materials and products and similar control work; (2) works problems including the curing of troubles and the improvement of processes and products; (3) fundamental research to find out the *why* of the operations or to secure quantitative scientific data covering materials, processes and products. In the glass industry almost all of the fundamental research work remains to be done. For example, very little is known of the relations between (1) viscosity and (2) temperature and composition, although viscosity has long been recognized as of great importance in making and working glass. Surface tension and vapor pressure and even density have scarcely been studied at all. Of the reactions and compounds we know almost nothing. The nature of gases remaining in solution is almost unknown, as well as their effect, if any, on the properties of the glass. Many unanswered questions are referred to, including relations between composition and properties, cause of greenish color resulting from substituting soda for potash, the condition of copper in glass, the cause of pink color from manganese, and red in chrome pink, and the function of arsenic. There are three

types of laboratories to carry out such researches: (1) industrial, (2) government or research foundations, and (3) university. The endowment of research professorships in glass would have a very stimulating effect.

Another article not on the regular program was presented by A. Malinovsky, who spoke regarding "Silimanite Brick."

"The Manufacture of Optical Glass" was discussed in an illustrated lecture by J. C. Hostetter. This article reviewed the war work in the various plants where optical glass was being produced and discussed many of the difficult problems which were solved so successfully by the chemists working in this field.

Special interest was given to the occasion of these meetings by the presence of Mr. Connolly, Mr. W. M. Travers, president of the English Ceramic Society, and Mr. W. E. S. Turner, secretary of the British Society of Glass Technology. These three foreign visitors added to the program by interesting contributions to the discussion of the several papers.

The technical sessions of the society were very effectively

supplemented by a special series of motion picture films and visits to the exposition booths, many of which contained material of great interest to the membership of this organization. Several social functions were also held.

AMERICAN STEEL TREATERS' SOCIETY

The American Steel Treaters' Society was organized in September 1918 and has for its purpose the increased efficiency of all of those interested in the heat treatment of steel. The society is entirely educational in its purpose, and is not for profit. Consequently, the success it has attained since its organization reflects the wonderful field for a society serving as a clearinghouse and a medium of exchange for new ideas, new methods, and equipment in this line.

The first annual convention and exhibit of this society was held at the Seventh Regiment Armory, Chicago, during exposition week. The program included over 70 reports and technical papers.

SCIENTIFIC SOCIETIES

FIFTY-EIGHTH MEETING AMERICAN CHEMICAL SOCIETY, PHILADELPHIA, PA., SEPTEMBER 2-6, 1919

PROGRAM OF PAPERS

GENERAL SESSION

Address of Welcome. JOSEPH S. McLAUGHLIN, Director of Supplies of City of Philadelphia.

Response. WILLIAM H. NICHOLS, President, American Chemical Society. Chemistry in Warfare. NEWTON D. BAKER, Secretary of War. Chemistry and the Navy. REAR ADMIRAL RALPH EARLE, Chief, Bureau of Ordnance, U. S. Navy.

President's Address—Research and Application. WILLIAM H. NICHOLS. Some Problems and Methods in Agricultural Research. H. J. WHEELER. Some Physiological Effects Produced by Radiating Definite Regions within a Single Cell. W. V. BOVIE.

Stream Pollution and Its Relation to the Chemical Industries. EARLE B. PHELPS.

The Building of Atoms and the Periodic Systems. (Lantern.) W. D. HARKINS.

The Chemical Laboratory as a Publicity Factor. (Lantern.) ROBERT P. FISCHER.

AGRICULTURAL AND FOOD CHEMISTRY DIVISION

W. D. RICHARDSON, Chairman T. J. BRYAN, Secretary

1. What was the Diet of Aboriginal Man? (Lantern.) W. D. RICHARDSON.
2. On the Constitution of Butterfat. (Lantern.) W. D. RICHARDSON.
3. Some Experiments on Simple Diets. (Lantern.) W. D. RICHARDSON.

4. Influence of Segregation upon the Composition of Sugar Products. C. A. BROWNE.

5. The Hygroscopic Capacity of Certain Food Constituents. C. A. BROWNE.

6. The Relative Importance of Some Coloring Matters in Sugar Cane Juices and Syrups. F. W. ZERBAN.

7. Nutrition Experiments with Low-Cost Protein Diets with Reference to the Utilization of Peanut and Soy Bean Flours. CARL O. JOHNS, A. J. FINES and MABEL S. PAUL.

8. The Amount and Distribution of Iron in the Corn Plant. G. N. HOFFER, R. H. CARR and I. L. BALDWIN.

9. The Effect of Concentration on the Deteriorative Activity of Mold Spores in Sugar. NICHOLAS KOPELOFF, S. BYALL and LILLIAN KOPELOFF.

10. Respiration of Cranberries. FRED W. MORSE.

11. Chemical Change in Cranberries during Storage. FRED W. MORSE.

12. The Cause of Deterioration and Spoiling of Corn and Corn Meal. J. S. McHARGUE.

13. Water Soluble Manganese of Soil. W. O. ROBINSON.

14. The Composition of Ultra Clay. W. O. ROBINSON.

15. Composition of Soil Extract. W. H. FRY.

16. Melzerite in Honey. EDGAR T. WHERRY.

17. Milk with High Apparent Acidity. FRANK E. RICE.

18. Effects of Sulfur on Manure Phosphate Composts. (By title.) W. E. TOTTINGHAM.

19. The Quantities of Preservatives Necessary to Inhibit and Prevent Alcoholic Fermentation and the Growth of Molds. (By title.) MARGARET C. PERRY and G. D. BEAL.

20. Shark Meat as an Edible Product. ALLEN ROGERS.

BIOLOGICAL CHEMISTRY DIVISION

I. K. PHELPS, Chairman R. A. GORTNER, Secretary

1. Chemotherapy of Organic Arsenicals. C. N. MEYERS.
2. The Chemical Composition of Arsphenamine (Salvarsan). G. W. RAZISS.

3. A Comparative Study of the Trypanocidal Activity of Arsphenamine and Nearsphenamine. J. P. SCHAMBERG, J. A. KOLMER and G. W. RAZISS.

4. Chemotherapeutic Studies with Ethylhydrocuprein and Mercurophen in Experimental Pneumococcus Meningitis of Rabbits. J. A. KOLMER and GORO IZUMI.

5. Codrination of the Principles of Chemotherapy with the Laws of Immunity and the Successful Application in the Treatment of Tuberculosis. BENJAMIN S. PARCHALL.

6. The Chlorinated Antiseptics (Chloramine-T and Dichloramine-T). I. F. HARRIS.

7. An Agent for the Destruction of Vermin—Method of Application. A. A. EPSTEIN.

8. An Iodine Preparation for Intravenous and Intraspinous Use—Its Therapeutic Action. A. A. EPSTEIN.

9. The Local Anesthetic and Other Pharmacological Actions of Saligenin and Other Phenolic Alcohols. A. D. HIRSCHFELDER, A. LUNDHOLM, H. NORRGAARD and J. HULTKRAUS.

10. Changes in the Irritability of Intestinal Loops under the Influence of Various Drugs which Inhibit the Parasympathetic Nervous System. A. D. HIRSCHFELDER, H. LUNDHOLM, A. NORRGAARD and J. HULTKRAUS.

11. Effect of Fever on the Toxicity of Digitalis in Frogs and Mammals. A. D. HIRSCHFELDER, J. BICK, F. J. KUCERA and W. HANSON.

12. The Toxicity of Tobacco Smoke from Cigars, Cigarettes and Pipe Tobacco. A. D. HIRSCHFELDER, A. E. LANGR and A. C. FRAMAN.

13. Some Applications of Protein Chemistry to Medicine and Pharmacy. I. F. HARRIS.

14. Action of Chlorotone on Animal Tissue. T. B. ALDRICH.

15. The Outlook for Chemotherapy in the Chemical Industry of America. C. L. ALSBERG.

16. Blue Eyes. W. D. BANCROFT.

17. Colloidal Reactions Fundamental to Growth. D. T. MACDOUGAL.

18. The Antiscorbic Value of the Banana. (By title.) H. B. LEWIS.

19. A Study of Various Culture Media, Especially with Reference to Increasing Their Buffer Effect and Adjusting Their pH Values. (Lantern.) M. R. MEACHAM, J. J. HOFFFIELD and S. F. ACKER.

20. The Cause of and Remedy for Certain Inaccuracies in Hausmann's Nitrogen Distribution Method. (Lantern.) S. L. JODID.

21. The Antiscorbic Properties of Raw Lean Beef. (Lantern.) R. A. DUTCHER, E. M. PIERSON and A. BIERSTER.

22. Preliminary Observations on the Influence of the Diet of the Cow on the Antiscorbic and Growth-Promoting Properties of Milk. (Lantern.) R. A. DUTCHER, E. M. PIERSON and A. BIERSTER.

23. Rhubarb as an Antiscorbic. (Lantern.) E. M. PIERSON and R. A. DUTCHER.

24. The Function of Vitamines in the Metabolism of *Sclerotinia Cinerea*. (By title.) J. J. WILLAMAN.

25. The Preparation of a Stable Vitamine Product and Its Value in Nutrition. H. E. DUBIN.

26. Chemical Isolation of Vitamines. C. N. MEYERS and V. VORGLIN.

27. The Vitamine Content of Wheat Flour. C. O. JOHNS, A. J. FINES and M. S. PAUL.

- 28 The Relation of Plant Carotinoids to Growth, Fecundity and Reproduction in Fowls. (By title.) L. S. PALMER AND H. L. KEMPSTER.
- 29 The Physiological Relation between Fecundity and the Natural Yellow Pigmentation of Certain Breeds of Fowls. (By title.) L. S. PALMER AND H. L. KEMPSTER.
- 30 The Influence of Specific Feeds and Certain Pigments on the Color of the Egg Yolk and the Body Fat of Fowls. (By title.) L. S. PALMER AND H. L. KEMPSTER.
- 31 The Relation of the Natural Enzymes of Butter to the Production of "Tallowiness" through the Agency of Copper Salts. (By title.) L. S. PALMER AND W. B. COMBS.
- 32 The Nutritive Value of Commercial Corn Gluten. C. O. JOHNS, A. J. FINES AND M. S. PAUL.
- 33 The Effect of Calcium on the Composition of the Eggs and Carcass of the Laying Hen. G. D. BUCKNER AND J. H. MARTIN.
- 34 Protein Requirement in the Maintenance Metabolism of Man. H. C. SHERMAN.
- 35 The Development of *Tribolium Confusum* in Certain Foods. R. N. CHAPMAN.
- 36 The Influence of Quinine on Uric Acid Excretion in Man. (By title.) H. B. LEWIS AND W. L. McCLURE.
- 37 The Uric Acid Content of Normal Human Saliva. (By title.) H. B. LEWIS AND W. S. GRIFFITH.
- 38 Studies on the Chemical Composition of the Brain of Normal and Ataxic Pigeons. M. L. KOCH AND O. RIDDLE.
- 39 A Comparison of the Distribution of Various Chemical Groups in Parts of the Human and Pigeon Brain. O. RIDDLE AND M. L. KOCH.
- 40 Calorimetric Determinations of the Energy in Yolk-Protein and Yolk-Fat of Doves and Pigeons. O. RIDDLE.
- 41 Some Properties of the Placental Hormone. P. M. GIESV.
- 42 The Preparation of Fatty Acid Esters of Cholesterol. G. D. BEAL AND J. B. BROWN.
- 43 Comparative Hydrolysis of Fibrin in the Presence of Various Aldehydes. G. E. HOHN AND R. A. GORTNER.
- 44 The Preparation of Cholesterol in Quantity. P. M. GIESV.
- 45 The Influence of Aspartic Acid and Asparagin upon the Enzymic Hydrolysis of Starch. H. C. SHERMAN AND FLORENCE WALKER.
- 46 An Improved Technic for Measuring Lipase Activity in Plant or Animal Extracts or Tissues. (By title.) LEROY S. PALMER.
- 47 The Influence of Various Antiseptics on the Activity of Lipase. (By title.) L. S. PALMER.
- 48 The Activity of Phytase as Determined by Increase in Specific Conductivity. (By title.) F. A. COLLATZ AND C. H. BAILEY.
- 49 The Fermentation of Fructose by a Group of Pentose Fermenting Bacteria. W. H. PETERSON, E. B. FRED AND A. DAVENPORT.
- 50 Factors Influencing the Invertase Activity of Mould Spores in Sugar. N. KOPELOFF AND S. BYALL.
- 51 Carbon-Nitrogen Ratio in Relation to Plant Metabolism. (By title.) A. M. GURJAR.
- 52 Vanillyl Acyl Amides. E. K. NELSON.
- 53 On a Phenol Produced by Growing *Aspergillus Tamari*. J. F. BREWSTER.
- 54 Climatic Control in Relation to Plant Growth. (By title.) W. E. TOTTINGHAM.
- 55 Studies in the Translocation of Nitrogenous and Carbohydrate Material into the Wheat Kernel. (By title.) G. A. OLSON.
- 56 Physical and Chemical Studies of Wheat Gluten. G. A. OLSON AND CHARLES H. HUNT.
- 57 The Composition of the Oil from the Okra Seed. G. S. JAMIESON AND W. F. BAUGHMAN.
- 58 The Composition of the Oil from the Seed of the Hubbard Squash. W. F. BAUGHMAN AND G. S. JAMIESON.
- 59 Notes on the Composition of the Sorghum Plant. J. J. WILLAMAN, R. M. WEST, D. O. SPIESTERSBACH AND G. E. HOLM.
- 60 The Physiology of Germinating Juniperus Seeds. D. A. PACK.
- 61 The Biochemist on the Hospital Staff. F. S. HAMMETT.
- 62 A Spectrographic Study of Certain Biochemical Color Reactions. (By title.) G. L. WENDT AND T. TADOKORO.
- 63 Studies of Wheat Flour Grades. I.—Electrical Conductivity of Water Extracts. (By title.) C. H. BAILEY AND F. A. COLLATZ.
- 64 Studies of Wheat Flour Grades. II.—Buffer Values of Water Extracts. (By title.) C. H. BAILEY AND A. PETERSON.
- 65 The Preparation of Certain Monocarboxylic Acids from Sugars. I. K. PHELPS AND W. T. MCGEORGE.
- 66 An Examination of Wisconsin Oil of *Monarda Punctata*. NELLIE A. WAKEMAN.
- 67 On Hemoglobin: Optical Constants. WM H. WELKER AND CHARLES S. WILLIAMSON.
- 68 Analysis of a Pleural Fluid from a Case of Chylothorax. WM H. WELKER AND CHARLES S. WILLIAMSON.
- 69 Digestibility of Avocado and Certain Other Oils. H. J. DEUEL.
- 70 Digestibility of Whole Wheat Flours, Ground by Various Processes. H. J. DEUEL.
- 71 Studies of Proximate Composition of Cooked Foods. I.—Variations in Fat Content of Fried Foods and a Consideration of the Causes of These Variations. M. C. DENTON.

INDUSTRIAL CHEMISTS AND CHEMICAL ENGINEERS DIVISION
H. S. MINER, *Chairman* H. E. HOWE, *Secretary*

I—Symposium on Refractories

1. The Classification of Refractories. (By title.) G. H. BROWN.
2. Work of the Technical Department of the Refractories Manufacturers' Association. R. M. HOWE.
3. The Selection of Refractories for Industrial Furnaces. W. F. ROCHOW.
4. Interesting Facts Concerning Refractories in the Iron and Steel Industry. C. E. NESBITT AND M. L. BELL.
5. Superior Refractories. R. C. PURDY.
6. Refractory Problems in the Gas Industry. W. H. FULWELER AND J. H. TAUSSIG.

II—Symposium on Annual Patent Renewal Fees

The symposium will discuss various features of the proposal that a system of annual patent renewal fees shall be adopted for the United States. There will be verbal or written discussions by: T. H. ANDERSON, L. H. BAEKELAND, J. M. FRANCIS, EDWIN A. HILL, A. D. LITTLE, JOHN URI LLOYD, L. V. REDMAN, R. L. STINCHFIELD, ELLIOT THOMSON, W. R. WHITNEY, and others, including members of the Patent and Related Legislation Committee of the American Chemical Society, and members of the Patent Committee of the National Research Council.

III—Papers

1. Incendiaries Used in Modern Warfare. (Lantern.) CAPT. A. B. RAY.
2. Gas Masks in the Industries. (Lantern.) A. C. FIELDNER.
3. Division of Industrial Research, National Research Council. H. E. HOWE.
4. The Value of Cost Accounting in Commercial Laboratories. WM. W. CASWELL.
5. Modern Commercial Explosives. R. L. HILL.
6. Chemical Reagents Received by the Bureau of Chemistry during the War. H. E. BUC.
7. Report on the Production of Synthetic Organic Chemicals in the Research Laboratory of Eastman Kodak Co., 1918 and 1919. C. E. K. MEES.
8. The Use of Crystallizers in Cane Sugar Manufacture. CHARLES E. COATES.
9. The Centrifugal Method for the Rapid Determination of Potash. L. S. CONVERSE.
10. Comparison of Methods for Determining Ammonium Nitrate. J. T. GRISSOM.
11. Effect of Chlorides on Nitrometer Determinations of Nitrates. M. T. SANDERS.
12. The Oxidation of Methane. Quartz Combustion Apparatus. (Lantern.) F. C. VIBRANDT AND JAMES R. WITHROW.
13. Carbon Black—Its Properties and Uses. (Lantern.) G. ST. J. FERROTTI.
14. Adherent Rust as an Accelerator in the Corrosion of Iron and Steel. (Lantern.) W. D. RICHARDSON.
15. Some Properties of Commercial Silicate of Soda. J. G. VAIL.
16. The Leaching of Zinc Chloride from Treated Wood. ERNEST BATEMANN.
17. Tensile Strength of Glue. G. HOPP.
18. A New Illuminator for Microscopes. (Third paper.) A. SILVERMAN.
19. The Stability of Tetryl. C. L. KNOWLES.
20. The Manufacture of Trinitroxylenes. JOHN MARSHALL.
21. The Preparation of Hexanitro-diphenylamine and Its Use as a Booster for Shell Charges. JOHN MARSHALL.
22. Composition of Some American Sponges. E. P. DUNNINGTON.
23. Quantitative Determination of Potassium as Bitartrate. SIGMUND WALDBOTT AND FRED. W. WRISSMANN.
24. The Properties of Pyroxylin Plastics. (By title.) R. P. CALVERT AND J. H. CLERWELL.
25. The Extraction of Potash Salts from Kelp Charcoal. (By title.) J. W. TURKENTINE AND P. S. SHOAFF.
26. "Kelpchar," a New Decolorizing Carbon Prepared as a By-Product in the Extraction of Potash from Kelp. (By title.) J. W. TURKENTINE, P. S. SHOAFF AND G. C. SPENCER.

ORGANIC CHEMISTRY DIVISION

LAUDER W. JONES, *Chairman* H. L. FISHER, *Secretary*

1. Cymene as a Solvent. A. S. WHEELER.
2. The Action of Basic Reagents on Certain Schiff's Bases. A. S. WHEELER AND S. C. SMITH.
3. Structural Problems of the Aniline Derivatives of Citric Acid. J. R. BAILEY AND E. B. BROWN.
4. The Synthesis of Capric Acid. G. D. BEAL AND J. B. BROWN.
5. The Action of Phosphorus Trichloride on Ketones and Aldehydes. JAMES B. CONANT AND A. D. MACDONALD.
6. Condensation of Acetylene with Benzene and Its Derivatives in the Presence of Aluminum Chloride. OTTO W. COOK AND VICTOR J. CHAMBERS.
7. The Structure of Azoxy Compounds. OLIVER KAMM AND E. E. A. CAMPBELL.
8. The Purification and Some Physical Properties of Some Aliphatic Alcohols. R. F. BRUNEL.

9. The Limit of Esterification of Certain Aliphatic Alcohols and Acids. R. F. BRUNEL and ELISE TOBIN.
10. The Condensation of Isoscyanic Acid with Alkyl Schiff Bases and Related Compounds. WILLIAM J. HALE.
11. The Oscillation Theory of Colors—Hydrazobenzene and Azobenzene. GERALD L. WENDT, RUTH O'BRIEN and F. W. SULLIVAN.
12. The Chemistry of the Heptane Solution: I—Introductory Remarks; II—Physical Constants of Heptane. EDWARD KREMER.
13. The Chemistry of the Heptane Solution: III—Purification of Heptane; IV—Hydrohalogen Solutions of Heptane. D. C. L. SHERK.
14. Report on the Production of Synthetic Organic Chemicals in the Research Laboratory of the Eastman Kodak Company for the Year 1918-9. C. E. K. MEES.
15. Perchlormethylmercaptan. OREGON B. HELPRICH and E. EMMET REID.
16. Butyl Alcohol as Medium for Saponification. A. M. PARDEE, B. HASCHKE and E. EMMET REID.
17. Halogen-Substituted Phenacyl Bromides as Reagents for the Identification of Acids. W. L. JUDEWIND and E. EMMET REID.
18. Molecular Rearrangement in the Acylation of Certain Aminophenols. L. CHAS. RAIFORD.
19. A More Nearly Rational System of Units. ELLIOTT Q. ADAMS.
20. Certain Metallic Derivatives of Hydroxy-Anthraquinones. M. L. CROSSLEY.
21. Pyrogenic Conversion of Phenol to Naphthalene. M. L. CROSSLEY.
22. The Reduction of Dihydroxythymoquinone by Means of Palladium-Hydrogen. NELLIE A. WAKEMAN.
23. Congo Red and Some Similar Diazo Dyes. W. R. ORNDORFF and F. E. CARRUTH.
24. Synthesis of Anthracene from Naphthalene. C. W. COLVER and W. A. NOYES.
25. Positive Iodine in Derivatives of Acetylene. L. B. HOWELL and W. A. NOYES.
26. The Attraction between Organic Substances and Water, and the Adsorption of Organic Substances. (Lantern.) W. D. HARKINS.
27. Determination of the Viscosity of Pyroxylin Solutions. (By title.) E. F. HIGGINS and E. C. PITMAN.
28. The Retention of Bromine by Silicic Acid Gel. W. A. PATRICK and E. L. RYERSON.
29. Determination of the Viscosity of Pyroxylin Solutions. E. F. HIGGINS and E. C. PITMAN.
30. A Slide Rule for Special Cases. F. C. BLAKE.
31. Adsorption by Precipitates. II—The Adsorption of Anions by Hydrous Ferric Oxide. HARRY B. WEISER and EDMUND B. MIDDLETON.
32. The Physical Character of Hydrous Ferric Oxide. HARRY B. WEISER.
33. Flame Reactions of Selenium and Tellurium. HARRY B. WEISER and ALLEN GARRISON.
34. The Catalyst in the Oxidation of Ammonia. G. A. PERLEY.
35. Equilibria in the Systems: Carbon Disulfide, Methyl Alcohol and Carbon Disulfide, Ethyl Alcohol. E. C. MCKELVY and D. H. SIMPSON.
36. Notes on the Estimation of Nitrates and Nitrites in Battery Acids. LILLY BELL SEFTON.
37. A Metal to Glass Joint and Some of Its Applications. E. C. MCKELVY and C. S. TAYLOR.
38. The Fluorides of Cobalt, Nickel, Manganese, and Copper. F. H. EDMISTER and H. C. COOPER.
39. The Determination of Mercury. H. B. GORDON.
40. The Preparation and Uses of $TiCl_3$ Solution. F. L. ENGLISH and H. S. TANNER.
41. Contrasting Effects of Sulfates and Chlorides on the Hydrogen Ion Concentration in Acid Solutions. A. W. THOMAS and M. E. BALDWIN.
42. Chromophor Tautomerism in Indicators. WILLIAM C. ARSENE.

DYE SECTION

CHARLES L. REESE, *Chairman* R. NORRIS SHREVE, *Secretary*

1. Introductory Remarks. CHARLES L. REESE.
2. Present Condition of German Dyestuff Plants. T. W. SILL.
3. Review of the Dye Situation. J. MERITT MATTHEWS.
4. The Progress of the American Dye Industry as Shown by the Census of the Tariff Commission. GRINNELL JONES.
5. Photosensitizing Dyes. E. Q. ADAMS.
6. The Color Laboratory of the Bureau of Chemistry. (Lantern.) H. D. GIBBS.
7. Alkali Fusions. (Lantern.) H. D. GIBBS and MAX PHILLIPS.
8. The System: Naphthalene-phthalic Anhydride. (Lantern.) K. P. MONROE.
9. The Melting Point of Pure Phthalic Anhydride. The System: Phthalic Anhydride-Phthalic Acid. (Lantern.) K. P. MONROE.
10. Benzene Sulfonic Acids. I—Benzene Disulfonic Acid from Benzene Mono Sulfonic Acid. (Lantern.) C. E. SENSEMAN.
11. Notes on Testing Dyed Goods. W. F. EDWARDS.
12. The Quality of American Dyes. R. S. LUNT.
13. The Application of Dyes. E. W. PIERCE.
14. Foreign Dye Patents. R. E. ROSE.
15. Some Stones in the Foundations of a Great National Industry. T. H. NORTON.
16. Explosibility and Inflammability. BURR HUMISTON, W. S. CALCOTT and E. C. LATHROP.
17. The Identification of Dyes. E. F. HITCH.
18. Indicators and Their Application. H. A. LUBS.
19. Vat Dyes. M. L. CROSSLEY.
20. Gentian Violet and Its Selective Bactericidal Action. M. L. CROSSLEY.
21. The Importance of Intensive and Original Research in the Development of the Dye Industry in America. M. L. CROSSLEY.
22. Logwood in Its Relation to the Silk Industry. EMIL LESSER and DAVID WALLACE.
23. Some Engineering Aspects in the Manufacture of Dyes. (By title.) CLARENCE K. SIMON.
24. Observations on the Estimation of the Strength of Dyes. W. H. WATKINS.
25. Application of Physical Chemistry Research on Dyes. E. K. STRACHAN.
26. Crystallographic Identification of Five Isocyanines. EDGAR T. WERRY.
27. The Dye Situation in the United States and England. (By title.) T. FRUSHER.

FERTILIZER CHEMISTRY DIVISION

F. B. CARPENTER, *Chairman* H. C. MOORE, *Secretary*

1. Injurious Effects of Borax in Fertilizers on Crops. B. W. KILGORE.
2. The Conservation of Nitrate of Soda in the Chamber Process for the Manufacture of Sulfuric Acid. ANDREW M. FAIRLIE.
3. Check Meal Work of the Society of Cotton Products Analysts (in Particular Reference to the Moisture and Ammonia Determinations). F. N. SHALLEY.
4. The Derode-Perchloric Acid Method for Determining Potash. T. E. KEITT.
5. A Rapid and Accurate Method for Determining Nitrogen in Nitrate of Soda by the Devarda Method, and the Use of the Davison Scrubber Bulb. C. A. BUTT.
6. The Rapid and Accurate Determination of Nitrate, as Ammonia, in Nitrate of Soda by a Modification of the Kjeldahl-Gunning Method vs. the Deceptive West Coast or Refraction Method. Correct and Rapid Application of the Modified Kjeldahl-Gunning Method to Mixed Fertilizers Containing Nitrate. H. C. MOORE.

PHARMACEUTICAL CHEMISTRY DIVISION

F. O. TAYLOR, *Chairman* GEORGE D. BEAL, *Secretary*

1. A New Field of Phytochemical Research Opened Up by the Cultivation of Medicinal Plants on a Semi-Economical Scale. EDW. KREMER.
2. Some of the Characteristic Toxic Principles of Western Poisonous Plants. O. A. BEATH.
3. A Comparison of Several Methods for Estimating Quinine and Strychnine when Occurring in the Same Solution. A. R. BLISS, JR.
4. Quantitative Determination of Mercury. SIGMUND WALDBOTT.
5. The U. S. P. Assay of Donovan's Solution. SIGMUND WALDBOTT.
6. The Theory of Emulsion Making. W. D. RANCOFT.

After the presentation of the regular papers there will be a Symposium on Research in the Field of Chemistry, similar to the one held at the Buffalo Meeting.

PHYSICAL AND INORGANIC CHEMISTRY DIVISION

W. E. HENDERSON, *Chairman* W. A. PATRICK, *Secretary*

1. The Vapor Pressure of Mercury in the Range 120°-250°. ALAN W. C. MENZIES.
2. The Vapor Pressure of Tetranitromethane. ALAN W. C. MENZIES.
3. Production of Hydrochloric Acid from Chlorine and Water. H. D. GIBBS.
4. Mineral Disintegration by Phosgene. CHARLES BASKERVILLE.
5. The Preparation of Colloidal Gold and Silver by New Reducing Agents. HARRY N. HOLMES.
6. Phase Rule Studies of the Nitrotoluenes. C. H. HERTY, JR.
7. Compression by Adsorption. WILLIAM D. HARKINS and D. T. EWING.
8. The Work Done by the Attraction between a Mercury Surface and the Surface of an Organic Substance. W. D. HARKINS, E. H. GRAFTON and D. T. EWING.
9. The Change of Molecular Kinetic into Molecular Potential Energy. WILLIAM D. HARKINS and L. E. ROBERTS.
10. The Separation of Yttrium from the Erbium Earths. P. H. MCP. BRINTON and C. JAMES.
11. A New Method for the Determination of Zirconium. M. M. SMITH and C. JAMES.
12. The Effect of Lead upon Thorium Nitrate in Aqueous Solution. FANNY R. M. HITCHCOCK.
13. An Electrometric Study of the Neutralization of Monocalcium Phosphate. GERALD WENDT, A. H. CLARKE and S. M. WEISMAN.
14. The Existence of an Ozone Form of Hydrogen. GERALD L. WENDT and ROB. S. LANDAUER.
15. Action of Thiosulfate on Arsenate in Acid Solution. (Lantern.) GEO. SHANNON FORBES and O. J. WALKER.
16. Specific Heat Determinations with an Adiabatic Calorimeter. (Lantern.) FARRINGTON DANIELS and CHARLES B. HURD.
17. The Partition of Metallic Radicals between a Salt Phase and an Alloy Phase. (Lantern.) HERBERT F. SILL.

7. The Caking of Sulfate of Ammonia and Acid Phosphate Mixtures. C. G. ATWATER AND J. F. W. SCHULZE.
8. The Caking of Sulfate of Ammonia. C. G. ATWATER AND J. F. W. SCHULZE.
9. The American Potash Industry. R. O. E. DAVIS
10. The Relative Availability of Nitrate Nitrogen and Commercial Organic Nitrogen in Cylinder and Field Experiments. A. W. BLAIR.

RUBBER DIVISION

JOHN B. TUTTLE, *Chairman*ARNOLD H. SMITH, *Secretary*

1. Report of Executive Committee.
2. Report of Secretary.
3. Report of Fruit Jar Ring Committee. L. J. PLUMB, *Chairman*.
4. Report of Committee on Physical Testing. H. E. SIMMONS, *Chairman*.
5. A New Method for the Determination of Sulfur in Rubber Mixtures. G. D. KRATZ, A. H. FLOWER AND COLE COOLIDGE.
6. The Extraction of Rubber Goods. S. W. EPSTEIN AND B. L. GONYO.
7. The Theory of Balloon Fabric Protection. JOHN B. TUTTLE
8. The Expansion of Rubber Compounds. C. W. SANDERSON.
9. Volume Increase of Compounded Rubber under Strain. H. F. SCHIFFEL.
10. The Determination of Cellulose in Rubber Goods. S. W. EPSTEIN AND R. L. MOORE.
11. The Variability of Crude Rubber. JOHN B. TUTTLE.
12. Symposium on the Action of Accelerators during Vulcanization. Opened by J. H. SCOTT.
13. The Action of Certain Organic Accelerators in the Vulcanization of Rubber. G. D. KRATZ, A. H. FLOWER AND COLE COOLIDGE.
14. Reactions of Accelerators during Vulcanization. C. W. BEDFORD AND WINFIELD SCOTT.
15. The Effect of Organic Acceleration on the Vulcanization Coefficient. D. F. CRANOR.
16. The Effect of Compounding Ingredients on the Physical Properties of Rubber. C. OLIN NORTH.
17. Some Methods of Testing the Hardness of Vulcanized Rubber. H. P. GURNEY.
18. Symposium on the Testing of Pigments. Opened by GEO. OEN-SLAGER. Contributions from M. M. HARRISON AND M. M. KAHN.
19. The Manufacture and Use of Crimson Antimony. J. M. BIERER.
20. Laboratory Aprons. C. P. FOX.
21. The Value of a Library to the Rubber Laboratory. H. E. SIMMONS.
22. Research on Zinc Products for the Rubber Industry. P. R. CROLL AND I. R. RUBY.

WATER, SEWAGE AND SANITATION DIVISION

ROBERT S. WESTON, *Chairman*W. W. SKINNER, *Secretary*

1. Determination of Iodide and Bromide in Mineral Waters and Brines. W. F. BAUGHMAN AND W. W. SKINNER.
2. The Determination of Bromide and Iodide in Mineral Waters and Brines. H. H. WILLARD AND C. C. MALOCHIE.
3. A Study of Well Water in a Rural Community. G. O. HIGLEY.
4. The Removal of Colloidal Silicic Acid and Clay from Natural Waters. OTTO M. SMITH.
5. Field Methods for the Chlorination of Small Amounts of Water. (Lantern.) F. R. GEORGIA.
6. The Electrostatic Precipitation of Dust in the Sanitary Analysis of Air. J. P. BILL.

AMERICAN CHEMICAL SOCIETY ADVISORY COMMITTEE MINUTES

The Advisory Committee met at the Chemists' Club on Monday, August 18, 1919, with President Nichols and Messrs. Herty, Hesse, and Parsons present. Also, Dr. H. S. Miner was present from Philadelphia to discuss with the Committee questions having to do with the program of the Industrial Division. The question of speakers for the general program was also discussed.

A letter was read from Dr. T. B. Wagner, stating that it would be impossible for him to continue as chairman of the Committee on Foreign Chemical Trade in its Relation to our Merchant Marine, to Cooperate with the U. S. Shipping Board. His resignation was accepted, and Dr. H. S. Miner was made chairman, Dr. Wagner being retained, however, as a member of the Committee.

Several letters were read regarding delegates to the Pharmacopoeial Convention. It was at once evident that the Advisory Committee in appointing delegates had mixed in their minds the credential form received from the Pharmaceutical Association with the request for delegates from the Pharmacopoeial Convention. The Secretary was, accordingly, instructed to bring this to the attention of F. R. Eldred, B. L. Murray

and F. O. Taylor and to inform them that the credentials given them were for the Pharmaceutical Association meeting in New York in August and that they consider their appointment as applying to that Association. The Advisory Committee will later advise the President as to the appointment of the three delegates to the 1920 Pharmacopoeial Convention.

A letter was read from Mr. Jos. L. Wheeler, requesting the Society to publish and distribute the lists of selective subjects for chemistry reading which had been prepared by the Committee on Preparation of a List Recommending Chemical Texts for Libraries. The Secretary was instructed to write Mr. Wheeler that while the Society would publish such lists in its *Journal of Industrial and Engineering Chemistry*, nevertheless it could not consistently recommend to the Directors, in view of the large cost involved, that the Society go to the expense of publishing this as a pamphlet and generally circularizing the libraries of the country.

CHARLES L. PARSONS, *Secretary*

WASHINGTON, D. C.

DIVISION OF INDUSTRIAL CHEMISTS AND CHEMICAL ENGINEERS

MINUTES OF SESSIONS, 58TH MEETING A. C. S.

The division held one of the largest and most successful meetings in its history, the program as printed in the October issue of *This Journal* being carried out. The attendance was good to the very last. All the papers on the program were presented, and the two symposiums were attractive. The Division was largely indebted to A. V. Bleining and E. J. Prindle for their success. At the Patent Fees Symposium held with the Pharmaceutical Division and the Dye Section resolutions supporting the bills already approved by the Advisory Committee regarding the changes in Patent Laws were passed. The membership has already been asked by the Advisory Committee to assist in the passage of these bills.

The following officers were elected:

H. D. BATCHLOR, *Chairman*; W. H. WALKER, *Vice Chairman*; H. E. HOWE, *Secretary*; J. G. VAIL, CHAS. H. HERTY, W. F. HILLEBRAND, EDMOND O'NEILL, S. W. PARR, JOSEPH H. JAMES, *Executive Committee*.

H. E. HOWE, *Secretary*

DIVISION OF FERTILIZER CHEMISTRY

MINUTES OF BUSINESS SESSION, 56TH MEETING, A. C. S.

The meeting of the Fertilizer Division was called to order Thursday morning, September 4, 1919, in the Bellevue-Stratford Hotel, in accordance with the official program, Chairman F. B. Carpenter presiding. The attendants of the meeting numbered fifty-three.

The minutes of the Cleveland Meeting of this Division were read and approved.

The reports of the following committees were made and accepted:

Committee on Fertilizer Legislation, F. B. Carpenter, *Chairman*.

Committee on Research and Methods of Analysis, Paul Rudnick, *Chairman*.

Committee on Sampling. Word was received from F. S. Lodge, *Chairman*, that no report was ready since there had been no meeting of the A. O. A. C. during the past year.

After the reports of committees, papers were presented, as announced on the official program (see page 987).

A short discussion followed the reading of the papers. The authors of Papers 1, 3 and 4 were unable to be present and their papers were read by the Secretary.

The report from the Committee on Fertilizer Legislation by F. B. Carpenter, *Chairman*, indicates the present trend of fertilizer legislation and the unnecessary hardships which some of the proposed legislations would impose on the fertilizer manufacturers. To overcome this situation a uniform fertilizer

law has been framed by the Soil Improvement Committee and a committee appointed by the chairman of the National Fertilizer Association which will be presented to the Association of Commissioners of Agriculture in the effort to enlist their co-operation toward uniform legislation in all states.

The report by Paul Rudnick from the Committee on Research and Methods of Analysis states that the committee has before it the following subjects:

METHOD FOR DETERMINATION OF SULFUR IN PYRITES—Mr. H. C. Moore has completed his work and has developed a satisfactory method, based on the Allen & Bishop Method, and intended to replace the faulty Lunge method. This will be presented to the Supervisory Committee for approval as soon as possible.

METHOD FOR VALUATION OF NITRATE OF SODA—This subject has been taken up by Dr. E. W. Magruder. The purpose of this work is to select or develop a suitable method for the valuation of nitrate of soda for commercial purposes to replace the antiquated, faulty West Coast Refraction method.

METHOD FOR THE ANALYSIS OF AMMONIUM SULFATE—The purpose of this work is to develop a satisfactory method for the sampling and analysis of commercial ammonium sulfate. It has not been possible to assign this subject up to the present time, but every effort will be made to get it under way as quickly as possible.

This being the regular meeting for the election of officers, a motion was passed authorizing the chairman to appoint a nominating committee to return recommendations for officers for the coming year. The chairman appointed for this committee Messrs. Atwater, Rudnick and Blair, who recommended the following:

Chairman, F. B. CARPENTER; Vice Chairman, R. N. BRACKETT; Secretary, H. C. MOORE; Executive Committee, H. J. WHEELER, C. H. JONES, E. W. MAGRUDER, A. J. PATTEN.

A motion was made and duly passed that the secretary cast the vote of the division for the names as recommended.

As there was no further business, the meeting was adjourned.

H. C. MOORE, *Secretary*

NOTES AND CORRESPONDENCE

CHANGE OF ADDRESS SECRETARY'S OFFICE, A. C. S.

Members should note that the address of the Secretary, Charles L. Parsons, is changed from Box 1505, Washington, D. C., to 1709 G St., N. W., Washington, D. C. The Society has opened new offices at this address. Dr. Parsons has resigned from the Bureau of Mines in order to give more time to Society work. He will also undertake a limited amount of private consulting work, especially in the lines of inorganic chemistry and mineral technology, which he has for the past eight years handled for the Bureau of Mines.

THE DECENNIAL INDEX AS AN AID TO ORGANIC RESEARCH

The final volume of the decennial index to *Chemical Abstracts* will soon be in the hands of subscribers. The two subject volumes form a practically complete index to chemical literature for the years which they cover and the annual indexes for 1917 and succeeding years, being arranged on the same system, may be regarded as supplements to it, bringing it up to date periodically. The object of this note is to call attention to the unique aid which this system of indexes offers in the searching of organic literature.

The naming of the organic compounds according to a *uniform system* and indexing them under the names of *parent compounds* to an extent not hitherto attempted in an index, give the system some of the features of a general handbook of organic compounds, combined with the very great advantage of up-to-dateness. It fills a need, therefore, which even a formula index (much as that is to be desired) could not meet; and it has, in fact, already been used at Ohio State University in manuscript form with gratifying results.

One example may be given: Suppose that someone wishes to look up the literature of the benzotriazoles (azimidobenzenes). At "Benzotriazole" in the decennial index will be found the full names of 115 compounds, arranged in order, with their page references. Of the 25 abstracts in which these compounds are described, only 6 give any indication in the title that would lead to their being indexed under one of the class names given above. Consequently, in the ten annual indexes, prepared in the customary way, only 15 of the 115 compounds would easily be found. The rest are scattered through the vocabulary by reason of the fact that their names have such beginnings as "dinitro-," "phenyl-," etc. Two more abstracts contain so much space on benzotriazoles that they should have been indexed under this class heading in spite of the fact that neither this name nor any

synonym of it is mentioned or implied in the title. If this had been done 48 more compounds could have been found, making 63, although they would not, of course, have been tabulated in convenient form as they are in the decennial index. However, it appears that nearly half (52) of the compounds of the benzotriazole group which were described during the ten years, were published more or less incidentally in 17 articles and could hardly have been found conveniently in the best of indexes on the old plan. If a decennial formula index were available the searcher could merely ascertain whether any particular compound had or had not been described.

The *ring index* is an additional, and, so far as is known, original, feature which will enable a user of the indexes to trace down by its formula (he need not know its name), any ring complex, however complicated, and its derivatives as well. Some 450 names of parent rings are listed in the decennial ring index alone, and many of these stand for two or more isomers, so it will be seen that such an index is needed. It is supplemented by a large number of numbered ring formulas in the main index. A list of organic *radical names* (about 330), with their formulas, is also given, so that no doubt will exist as to their meaning.

The present editors of *Chemical Abstracts* are to be congratulated on the many admirable general features of the new indexes, such as the "entry-a-line" plan, abundant use of cross references and notes, indexing of subjects rather than words, etc. One of these features will be of special help to the organic chemist if he will take the trouble to become used to it, namely, the little superior figure at the end of the page reference which indicates the ninth of a page. When the page is full of organic names a great deal of time is saved by narrowing down the choice to one or a few. With a little practice the location becomes very easy indeed.

XENIA, OHIO
August 27, 1919

AUSTIN M. PATTERSON

AN ACKNOWLEDGMENT

At the 58th Meeting of the AMERICAN CHEMICAL SOCIETY a large banner in the SOCIETY's colors was hung in front of the Bellevue-Stratford Hotel. This banner, which is made of the best material and is a beautiful SOCIETY emblem, was purchased by Dr. George D. Rosengarten and has been presented to the SOCIETY to be kept in charge of the Secretary to be used when needed at future meetings of the SOCIETY. I feel also that public acknowledgment should be made of the fact that has heretofore been unknown to the members that Dr. Rosengarten has for some years furnished to the SOCIETY the high-

grade stationery attractively embossed with the SOCIETY pin, which is used in the offices of the President and Secretary. I feel that these contributions to the SOCIETY's welfare should be known to all of our members and, accordingly, make this grateful acknowledgment here.

CHARLES L. PARSONS, *Secretary*

WASHINGTON, D. C.

LECTURES IN PREVENTIVE MEDICINE HARVARD UNIVERSITY

Harvard University announces that Dr. Thomas M. Legge, Chief Medical Inspector of Factories in Great Britain, has been invited to give a course of Lowell Lectures and the Cutter Lectures in Preventive Medicine for the coming year. These lectures will be given under the auspices of the School of Public

Health of Harvard University and the Massachusetts Institute of Technology, and the Division of Industrial Hygiene. Dr. Legge will lecture in Boston on November 18 and ensuing dates upon the following subjects. The completed schedule of lectures will be issued on October 20.

Twenty Years' Experience of the Notification of Industrial Disease.

Twelve Years' Experience of Workman's Compensation Act and Industrial Diseases.

Medical Supervision in Factories.

Industrial Poisons and Their Prevention.

Anthrax.

Fumes and Gases.

Industrial Fatigue.

Industry as a Subject for Art.

Manufacture under the Mediaeval Trade Guilds.

WASHINGTON LETTER

By J. B. McDONNELL, Union Trust Building, Washington, D. C.

So far as Washington is concerned, the question of what protection will be granted the American dye industry by Congress, probably overshadows other things of interest to the chemical world. The Longworth measure, in brief, provides for increased ad valorem duties, imposes higher specific duties, and has embodied in it the 45 amendments to the existing tariff law which were recommended some time ago by the United States Tariff Commission. The fight that is certain to take place on the bill, however, will come upon its provision for a dye import licensing commission which shall have control of all imports and from whom it will be necessary to obtain licenses for importation of dyes.

Passage of the measure, without changes that will make it materially different, is probable, although the opponents of the measure both among the dye consumers and dye importers have been busily endeavoring to strengthen their lines in Congress. With what success they have met yet remains to be seen; there is, however, little doubt of its passage. The Democratic members of the Ways and Means Committee, led by Representative Kitchen, of North Carolina, have solidly voiced their approval of an import licensing commission as a means of protecting the dye industry. They have also vigorously scored the tariff imposed in the measure as entirely too high, and unnecessary in view of the licensing feature.

Republican members, on the other hand, are in support of the high tariff feature, and the majority are willing to accept the licensing provision if they are convinced it is necessary. While Chairman Fordney of the committee has declared that "he has little faith" in the licensing provision, he has promised that he "will vote with the majority of the committee members in favor of the bill as it stands."

The sentiment in Congress is practically unanimous that the American dye industry should be protected sufficiently to insure its continued growth and development. The Republicans are, naturally, protectionists, and the Democrats have before them the fact that President Wilson specifically mentioned the dye industry as one whose growth should be assured through protection. The question remaining to be solved is the method of protection. So ably was the case of the industry presented before the committee that, with the exception of one or two, members have been satisfied that the main essentials of the Longworth measure are necessary to proper protection.

Representative J. Hampton Moore, of Pennsylvania, recently chosen as the Republican candidate for mayor in Philadelphia, is the chief opponent of the licensing commission. It was the absence from Washington of Mr. Moore, who under a leave of absence from the House was conducting his campaign in Philadelphia, which has been the principal cause of delay in consideration of the bill. Plans to have the measure called up on September 15 met with failure because of the absence from Washington of Chairman Fordney, who under the rules of the House is formally in charge of the bill reported out by his committee.

Representative Longworth has been active in rallying leaders to the support of his measure, however, and several members of the Republican steering committee are among its supporters. Representative Moore has been determined in his opposition. It was at his instance that the hearings before the committee

were reopened and several consumers and dye importers were heard by the committee. The reason for his opposition, it is believed, is to be found among certain textile interests in Philadelphia. Mr. Moore also has held several conferences with Herman A. Metz, who is active in his efforts to defeat the licensing commission proposal and has charged several times that the American dye industry has not developed as has been stated by the dye manufacturers.

The great body of the House will follow the leaders in voting on the measure. Republican leaders will support it because of its high tariff, and Democratic leaders will support it for the licensing provision, and although the latter probably will attempt to reduce the tariff rates, they are expected to lend sufficient votes to pass it. Following passage by the House the bill will go to the Senate. There it will be referred to the Finance Committee, of which Senator Penrose, of Pennsylvania, is chairman. In all probability hearings will again be held on the measure before the Finance Committee, and it is safe to assume that opponents of the licensing feature will attend in greater force, and perhaps, better prepared, than was the case during the hearings before the House Ways and Means Committee. As to the probable fate of the measure in the Senate, it is yet too early to speculate. Senator Penrose, however, has said that he will not strongly oppose the licensing commission, having been convinced that a greater number of dye consumers had offered their support to it than had opposed it.

Chairman Fordney has put off consideration of the dye bill until all of the several other tariff measures which have been acted on by his committee have been disposed of. Early in August the House passed the measure introduced by Representative Bacharach, of New Jersey, which provided tariff protection for laboratory glassware, laboratory porcelain ware, optical glass and scientific and surgical instruments. It provides a tariff on glasswares and porcelain wares, laboratory apparatus, and other apparatus and appliances wholly or in part of glass or porcelain, for use in the sciences, or in analyzing or testing or for use in education, of 60 per cent ad valorem. A duty of 45 per cent ad valorem is imposed on philosophical, scientific and laboratory apparatus, utensils, instruments, and appliances and parts thereof, finished or unfinished, and preparations, including boxes and bottles containing the same. Dental and surgical instruments are given the protection of a duty of 60 per cent ad valorem and optical glass and instruments, are assessed 45 per cent ad valorem.

Some other tariff measures have been passed by the House, but these, together with the dye bill, which still is to be acted upon, must go to the Senate, and when they will be acted upon by that body depends largely upon the speed with which the Treaty of Peace is disposed of. This may be passed within a short time or it may take several weeks before action is taken. It is hardly possible that either the dye bill or the scientific instruments measure will reach the floor of the Senate before the middle of October at the earliest, according to present indications.

A supply of German vat dyestuffs, and possibly some other chemicals, is expected to be received in this country within the next sixty days. Dr. Charles H. Herty, editor of the *Journal of Industrial and Engineering Chemistry*, sailed for France

early in September as the representative of the War Trade Board Section, State Department, to act with the interallied Reparations Commission in distributing the supply of German dyes.

The War Trade Board has been active for several weeks in obtaining data relative to the needs of dye consumers for the six months' period from October 1 to April of next year. Questionnaires have been sent out to consumers throughout the country asking that the Board be furnished with a list of the dyes required by each consumer. The designation of the dye, its Schulz number, 1914 edition, and the number of pounds needed, are asked for. Incidentally, the form which has been submitted to the dye consumers contains an agreement that the dyes ordered are for the use of those ordering them, and it is agreed that they are not to be re-sold.

Distribution of German dyes and other chemicals has been held up largely because of the lack of American representation upon the Reparations Commission, under whose direction the chemicals will be distributed to the allied countries. According to the provisions of the Treaty of Peace the allied and associated governments have an option on fifty per cent of the dyes and chemicals Germany offers for export, and an option on 25 per cent of the amount offered for export for the next two years. It was to have an American representative advise with the Commission, so as to permit distribution of the German chemicals, that Dr. Herty was commissioned to go abroad.

Reports reaching here are to the effect that the representatives of France, Italy and Belgium, who frankly view the question practically from the standpoint of the consumer, are anxious to obtain immediate distribution and have several times attempted to do so. Up until recently, however, their efforts failed because of the objection of the British and the then American representative, John W. Dulles, who was acting unofficially with the Commission. A limited amount of the German dyes have now been allowed these three countries with the understanding that they are to be used solely for domestic consumption and are not to be re-exported, or used in articles exported. France, under this arrangement, was granted 350 tons of the German dyes. An important conference with regard to the German chemicals and their distribution is to take place in Paris within the next few days, advices reaching here state.

The attitude of the British toward their distribution has been guided almost solely by their determination to protect their own dye and chemical industry as much as possible. Confidential official advices received here quote an official of the British Foreign Office as stating that so far England has received none of the German chemicals and it was the intention to accept just as little as possible. The government, he stated, expected to bring in only a very small amount of the German dyes.

Other reports show that at least some British consumers are not among those who have been impressed with the much heralded progress of the British dye industry. The British industry is short of intermediates, and consequently the choice of the users is limited and they are not permitted the wide variety of shades they desire. It was stated by one of the largest dyers in London that many American dyes were being imported and mixed with colors manufactured in England and sold as British products.

It is the intention of the War Trade Board to continue in force its restrictions against imports of chemicals and dyes. At present chemicals and dyes can only be imported under license. This ruling by the Board gives it effective control over imports from Germany as well as other countries. The power of the Board, however, ceases with the formal proclamation of peace, and thereafter importation may be made freely, subject only to the provisions of the present weak and inadequate tariff law, unless Congress takes action in the meantime upon the pending Longworth measure.

American dye manufacturers will begin placing vat dyes upon the market here by the first of the year, dye consumers of the country were told at a conference held here recently between War Trade Board officials, members of the dye advisory committee of the Board, and a committee on dyes of the National Association of Shirt Manufacturers. The conference was called at the instance of the shirt men, who declared their inability to obtain American vat dyes made it imperative that supplies be obtained from Germany. No opposition to the desire of the shirt manufacturers or other dye or chemical consumers was voiced at the meeting, officials on the contrary outlining just what plans had been made by them for obtaining supplies of German chemicals. It was shortly after this conference that approval of the President was obtained to the appointment of Dr. Herty to go abroad and act for this country in distribution of the German chemicals.

While certain dye consumers, particularly among the textile manufacturers, have been declaring their need for German dyes for several weeks, preliminary reports of the amounts they actually care to order indicate that the total will be a small one. Under the ruling of the War Trade Board, which some time ago was taken over by the Department of State, consumers will be permitted a six months' supply, based, not upon war-time consumption, but upon pre-war consumption figures. This is an important difference from the consumers' point of view, because during the war the use of vat dyes was generally cut down to the barest minimum.

While American potash producers have had some fear of Germany exporting large amounts of potash to this country at prices which they could not meet, reports from Germany continue to state that there is little probability of any large amounts of German potash being shipped to this country. Cost of production has risen in Germany and under the Peace Treaty she has lost large deposits to the French. The French for the present have little desire to ship potash from their own country, and for a time at least it appears as if the production would be consumed in France and Germany, with some going to England, a much shorter haul than to the United States. The prices, too, at which the European potash is offered, are far above pre-war figures, and it is stated that very little can be expected here, and that only at prices not less than three times pre-war costs. A measure providing for protection of the American war-born potash industry through imposition of high tariff duties is pending in Congress. This measure also contains a provision for an import licensing commission which shall have control of all imports, and shall admit foreign potash in decreasing amounts each year.

Work of the scientists of the Bureau of Chemistry of the Department of Agriculture upon new chemical processes and new processes for dyes has been renewed with earnestness, and under an appropriation obtained in the last appropriation bill, officials state they hope to see several new strides made before the end of the year.

September 17, 1919

After months of moves and counter-moves, the opposition to the Longworth dye bill has been steam-rollered, and that measure, modified somewhat, it is true, but still containing an importing licensing system, passed the House on September 26, and now is before the Senate for final action. As passed by the House the licensing commission as contained in the bill when it was reported from committee was amended, so as to place the import licensing authority under the Tariff Commission. The final vote on the measure was 156 for and 119 against passage.

Passage of the dye bill came after a final day of bitter fighting, in which the opponents resorted to every subterfuge to defeat the licensing proposal. Most of the battle took place in the House, sitting in committee of the whole House. It was on the first record vote in the House proper, demanded by Representative Cannon, of Illinois, on the amendment placing the administration of the licensing system under the Tariff Commission, that the opposition was shattered with 206 votes in favor and only 62 opposed to the amendment.

The fight against the licensing system was led by Representative Moore, of Pennsylvania, and Representative Fordney, of Michigan, chairman of the Ways and Means Committee. Only a solid Democratic vote, and the efforts of Republican leaders to rally a divided following, brought about passage of the bill with a licensing provision in it. The first victory of the dye manufacturers has been scored in one of the bitterest and most complicated fights staged in the House on a tariff measure in recent years.

Representative Moore, leader of the opposition, directed his chief attack, throughout the hearings before the Committee, and debate on the floor which occupied four days, at the motives of the founders of the Chemical Foundation. The import licensing scheme, he reiterated again and again, was one put forward by the du Pont and the National Aniline and Chemical companies in order to build up a monopoly through which they might gouge the dye consumers of the country. It must be said that, at best, Mr. Moore's case as he presented it, was but a poor one.

The bill now goes to the Senate. There it will be referred to the Senate Finance Committee, which will hold hearings on it and report it back to the Senate, which must then act upon it before the bill becomes law. Engrossed in the fight on the Treaty of Peace, it is difficult to say when definite action will be taken by the Senate. It is not expected for several weeks at least.

September 27, 1919

OBITUARY

EDWARD G. LOVE
AN APPRECIATION

Dr. Edward G. Love, treasurer of the AMERICAN CHEMICAL SOCIETY, died on September 11, 1919, in Roosevelt Hospital, New York City, from shock following a capital operation, in his 69th year. Dr. Love was a well-known figure among American chemists both at home and abroad. He was always active in the interests of the SOCIETY, as well as diligent in attendance at its meetings. There may be counted among his special contributions the establishment and organization of its library, now incorporated with that of the Chemists' Club.

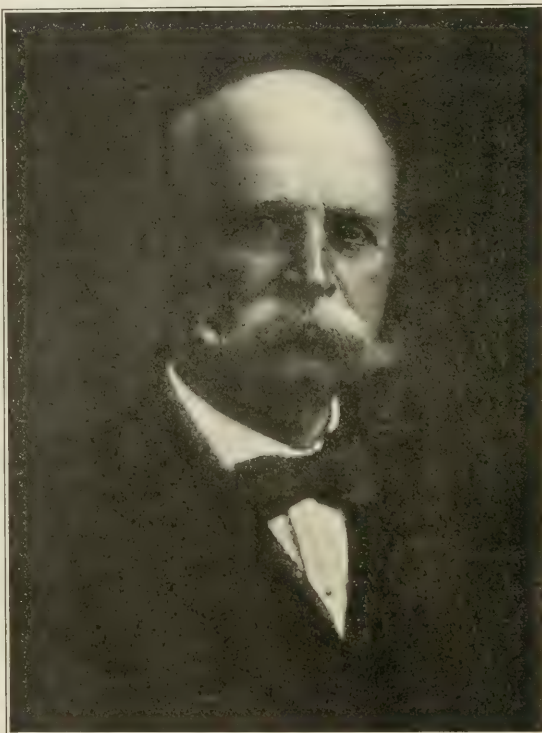
Dr. Love was a veteran of the Civil War, in which he enlisted as a drummer boy in 1864. He first studied at Hamilton College, which he entered in 1868, being graduated in 1872. He then attended the School of Mines of Columbia University, studying chemistry under Professor Chandler, whose assistant he became after obtaining his diploma in 1876. Later he also received his doctorate in philosophy at Columbia. In 1877 he was appointed the first gas examiner for New York City. Establishing a general analytical laboratory down town, he became analyst for both New York State and City Boards of Health, and was recognized as an authority on the chemical tests of foods. As municipal gas examiner he had to do with many competing companies and with contracts that often made demands on his diplomacy no less exacting than on his chemical scholarship. In his hands the city's interests were always safe, conserved with sterling integrity, and administered without friction. He had a happy faculty of meeting difficulties without borrowing trouble or permitting quarrels to intervene. In 1913 the Consolidated Gas Company made him its chief chemist, whereupon he gave up his official connection with the city and his private practice. With his clear scientific intelligence he soon became as proficient in the principles of making gas as he had shown himself in testing it. It was largely due to his energetic work that the Company was enabled to separate its toluene for the use of the Government in making TNT when this was one of the products most ardently sought for war purposes. His quick response to the demand for toluene, as soon as this was uttered, was a splendid war contribution.

Dr. Love took his work seriously; generally he was the last to leave his office or laboratory, but once away from his task he was a prince of good fellows, and a delightful companion. Perhaps his most engaging attribute was his boyish enthusiasm that, once aroused, seemed to know no bounds. He was president of the Chemists' Club in 1902, and when it moved, in 1911, to the present quarters, he became chairman of its House Committee, holding this office through several administrations, and by the unstinted expenditure of his energy and his substance he did much to promote that rare spirit of camaraderie that pervades the place to this day. Entomology was his avocation and he leaves a valuable collection of specimens. He was a member of many learned societies and institutions.

ELLWOOD HENDRICK

HIS RELATION TO THE
SOCIETY

When I accepted the secretaryship of the AMERICAN CHEMICAL SOCIETY in 1907, Dr. Love was librarian of the SOCIETY and I need make no mention of the work that he did while holding that office, and of the hours he spent, often way into the night in the old library, arranging the publications, filling out incomplete volumes, and getting them in form for future use. Others have already called attention to the fact that the present library of the Chemists' Club is largely due to his efforts, and this library contains all of the collections made by the AMERICAN CHEMICAL SOCIETY in the past. In addition to his work as librarian, Dr. Love was handling all the changes of address for the SOCIETY, he had full care of the mailing lists, of the stock of back numbers, of the subscriptions and of the sales of back journals, and this work to-day with the increased compilation of mailing lists and a largely increased membership is a goodly portion of the work of the present secretary. In 1908, by arrangement of the Business Committee, all of this work which Dr. Love was doing was given over to the secretary's office, but almost simultaneously with this change, when it seemed that Dr. Love was to be relieved, he was appointed to and accepted the chairmanship of the Finance Committee. He was a live chairman, and found work to do—work which was not always attended to properly before it came into his hands. On September 27, 1916, he was elected treasurer of the SOCIETY. No bill was paid by the AMERICAN CHEMICAL SOCIETY that



EDWARD G. LOVE

did not pass through his hands; no officer of the Society could draw one cent over the appropriation made to him, and if there was the slightest inaccuracy in any bill, whether in arithmetic or in a divergence from contract conditions, Dr. Love always found it. I have never known an error to get by him, nor have I known an officer of the Society who has ever been able to over-run his appropriation, or, for that matter, to draw near to its exhaustion without being checked up by Dr. Love, and the matter brought to the attention of the Directors.

Dr. Love did all of this work quietly, unassumingly, apparently without the slightest desire for compensation, even in the appreciation of his fellow chemists, but this appreciation has come to him, for such work as he has done is invaluable and cannot be hidden. He was a splendid, clear thinking, accurate business man, a gentleman through and through, a loyal and devoted friend to all chemists, and a real man. His place can not be filled.

CHARLES L. PARSONS

INDUSTRIAL NOTES

The War Trade Board Section of the Department of State has determined to permit the importation of vat dyes from Germany in quantities sufficient to supply the requirements of the consumers of the United States for the six months' period October 1, 1919, to April 1, 1920. Importations of these articles will be governed by rules and regulations which will be announced as soon as the necessary details have been completed. In the meantime, users of vat dyes have been requested to file with the War Trade Board Section applications giving their estimates of the amounts of vat dyes which will be required for consumption in their plants during the above mentioned six months' period.

Prominent educators and chemists of this country and Canada have organized the American Society of Biological Chemists, Inc., which has received the approval of the Supreme Court to its application for a certificate of incorporation. The temporary directors stated in their petition that the society's purpose was "to further the extension of biochemical knowledge and to facilitate personal intercourse between American investigators, in biological chemistry." The society's headquarters will be established in New York City. Under the by-laws adopted, the annual meeting will be held the last Monday of December each year and seven directors will be elected to direct the affairs of the society. The petitioners for incorporation and temporary directors are: Andrew Hunter, of the University of Toronto; Lafayette B. Mendel, of Yale University; E. V. McCollum, of Johns Hopkins University; Harold C. Bradley, of the University of Wisconsin; Victor C. Myers, of New York City; Donald D. Van Slyke, New York City, and Stanley R. Benedict, of New York City.

The Interstate Commerce Commission has issued a supplement to the regulations for the transportation of explosives and other dangerous articles by freight and express and specifications for shipping containers. It contains changes and new matter relating to inflammable liquids, zinc dust, arsenic, arsenate of lead, calcium arsenate, etc., and manufactured articles made of or containing pyroxylin plastics.

Edgewood Arsenal has listed the following surplus materials:

Acid, picric.....	195 tons
Acid, sulfuric.....	253,076 tons
Chlorine, liquid.....	589.5 tons
Kaolin.....	44 tons
Phosgene.....	78 tons
Sodium silicate.....	7 1/2 tons
Sulfur chloride.....	2,500 tons
Titanium tetrachloride.....	72 tons
Turpentine.....	30 tons
Gas masks.....	1,264,080 approx.
Cansisters.....	82,221 approx.
Locomotives, gasoline.....	6

Any inquiries regarding same should be addressed to Materials' Disposal Section, attention Captain E. C. Thompson, Edgewood Arsenal, Edgewood, Md.

Among the plaintiffs associated with the Chemical Foundation, Inc., in the suit against Robert C. Harrison, doing business as the Anglo-French Drug Company, for infringement of patents for the manufacture of arspenamine and neo-arspenamine, are the Dermatological Research Laboratories, the Takamine Laboratory, the Diarsenol Company, and the H. A. Metz Laboratories. Importations of these products, known as salvarsan and neo-salvarsan, are said to have been made through the principal ports of the Pacific Coast and Atlantic Coast, coming from Tokyo, London, and Paris. Further large shipments are expected from Europe, it is said in the complaint which was filed, and an application for an injunction was made to prevent the sale of the imported goods.

At the recent annual meeting of the American Zinc Institute it was decided to set aside \$25,000 for research and for a campaign advertising new uses of zinc.

The American Aniline Products, Inc., New York, was the successful bidder for 6,018 shares of the German-owned capital stock of the Roessler & Hasslacher Chemical Company, sold at public auction by the Alien Property Custodian at the New York offices of the Custodian, recently. The price paid was \$505 per share, totalling \$3,039,090 for the 6,018 shares. The 110 shares of stock of the Niagara Electrochemical Company of New York were also purchased by the American Aniline Products, Inc., in conjunction with W. E. Coffin at \$4,000 per share, totalling \$440,000 for this block. The same syndicate was successful in securing 1,960 German-owned shares of the stock of the Perth Amboy Chemical Works, of New Jersey, for which they paid \$480 per share, or \$930,800. For 4 months ending April 30, 1919, the gross sales and net incomes of the respective companies were as follows: Roessler & Hasslacher Chemical Company, sales \$3,814,435.84, net income \$40,039.15; the Niagara Electrochemical Company, sales \$2,063,764.59, net income \$128,162.45; the Perth Amboy Chemical Works, sales \$1,019,887.74, net income \$262,280.27.

Contract has been awarded by the Dewey & Almy Chemical Co., Boston, Mass., for the erection of a new one-story plant to be located on Harvey Street, Cambridge. The structure will be about 100 x 100 feet.

Work has recently been commenced by the Maas and Waldstein Co., Newark, N. J., on the reconstruction of the section of its chemical plant recently destroyed by fire, with loss estimated at \$100,000.

The plant of the Texas Creosote Manufacturing Company at Forth Worth is rapidly nearing completion, and is practically ready for operation. Creosote, rubberoid and roofing will be made. The first unit of three stills has been completed and will have a capacity of 6,000 gals. per hour. Three other units are to be built. It is planned to manufacture a number of other products from fuel oil, a plentiful supply of which will be had from refineries adjacent to the new plant.

The Southern Agricultural Chemical Corporation, which is a subsidiary of the Tennessee Copper & Chemical Corporation, has been incorporated in Virginia with a capitalization of \$1,000,000. The new company is expected to become a very important factor in the fertilizer field inasmuch as it will handle the entire output of sulfuric acid and acid phosphate of the Tennessee Company. The officers of the new company are Adolph Lewisohn, president; Sam A. Lewisohn, E. H. Westlake and A. H. Sterne, vice presidents; and F. M. Loper, secretary and treasurer. The principal office of the company will be at 61 Broadway, New York, with southern headquarters in Atlanta, Ga.

The War Industries Board has issued a series of bulletins covering the history of prices of various commodities. The chemical group includes the following titles:

Mineral acids	Natural dyestuffs and tanning chemicals
Heavy chemicals	Chemicals
Miscellaneous inorganic chemicals	Coal-tar crudes, intermediates and dyes
Fertilizers	Drugs and pharmaceuticals
Soaps and glycerin	Proprietary preparations
Essential oils, flavoring, and perfumery materials	Explosives
Wood distillation products and naval stores	Miscellaneous organic chemicals

Copies may be secured from the Superintendent of Documents, Government Printing Office, Washington, D. C.

The Eastern Oil Co., Suffolk, Va., is planning a new plant for the manufacture of cottonseed and peanut oils, with daily capacity of about 75,000 tons. The plant, with machinery and equipment, is estimated to cost about \$125,000.

The Snyder & Swain Corporation, Newark, N. J., manufacturer of chemicals, is planning the erection of a six-story, reinforced concrete building to cost about \$200,000.

The recent figures of the U. S. Geological Survey indicate a greater production of crude oil for June 1919, than for any month during the last year and a half, credit for which is given to Central and North Texas. The production for the first six months of 1919 as compared to the first six months of 1918, indicates a greater production for the year 1919 than for 1918. The production for the first six months of 1918 was 172,000,000 barrels, while for the first six months of 1919 it was 177,000,000 barrels, or an increase of 5,000,000 barrels.

The production of talc in the United States has increased about 90 per cent in the last ten years. During this period the production of ground talc has increased about 115 per cent. This indicates a great expansion in the use of this grade of material, and suggests the possibilities of even greater expansion under favorable conditions. These conditions can be brought about through technical research and publicity. Over forty uses for talc are now known, of which only a few have been exploited at all extensively. The principal uses of ground talc at present are in the paper, paint, rubber, roofing, and toilet powder industries.

A gum which is in demand by the manufacturers of perfumes, tobacco, adhesives, and pharmaceutical preparations, is produced by the red gum tree (*Liquidambar styraciflua*) of the South, though few owners of this tree apparently are yet aware that the gum has any commercial value. The properties and composition of this "sweet gum," as it is called, are similar to those of oriental storax, obtained from a tree (*Liquidambar orientalis*) which grows in Asia Minor. Cinnamic acid and cinnamic alcohol are two of its valuable components. Because the war curtailed the supply of the imported product, the U. S. Forest Products Laboratory this season undertook some co-operative experiments to develop methods of gathering "sweet gum" or "American storax." Although the yield of gum from each tree is not large, a price of \$2 or more a pound has made its collection attractive to many individual operators, and a considerable quantity has been put on the market. The laboratory experiments will be completed in November, and it is hoped that they will provide some cost data which will indicate to what extent "American storax" can profitably compete with the foreign product when normal conditions return.

The American Electrochemical Society has issued a pamphlet giving a reference list of firms engaged in the electrochemical industry and their products, and a second list of electrochemical products with the names and firms producing them. The Bulletin may be secured by addressing the secretary of the society at South Bethlehem, Pa.

At Lancaster, Mass., occurs a deposit of fuller's earth which has been worked intermittently since 1856. While this earth possesses most of the properties common to other fuller's earths it has the additional characteristic of breaking down upon drying, and without crushing, to a closely uniform, fine product, free from grit, which will pass through a screen of about 250-mesh. While this property makes the material unfit for some uses, such as a filtering medium, it is peculiarly well adapted to certain other uses. In the fulling of woolen cloth uniformity, fineness, and freedom from grit are essential, for grit or pebbles abrade and cut holes in the cloth as it passes over the rolls. Fuller's earth not only removes any grit remaining in the wool, but helps to flow the dye uniformly over hard-finished woollens. The earth from this deposit has been used in the woolen industry for over 60 years. Another use has been developed in recent years dependent not upon its absorbent action, but upon its value as a binder when fused. Manufacturers of abrasive wheels and stones made both from natural and from artificial abrasives have used this earth as a binder.

The inactivity of the Russian platinum mines has caused a corresponding increase in activity in Colombia. A large company has recently been formed to operate in Colombia, which is reported to hold 10,000 acres of land as well as 50 miles of river bottom. The operations of this company should materially increase the output of platinum from Colombia. A substitute for platinum in electrical apparatus has been the object of some private investigations. One satisfactory substitute for cathodes was found to be 90 per cent gold and 10 per cent copper. The same alloy was found suitable as an anode after being electrically coated with a thin layer of platinum and then carefully polished and burnished.

Virginia-Carolina Chemical Company's annual report for the year ended May 31, 1919, shows surplus, after Federal taxes and charges, of \$6,665,256, equivalent after preferred dividends to \$18.08 a share earned on the \$27,984,400 common stock as compared with \$8,384,668 or \$24.24 a share in the preceding year.

The Potash Salts Bill (H. R. 4870) providing for licensing control of imports of potash salts in the interests of potash salts producers is still in the hands of the Ways and Means Committee, and it is not known when it will be reported out. No definite decision has been reached with regard to the Bill. There seems to be a desire to aid the potash salts industry, but there is difficulty in meeting the objection of the ultimate consumers, the farmers and others who contend that any restrictions on the importation of potash salts will aid materially to the cost of fertilizer and be reflected in the cost of living.

An explosion of chemicals, from an undetermined cause, started a fire in the plant of the McCoy-Howe Chemical Company, manufacturers of pharmaceutical supplies, Indianapolis, causing a loss estimated by officials of the company at between \$15,000 and \$20,000.

An exposition of the manufactured and other products of the Mississippi Valley will be held in St. Louis, Mo., this fall from October 27 to November 3. Various civic and commercial organizations are co-operating and all manufacturing enterprises in the Mississippi Valley have been invited to exhibit.

The semi-annual statement comparing the profit and loss of the General Chemical Company for the first six months of the present year, with those for the corresponding period of last year, was issued recently. The statement, signed by Lancaster Morgan, treasurer of the company, shows a decline in the net profits of the company of \$1,482,235.97, or more than 65 per cent of the net profits for 1918. A further statement to the effect that the surplus shown on the books of the company at the time of its last report to stockholders has been reduced by \$1,363,679.07 for plant amortization is a feature of the report.

Chemical and dye companies of Chicago, which have recently been voted in as members of the Association of Commerce, are the Sherwin-Williams Company, manufacturers of paints, varnishes, dyes and chemicals; the Lithflux Mineral and Chemical Works, and the Semet-Solvay Company, manufacturers of coal-tar products.

The Baltimore Cork Company has purchased the property of the Wilson Distillery and will remodel it for the purpose of manufacturing crown cork and other cork products. The company expects to employ from 300 to 500 operatives, and it is estimated that the capacity of the plant will exceed \$1,000,000 annually.

The absorption of a number of British glass works is being brought about by the recently organized British Glass Industries, Ltd., which was registered officially a few months ago, to take over the glass works at Canning Town (London) and at Leeds. An arrangement has just been completed by the new concern to take over the whole of the shares of the Queensborough Glass Bottle Works, Ltd., one of the largest and most important concerns of its kind in Great Britain. In addition the company has also acquired the business of Payne Bros., who have been trading as the British & Foreign Bottle Company, for which an aggregate price of £400,000 was paid. The new combination will control over 30 furnaces when 20 furnaces now being erected at Canning Town have been completed. This will make the company the largest of its kind in all Europe.

A good deal of attention is being given to the extraction of algin from kelp. Algin is a vegetable gum of extremely high viscosity whose properties are widely known. It is manufactured and used in Europe, but so far the industry has never become well established in this country, probably because of difficulties in securing a uniform supply of fresh kelp at a reasonable cost. The experience gained by the Hercules Powder Company in harvesting kelp for the manufacture of war materials has overcome many of these difficulties.

There is a wide field of possible usefulness for algin. Its compounds in general give an exceedingly viscous solution, and for that reason their application as a sizing for textiles and paper, as a thickener for printing colors, and as proofing for interior walls and ceilings is at once apparent. The sodium compound of algin is soluble in water, a five per cent solution thereof being so viscous that it can hardly be poured from a vessel. The compounds of the heavy metals with algin are insoluble in water, some of them being soluble in ammonia, which solvent is used in their application as a waterproofing material in textiles.

An Institute of Industrial Hygiene, for graduate instruction in the sanitation and care of the health of employees in industrial enterprises and the scientific study of industrial diseases and accidents is to be established by Columbia University.

The Hadeigh Rendering Company, Philadelphia, is planning for the rebuilding of the portion of its fertilizer works recently destroyed by fire with a loss of about \$40,000.

PERSONAL NOTES

Dr. Chas. H. Herty, Editor of *THIS JOURNAL*, sailed for Europe on September 3, having been appointed by President Wilson to secure for the American dye consuming industry a six months' supply of vat dyes from the stocks now held by the Reparations Commission, under the terms of the Peace Treaty. It is expected that before the expiration of the six months' period American producers of vat dyes will be ready to supply the needs of the consumers. Dr. Herty will be absent about two months. During his absence Miss Lois W. Woodford is Acting Editor.

Dr. John E. Teeple, 50 E. 41st St., New York City, has been elected Treasurer by the Directors of the AMERICAN CHEMICAL SOCIETY to fill the unexpired term of Dr. E. G. Love.

Lt. Martin Meyer, Infantry, has returned to the College of the City of New York as Fellow, as has also **Moses Chertcoff** of the National Army.

Mr. W. C. Marckworth has left the casinghead gasoline division of the Ohio Cities Gas Company, Columbus, Ohio, and has entered upon research work in the refining division of the same company at Marcus Hook, Pa.

Prof. Alexander Smith, head of the Department of Chemistry of Columbia University, has received the Honorary Degree of Doctor of Laws from the University of Edinburgh, Scotland, from which he was graduated.

Mr. James W. Martin, Jr., who has been discharged from the Service, is now with the National Carbon Company, Cleveland, Ohio, where he has charge of their development laboratory.

Mr. W. G. Crockett, who since his discharge from the Chemical Warfare Service has been employed as a chemist with E. I. du Pont de Nemours & Co., Wilmington, Del., was recently elected professor of pharmacy in the College of Pharmacy of Baylor University, and is also opening a chemical laboratory for analytical and consulting work.

Miss Ruth Okey has resigned as instructor in physiological chemistry at the University of Illinois to accept a position as assistant professor of household science at the University of California.

Dr. L. H. Baekeland, Honorary Professor of Chemical Engineering in Columbia University, has been decorated by King Albert with the Order of the Crown of Belgium.

Mr. Wilmer C. Powick, formerly in the Sanitary Corps of the U. S. Army, having served in France for twenty-two months, attached to the Interministerial Research Commission and assigned for duty to Professor Lapicque of Le Laboratoire du Museum, Paris, who was then in the service of the French Ministry of Armament, has recently been discharged from the Army, and has resumed his pre-war duties as biochemist, U. S. Bureau of Animal Industry, Washington, D. C.

Major F. E. Breithut, Chemical Warfare Service, has been honorably discharged from the Army and has resigned as assistant professor of chemistry at the College of the City of New York to take a position with the Foundation Oven Corporation, Woolworth Building, New York City.

Mr. L. E. Kelly, formerly assistant material engineer, Bureau of Construction & Repair, Navy Department, Washington, D. C., has entered the Sales Department of the Eagle-Picher Lead Company, Chicago, Ill.

Mr. Walter F. Meister, formerly chief chemist for the Eagle-Picher Lead Company, is now chief chemist for the Collinsville Zinc Corporation at Collinsville, Illinois.

Mr. Joseph E. Plumstead has resigned from his position with The Cellulose Co., of Newark, N. J., where he was doing development work, to accept the position of assistant superintendent of the Delaware Mills plant of The Jessup & Moore Paper Co., and consulting chemist for their five pulp and paper plants.

Mr. J. H. Calbeck, recently First Lieutenant, Chemical Warfare Service, U. S. A., A. E. F., is now in the research laboratory of the Eagle-Picher Lead Company, of Joplin, Mo.

Mr. Robert Fogelson, who was with the research division, Chemical Warfare Service, has accepted a position with the Newport Chemical Works, Inc., Carrollville, Wis., as chemist.

Prof. Lauder W. Jones, now dean of the School of Chemistry at the University of Minnesota, was appointed dean of the College of Engineering and Architecture, at a recent meeting of the Board of Regents of the University of Minnesota. Professor Jones has assumed the duties of his new office and will continue to occupy the office of dean in both these schools.

Mr. E. N. Ehrhart, formerly Ensign in the U. S. Navy, is now located at Franklin, La., as chief chemist for the Sterling Sugar and Railway Co., Ltd., a 2,000-ton capacity sugar house.

Prof. Merle Randall, of the department of chemistry of the University of California, has returned to Berkeley after having spent the summer as research chemist in the laboratories of the Experimental Kelp-Potash Plant of the U. S. Department of Agriculture, at Sumnerland, California.

Dr. Samuel A. Tucker, formerly professor of electrochemistry at Columbia University, and who served as Major in the Chemical Warfare Service, is now chief chemist for the Chemical Foundation, Inc.

Mr. R. W. Frey, formerly with the leather and paper laboratory, Bureau of Chemistry, U. S. Department of Agriculture, Washington, D. C., has accepted a position in the chemical department of John H. Heald & Co., Inc., manufacturers of tanning and dye-wood extracts, and will be located at the main plant at Lynchburg, Va.

Mr. Charles B. Spofford, Jr., has resigned as manager of the Crane Felt Company, Belvidere, N. J., and has accepted a position as chief chemist for the Angus Jute Co., Ltd., Calcutta, India, and until he sails, November 27, will be with the Bemis Brothers Bag Company, of Boston.

Mr. Jack A. Thomas has resigned his position as department manager of the Rollin Chemical Company, Inc., Charleston, W. Va., in charge of the chlorinated products section, to make an extended trip to higher altitudes to regain his health.

Mr. Jerome D. Stein, formerly control supervisor of the Nitrate Division, U. S. Nitrate Plant, No. 2, Muscle Shoals, Ala., has accepted a position with the Gordon Dryer Corporation, N. Y., in their development department.

Mr. William H. Harrison, formerly deputy dairy and food commissioner with the State Dairy & Food Department, Des Moines, Iowa, is now director of inspection of the Iowa District for the National Canners Association, Ames, Iowa.

Mr. Paul A. Keene, who for the last fourteen months has been engaged in government nitrogen fixation work in both enlisted and civilian capacities, has accepted a position with the Solvay Process Company, and is now located at their laboratory in Syracuse, N. Y.

Mr. R. V. Cook, recently research engineer with the Koppers Co., of Pittsburgh, has joined the sales-engineering staff of the Brecht Co., St. Louis, Mo.

Dr. F. G. Cottrell, chief metallurgist in the U. S. Bureau of Mines, has been named assistant director in charge of investigative and scientific work. Other changes in the Bureau are the appointment of the former chief clerk, **Mr. F. J. Bailey**, as assistant to Director Manning in charge of executive work, and **Mr. H. W. Meyer**, chief clerk of the War Minerals Relief Commission, to be chief clerk of the Bureau, succeeding Mr. Bailey.

Dr. R. A. Baker, recently Major, Chemical Warfare Service, and Commandant of the U. S. Gas School at Camp Kendrick, N. J., and prior to which service he was assistant professor of inorganic chemistry at the University of Minnesota, has been appointed professor of general and inorganic chemistry at Syracuse University.

Mr. Alfred C. Chambers, recently resigned his position as chief of the Quality of Water Division, Water Resources Branch of the Geological Survey, to accept a position as chemist in the laboratory of The Youngstown Sheet & Tube Co., Youngstown, Ohio.

Mr. Arthur S. Schulhoff has resigned his position as chief chemist at the Hermon, N. Y., plant of the Nestles Food Company in order to resume the study of chemistry at the Massachusetts Institute of Technology.

Mr. Harry I. Johnson, formerly assistant professor of chemistry at the University of Louisville, will be employed in a similar capacity at the North Carolina State College, W. Raleigh, N. C., this coming year.

Mr. A. G. Davis, formerly of Delicias, Cuba, is now with the central control laboratory of the Cuban-American Sugar Company, Cordenos, Cuba.

Mr. Ralph C. Holder, who was discharged from the Chemical Warfare Service last December, having been stationed at the American University, Washington, D. C., is now chemist at the U. S. Department of Agriculture, Food Research Laboratory, Indianapolis, Ind.

GOVERNMENT PUBLICATIONS

By R. S. McBRIDE, Bureau of Standards, Washington

NOTICE—Publications for which price is indicated can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. Other publications can usually be supplied from the Bureau or Department from which they originate. Commerce Reports are received by all large libraries and may be consulted there, or single numbers can be secured by application to the Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington. The regular subscription rate for these Commerce Reports mailed daily is \$2.50 per year, payable in advance, to the Superintendent of Documents.

WAR DEPARTMENT

Electrical Apparatus and Wiring Supplies. War Department Catalogue 6. 162 pp. Issued by the Engineering and Standardization Branch of the Purchase, Storage, and Traffic Division, May 1, 1919. An illustrated outline of War Department Standards.

The Principles Underlying Radio Communication. Radio Pamphlet 40. 355 pp. Fabricoid, 55 cents. Prepared by the Bureau of Standards under the direction of the Office of the Chief Signal Officer of the Army Training Section. "Acknowledgment is made of the valuable service rendered the Signal Corps by the Bureau of Standards through the work of Dr. J. H. Dellinger and the following men engaged with him in the writing of this book: F. W. Grover, C. M. Smith, G. F. Wittig, A. D. Cole, L. P. Wheeler, and H. M. Royal. In this book are presented briefly the basic facts and principles of electromagnetism and their application to radio communication. In the effort to present these topics in a simple manner for students with very little mathematical preparation it has been necessary at times to use definitions, illustrations, and analogies which would not be used in a work prepared for more advanced students. Frequent references to standard books are given for further study, and students should be encouraged, as far as possible, to consult them."

America's Munitions, 1917-18. Report of B. CROWELL. (Edited by R. J. BULKLEY, R. F. WILSON AND B. E. LING.) 592 pp. 218 pp. of plates. Cloth, \$2.00.

NATIONAL ACADEMY OF SCIENCES

Triad Systems. Memoirs of National Academy of Sciences, 1919. Vol. 12, 2nd memoir. 89 pp. Paper, 15 cents.

CONTENTS—Complete classification of triad systems on 15 elements, [articles] by H. S. White, F. N. Cole, and Louise D. Cummings; Pt. 1, Triad systems on 15 elements whose group is of order higher than unity, by H. S. White; Pt. 2, Triads for triad systems on 15 elements whose group is of order higher than unity, by L. D. Cummings; Pt. 3, Groupless triad systems on 15 elements, by H. S. White and L. D. Cummings; Pt. 4, Structure as defined by interlacings, heads, and semiheads, complete census of triad systems in 15 elements, by F. N. Cole; Pt. 5, Sequences and indices for all groupless triad systems on 15 elements, by L. D. Cummings.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

Nomenclature for Aeronautics. Report 25. 11 pp.

SUPERVISING ARCHITECT TREASURY DEPARTMENT

Specification for Lubricating Oils, Fiscal Year 1920. For Use in Public Buildings under Control of Treasury Department. 7 pp.

PUBLIC HEALTH SERVICE

A Department of Health for Canada. Public Health Reports, 34, 1973-6 (August 29).

An Investigation of the Changes in the Blood and Urine Resulting from Fatigue. A. B. HASTINGS. Public Health Reports, 34, 1682-90 (August 1).

Water for Drinking or Culinary Purposes Provided on Cars and Vessels by Interstate Carriers. Amendment 8 to Interstate Quarantine Regulations of 1916.

City Health Officers, 1919. Issued July 4, 1919. This gives the public health officers of cities of 10,000 population and over.

The Standardization of Pituitary Extracts. R. A. SPARTH. Hygienic Laboratory Bulletin No. 115, Part II.

Regulations for the Sale of Viruses, Serums, Toxins, and Analogous Products in the District of Columbia and in Interstate Traffic. Miscellaneous Publication No. 10. Dated February 12, 1919.

Sale of Condensed Milk. Public Health Reports. Vol. 34, p. 1430. Issued June 27, 1919. United States Supreme Court decision under Ohio law. An Ohio statute prohibited the sale of condensed milk unless made from pure unskimmed milk. The United States Supreme Court has decided that this law prohibits the sale of an article consisting of condensed skimmed milk and a vegetable fat, although not sold as condensed milk.

The Dust Hazard in the Abrasive Industry. C. E. A. WINSLOW, L. GREENBURG AND D. GREENBURG. Public Health Reports, 34, 1171-1187 (May 30, 1919).

Trinitrotoluene Poisoning. C. VOEGTLIN, C. W. HOOPER AND J. M. JOHNSON. Public Health Reports, 34, 1307-1311 (June 13, 1919). From a paper read at the annual meeting of the American Federation of Biological Societies in Baltimore, Md., April 24, 1919.

FUEL ADMINISTRATION

Prices and Marketing Practices Covering Distribution of Gasoline and Kerosene throughout the United States. A. G. MAGUIRE. 24 pp. Prepared in Bureau of Prices and Licenses, Oil Division.

Prices of Petroleum and Its Products during the War. J. E. POGUE AND I. LUBIN. Prepared by Oil Division of Fuel Administration in cooperation with Planning and Statistics Division of War Industries Board. 55 pp. Paper, 5 cents. Also issued as War Industries Board Price Bulletin 36.

BUREAU OF THE CENSUS

Census of Manufactures, 1914, Vol. II. Reports for selected industries and detail statistics for industries, by states, 1,047 pp. 9 maps. 14 text fig. This work presents data for certain selected industries which have been issued sometime since as separate bulletins and are collected in the present volume. In addition are given in detail the statistics for each industry included in the census, by states. Report distinguishes 344 industries, although for certain purposes some of these are subdivided into two or more subclassifications. There are 271 of these subgroups of industries; thus separate totals are given for 615 industries or subclasses of industry.

Textile Fibers; Wool, Silk, Jute, and Kapok; Census of War Commodities, 1918. 16 pp. This gives statistics of wool, silk, jute, and kapok, gathered by the Bureau during war period, at request of the War Industries Board, to ascertain available stocks, data bearing upon consumption and products, and machinery capacity of country for textile production in certain cases, which were used by various war activities of Government.

Statistical Abstract of United States, 1918. 897 pp. Paper, 40 cents. This presents in condensed form statements regarding commerce, productions, industries, population, finance, currency, indebtedness, and wealth of country for series of years, compiled from more important statistical data collected by various government departments; also condensed statement of commerce of principal foreign countries.

Cotton Production in United States, Crop of 1918. 39 pp. This paper presents a series of tables giving statistics of cotton ginned from the crop of 1918 for United States, several states, and individual counties.

Antimony and Graphite Crucibles; Census of War Commodities. 10 pp. This consists of statistics gathered during war period by Bureau in endeavor to ascertain stocks of antimony available for war activities and for requirements of both peace and war industries, and which were given as soon as compiled to various war agencies of Government. Statistics showed antimony content of stocks on hand, in transit, and afloat; imports and exports for fiscal years ended June 30, 1918 and 1917; and consumption and production.

BUREAU OF MINES

The Determination of Combustible Matter in Silicate and Carbonate Rocks. A. C. FIELDNER, W. A. SELVIG, AND G. B. TAYLOR. Technical Paper 212. 22 pp. Paper, 5 cents. Issued April 1919. Owing to the presence of combined water in shale and clay, and of carbon dioxide in carbonate rocks, the percentage of combustible matter in these materials cannot be calculated from the loss on ignition, as is done in coal and other fuels containing a relatively small proportion of constituents that are incombustible; neither can the combustible be taken as the sum of the total carbon and hydrogen as obtained in the ordinary ultimate analysis, for in both these methods the organic matter is oxidized to water and carbon dioxide, simultaneously with the liberation of water and carbon dioxide from the hydrous silicates and inorganic carbonates in the rock. Therefore, special methods are required that will differentiate between the organic and the inorganic carbon and hydrogen.

Petroleum Investigations and Production of Helium. VAN H. MANNING. Bulletin 178-C. 24 pp. Issued June 1919. Advance Chapter from Bulletin 178, War Work of the Bureau of Mines.

Vitiation of Garage Air by Automobile Exhaust Gases. G. A. BURRELL AND A. W. GAUGER. Technical Paper 216. 12 pp. Paper, 5 cents. Issued April 1919.

Recent Developments in the Absorption Process for Recovering Gasoline from Natural Gas. W. P. DYKEMA. Bulletin 176. 90 pp. Paper, 25 cents. Issued April 1919. This report gives the results of a study conducted by the Bureau of Mines for the purpose of informing the petroleum industry on the recent progress in the development and application of the absorption process for recovering gasoline from natural gas. The work has been undertaken entirely with regard to plant practice and for the purpose of describing the features and the operation of units of the plants now in use, the improvements that have been made, and the reasons for any changes contemplated by the engineers in charge of the plants studied.

Throughout the United States the improvements in the absorption process that are under consideration by engineers not only widen practice so as to include gases at pressures and percentages of gasoline content, but seem to be developing definite standards as to dimensions of towers, velocities of flow, saturation of oils, areas of cooling surfaces, and quantities of menstruum to be circulated. Although perfect practice has by no means been attained, the writer believes that a description of the current practice at various plants, including those obviously more efficient features that each plant has developed and uses at one or another stage of treatment, will interest and possibly help all persons operating or designing absorption plants.

Motor Gasoline: Properties, Laboratory Methods of Testing, and Practical Specifications. E. W. DEAN. Technical Paper 214. 33 pp. Paper, 5 cents. Issued February 1919. This report is issued as a revised edition of Technical Paper 166, on the properties and testing of gasoline. Discussion that has lost its significance since the date of issue of Technical Paper 166 has

been omitted, and much information has been added that has become of recent importance. With conditions in the oil refining and marketing industries even more unsettled than they were at the time of issue of Technical Paper 166, anything approximating a last word on the subject treated is impossible. But because of the need of keeping the public in touch with this important and rapidly developing technical field the Bureau of Mines issues this report.

Report of a Joint Committee Appointed from the Bureau of Mines and the United States Geological Survey by the Secretary of the Interior to Study the Gold Situation. Bulletin 144. 84 pp. Paper, 15 cents. Issued January 1919. The status of the industry and the conclusions and recommendations of the committee, as presented therein, may be briefly summarized as follows: Statistics of production dating from the discovery of America in 1492 show that the annual average output was small until 1850, when the discovery of gold in California and Australia marked the beginning of great gold output. The figures show a slight decline from 1855 to the opening of the mines in the Transvaal in 1887; then there was a very large increase in the yearly output until 1910, since which date there have been irregular fluctuations until 1915, when a serious decline took place. Though the increase in the output of gold has been rapid during the past 25 years, it has not kept pace with the output of coal, iron, copper, or petroleum, or with the rapid growth of bank deposits.

The present decrease in gold production demands serious consideration, as the maintenance of a sufficient gold reserve is essential to the security of our national finance and credit. The United States is at present the most favored nation in regard to gold reserves, holding over \$3,000,000,000, or more than one-third of the gold stock of the world, but it has contracted debts on a gold basis many times that existing before the war. The principal causes of the decline in gold mining in this country are the shortage of labor and higher wages due to the war, the lower efficiency of available labor, the great increase in the cost of supplies, and the higher cost of power. In addition, the depletion of certain deposits and the lower grade of ore mined in others have contributed to reduction of output.

Bibliography of Petroleum and Allied Substances in 1916. E. H. BURROUGHS. Bulletin 165. 159 pp. Issued February 1919. Paper, 20 cents.

The Decline and Ultimate Production of Oil Wells, with Notes on the Valuation of Oil Properties. C. H. BEAL. Bulletin 177. 213 pp. Paper, 30 cents. Issued April 1919. In this bulletin Mr. Beal furnishes several new methods for estimating the future output of oil producers and engineers in determining the probable amount of oil that oil properties in the different fields of the United States will yield. The material is, therefore, presented in two parts: the first part explains in considerable detail the methods that should be used in estimating the future production of oil and the manner of applying those methods to the valuation of oil lands; whereas the second gives in detail such information as was available on the ultimate oil recovered in different fields and the usual rate at which the average oil well in each field will produce.

Abstracts of Current Decisions on Mines and Mining, Reported from September to December 1918. J. W. THOMPSON. Bulletin 179. 169 pp. Issued February 1918. Paper, 20 cents.

Metal-Mine Accidents in the United States during the Calendar Year 1917 (with supplemental labor and accident tables for the years 1911 to 1917, inclusive). A. H. FAY. Technical Paper 224. 80 pp. Issued April 1919. Paper, 10 cents.

Cost Keeping for Small Metal Mines. J. C. PICKERING. Technical Paper 223. 46 pp. Paper, 10 cents. Issued February 1919. The importance of keeping accurate accounts of costs at small or medium-sized mines is not as well recognized

as it might be. This report outlines methods of cost keeping suitable for metal mines of small or moderate size and presents various forms and cost sheets that have been found useful in actual practice. The report is published by the Bureau of Mines in the hope that it will be of help to mine owners and operators who have had difficulty in working out a satisfactory system of cost keeping, and will be of interest to the industry in general. The methods and forms herewith submitted are modifications of practice at mines with which the writer has been connected.

Recovery of Zinc from Low-Grade and Complex Ores. D. A. LYON AND O. C. RALSTON. Bulletin 168. 145 pp. Paper, 20 cents. Issued March 1919.

Method of Administering Leases of Iron-Ore Deposits Belonging to the State of Minnesota. J. R. FINLAY. Technical Paper 222. 40 pp. Paper, 5 cents. Issued May 1918. This report on the mining properties of the state of Minnesota is the result of work begun through inquiries made by the state auditor, J. A. O. Preus, during the summer of 1917, as to whether the Bureau of Mines could supervise an investigation of those properties with the general object of ascertaining: (1) Whether in the administration of the properties in the past the state had received such returns as could reasonably have been expected, and (2) whether any recommendations could be made as to improvements in the administration of the properties in the future.

War Minerals, Nitrogen Fixation and Sodium Cyanide. V. H. MANNING. Bulletin 178-B. Advance Chapter from Bulletin 178 War Work of the Bureau of Mines. 20 pp. Paper, 5 cents. Issued June 1918. The term "war minerals" has been applied to those ores and minerals that were largely imported before the war. Among the more important of these are manganese, essential for making high-grade steel for munitions and industrial use; graphite, for making crucibles; tin, for plating utensils and for bearing-metal; mercury, used as fulminate to explode shells; potash, for making fertilizer and explosives; tungsten and molybdenum, for high-speed tool steel; antimony, for hardening bullet lead; chromite, for tool steel, for tanning leather, and as a refractory lining in furnaces; magnesite, for refractory linings; mica, as insulating material; platinum, for the manufacture of sulfuric acid and for electrical apparatus.

Electrodeposition of Gold and Silver from Cyanide Solutions. S. B. CHRISTY. Bulletin 150. 171 pp. Paper, 25 cents. Issued December 1918. The author says, "This report on the electrodeposition of gold and silver from cyanide solutions represents work that has occupied my time at intervals during the past 20 years. The investigation has been carried on simultaneously with my duties as professor of mining and metallurgy of the University of California."

BUREAU OF STANDARDS

Strength and other Properties of Wire Rope. J. H. GRIFFITH AND J. G. BRAGG. Technologic Paper 121. 80 pp. Paper, 20 cents. Issued July 16, 1919.

Determination of Free Carbon in Rubber Goods. A. H. SMITH AND S. W. EPSTEIN. Technologic Paper 136. 8 pp. Issued August 12, 1919.

Constitution and Metallography of Aluminum and Its Light Alloys with Copper and with Magnesium. P. D. MERICA, R. G. WALTEMBERG AND J. R. FREEMAN. Scientific Paper 337. 15 pp. Paper, 10 cents. Issued August 16, 1919.

Some Optical and Photoelectric Properties of Molybdenite. W. W. COBLENTZ AND H. KAHLER. Scientific Paper 338. 42 pp. Paper, 10 cents. Issued August 16, 1919. The paper gives data on the spectral photoelectric sensitivity of molybdenite, under various conditions of operation. Molybdenite was selected for detailed examination because it is one of the few minerals available which is sufficiently homogeneous to

determine various optical and electrical properties, all of which data may prove useful in arriving at an explanation of the phenomenon of change in electrical resistance of certain substances when exposed to thermal radiation.

DEPARTMENT OF AGRICULTURE

Saving Man Labor in Sugar Beet Fields. L. A. MOORHOUSE AND T. H. SUMMERS. Farmers' Bulletin 1042. Contribution from the Office of Farm Management. 18 pp.

A Study of the Alkali-Forming Bacteria Found in Milk. S. H. AYERS, PHILIP RUPP AND WM. T. JOHNSON. Bulletin 782. Contribution from the Bureau of Animal Industry. 39 pp. Paper, 5 cents. Issued June 17, 1919.

Standards of Purity for Food Products. Circular 136, Office of the Secretary. Supersedes Office of the Secretary Circulars 13, 17, and 19. 22 pp. Paper, 5 cents. Issued June 1919.

Report of the Committee Appointed by the Secretary of Agriculture to Consider the Subject of Land Economics as One of the Divisions of Research Work of the Proposed Bureau of Farm Management and Farm Economics. Circular 138, Office of the Secretary. 8 pp. Paper, 5 cents. Issued June 1919.

The Relation of the Shrinkage and Strength Properties of Wood to Its Specific Gravity. J. A. NEWLIN AND T. R. C. WILSON. Bulletin 676. Contribution from the Forest Service. 35 pp. Paper, 10 cents. Issued July 16, 1919.

Factors Influencing the Carrying Qualities of American Export Corn. E. G. BOERNER. Bulletin 764. Contribution from the Bureau of Markets. 99 pp. Paper, 20 cents. Issued July 5, 1919. This gives the results of experiments carried on to determine the reasons for the spoiling of corn during shipment to Europe.

The Adulteration of Insect Powder with Powdered Daisy Flowers (*Chrysanthemum leucanthemum* L.). R. C. ROARK AND G. L. KEENAN. Bulletin 795. Contribution from the Bureau of Chemistry. 12 pp. Issued July 28, 1919.

Yearbook of the United States Department of Agriculture for 1918. 760 pp. Paper, 85 cents. This Yearbook contains the annual report of the Secretary, 73 pages; 28 miscellaneous articles, 441 pages; an appendix, 218 pages; an index, 34 pages. Only 30,000 out of the 500,000 edition are allotted to the Department, and this amount is insufficient to supply it agents, correspondents, and employees. The remainder of the edition is allotted to Senators, Representatives, and Delegates in Congress, and applicants, other than persons connected with the Department, are therefore advised that the publication cannot be furnished to them by the Department. The Superintendent of Documents, Government Printing Office, Washington, D. C., has it for sale.

Article from the Journal of Agricultural Research

Relation of Sulfates to Plant Growth and Composition. H. G. MILLER. 17, 87-103 (June 16, 1919).

COMMERCE REPORTS—JULY 1919

Owing to the scarcity of sulfur during the war, paper plants of Sweden have been adapted to the use of Norwegian pyrite. There is a possible field for American sulfur. (P. 270)

Efforts are being made to develop deposits of lignite in the British Empire, especially in Devonshire, England; Alberta, Canada; and near Belfast, Ireland. Its use in powdered form is suggested or possibly distillation for the by-products. (Pp. 277-9)

Oil of good quality has been discovered in considerable quantity in Derbyshire, England. (P. 281)

A summary is given of foreign markets for drugs and chemicals in British South Africa, China, Italy, and Japan. Statistics of normal imports of chemicals into these countries are given. (Pp. 292-6)

A fund of \$1,050,000 has been donated by British oil interests to found a school of chemistry for Cambridge University. (P. 361)

A weekly Metallurgical Exchange has been established in Zurich, Switzerland, to serve as a clearinghouse for metals and machinery. (P. 387)

Since the end of the war there has been a marked decrease in the mineral output of Ontario, especially of nickel matte, copper, gold, and silver. (P. 399)

The Australian government has commandeered the entire coal supply of that country and will fix prices. (P. 408)

In spite of the threatened German competition, the demand for American dyes in China and the Far East continues. The Japanese have not succeeded in building up a strong dye industry. (Pp. 411-3)

A Central Importing Agency for Dyes has been established by the British Government Board of Trade, through which all

imports of dyestuffs into the United Kingdom must be made. (P. 423)

Aluminum ware, especially from the Birmingham district, is largely replacing enamel ware in Great Britain. Efforts are being made to increase the production of enamel ware, most of which was formerly obtained from Germany. (P. 426)

From 900 to 1800 tons of tungsten ore per year were produced in Portugal during the war, but now the industry is paralyzed. (P. 469)

The tin output of New South Wales is increasing. (P. 553)

The principal delays in the revival of the Belgian glass industry are due to the transportation and labor difficulties. (P. 564)

SPECIAL SUPPLEMENTS ISSUED IN JULY
IRELAND—192
UNITED KINGDOM—LEEDS, NOTTINGHAM AND SHEFFIELD—196

The following table shows the principal chemical exports in June from a number of foreign ports to the United States, based on cabled information from the ports in countries named.

CANADA		ENGLAND		CHINA	
Pulpwood.....	350 cords	Earth paint.....	14 tons	Peanut oil.....	1,816 tons
Creosote.....	30,000 gal	Plasticine.....	13 tons	BRITISH INDIA	
CENTRAL AMERICAN STATES		Whiting.....	35 tons	Paraffin.....	640 tons
Cocoanuts.....	20 tons	Fuller's earth.....	18 tons	Coconut oil.....	1,015 tons
Sugar.....	1,340 tons	Sal ammoniac.....	13 tons	Rubber.....	580 tons
Castor beans.....	127 tons	Creosol.....	108 tons	JAPAN	
Rubber.....	5 tons	Wash blue.....	12 tons	Porcelain and lacquer ware	12 tons
Cocoanuts.....	1,400,000 units	Ultramarine.....	10 tons	Copra.....	39 tons
Tallow.....	23 tons	Creosote oil.....	8 tons	Crude arsenic.....	11 tons
Tuna gum.....	1 ton	Paper stocks.....	106 tons	Chlorate of potash.....	6 tons
MEXICO		Ferromanganese.....	900 tons	SOCIETY ISLANDS	
Lead concentrates.....	13 tons	Salt.....	592 tons	Copra.....	1,933 tons
Silver bullion.....	140,639 oz.	Hides and skins.....	120 tons	Coconut oil.....	300 tons
Gold bullion.....	2,554 oz.	Palm oil.....	866 tons	Cocoanuts.....	237,639 tons
Hides.....	44 tons	CHINA		BRAZIL	
Chicle.....	5 tons	Soy bean oil.....	191 tons	Rubber.....	852 tons
JAMAICA		Sesame seed oil.....	99 tons	Carnauba wax.....	158 tons
Logwood.....	1,748 tons	Wood oil.....	2,097 tons	Castor oil.....	8 tons
Hides.....	127½ tons	Antimony, regulus and		CHILE	
Orange oil.....	4 tons	crude.....	350 tons	Hides.....	288 tons
Copra.....	2 tons	Tallow, animal and vege-		Beeswax.....	37 tons
Annatto.....	2 tons	table.....	18 tons	FRANCE	
Cocoanuts.....	354 tons	Hides.....	1,061 tons	Hides.....	206 tons
CUBA		Albumen.....	9 tons	Ocher.....	222 tons
Sugar.....	22,879 tons	JAPAN		Glycerin, crude.....	77 tons
Molasses.....	1,050,000 gal.	Vegetable wax.....	37 tons	Egg albumen.....	25 tons
Moist hides.....	207 tons	Matches.....	13,200 gross	Graphite.....	325 tons
Hides.....	24½ tons	Porcelain.....	\$149,262 value	Glue stock.....	82 tons
Wax.....	7½ tons	Campbor.....	91 tons	BRITISH INDIA	
ARGENTINA		CANARY ISLANDS		Poppy seed.....	24 tons
Linseed.....	2,254 tons	Cochineal.....	6 tons	Casein.....	1 ton
COLOMBIA		EGYPT		Gum ojinaga banum.....	22 tons
Hides.....	109 tons	Gum.....	267 tons	Gum raraya.....	27 tons
BRITISH GUIANA		Hides.....	37 tons	Nux vomica.....	64 tons
Bauxite.....	940 tons	FRENCH AFRICA		Manganese ore.....	500 tons
Balata.....	3 tons	Crude argols.....	25 tons	Asafetida.....	2 tons
Sugar.....	1,400 tons	Rags.....	169 tons	Turmeric.....	22 tons
Cocoanuts.....	61 tons	Glue stock.....	11 tons	DUTCH EAST INDIES	
FRANCE		MEXICO		Rubber.....	850 tons
Crude drugs.....	5 tons	Manganese.....	½ ton	Kapok.....	86 tons
Muriate of potash.....	281 tons	PERU		Jeluton.....	80 tons
Glue stock.....	20 tons	Copper bars.....	1,801 tons	Gutta Hongkong.....	86 tons
Hides, salted.....	226 tons	Hides.....	101 tons	Sisal fiber.....	1,648 tons
ITALY		Vanadium ores.....	292 tons	JAPAN	
Essences.....	19 tons	Copper matte.....	34 tons	Antimony.....	178 tons
Citrate of lime.....	40 tons	Copper and silver ores.....	10 tons	Porcelain.....	35 tons
NORWAY		Silver sulfide.....	1,149 tons	Bean oil.....	23,800 tons
Hides and skins.....	17 tons	Molybdenum ores.....	2 tons	Sesame oil.....	3,000 tons
Oxalic acid.....	15 tons	ITALY		Arsenic.....	1,000 tons
Matches.....	49 tons	Sumac.....	608 tons	Vegetable wax.....	1,762 tons
PORTUGAL		Citric acid.....	4 tons	Agar-agar.....	150 tons
Hides.....	105 tons	TURKEY		Pyrethrum.....	87 tons
Argols.....	35 tons	Hides.....	63 tons	Peanut oil.....	131,821 tons
Olive Oil.....	800 tons	Opium.....	5 tons	Perilla oil.....	3,500 tons
Paper stock.....	39 tons	Gum tagacanth.....	12 tons	Coconut oil.....	2,000 tons
Red oxide.....	415 tons	Rose oil.....	107 tons	Rubber.....	25 tons
WALES		ADEN		Gum copal.....	60 tons
Nickel salts.....	21 tons	Wax.....	8 tons	Campbor.....	310 tons
		Hides.....	10 tons		

BOOK REVIEWS

Coal Tar Distillation and Working Up of Tar Products. By ARTHUR R. WARNES. D. Van Nostrand Co., New York City, 1918. Price, \$5.00.

This is the second effort of Mr. Warnes in this field.

His opening chapter devotes some discussion to the physical nature of coal tar. He has several good points to make with regard to the character of the retort in which the coking is done but he adds nothing to the field of experiment that is going on along this line.

In the second chapter he goes into some detail with regard to the mechanical devices for handling coal tar. These are based more or less on English methods and are not particularly applicable to our procedure.

He has a good deal to say, in succeeding chapters, with regard to mechanical features of stills. His statements are open to question as he will find almost as many ideas as to type of still as there are distillers.

It is interesting to note his remarks on dehydration, which he speaks of as having come into use lately. In this country dehydration has been going on for some time and from a mechanical standpoint it is one of the most crude operations we have and yet in efficiency it is very high.

The continuous distillation, which in the mind of the art distiller is the paramount issue of to-day, he takes up in Chapter 5 but very briefly and to the reviewer's mind this is the error of the book if any. It seems impossible that a book published as late as 1917 should not devote a considerable amount of time to this most important phase of tar distillation.

He touches rather lightly on the method of removing cresylic and carboic acids from oils and gets into a considerable amount of chemistry, which, generally speaking, is not the province of the tar distiller as the procedure in this country makes the tar distiller more of a mechanical operator than chemical, and refiners of the chemical products look after the chemical features. This, coupled with Chapter 9, where he outlines the practice with regard to the recovery of benzol, toluol, naphtha, etc., makes the book of some value to the refiner as well as the tar distiller.

It is curious to the reviewer to see at this late date discussions of sulfuric acid in degrees Twaddell. It is a singular fact that the English never succeeded in controlling the petroleum situation in this country because no two institutions have as great a love for the antiquated expressions of science as the English scientist with his degrees Twaddell and the American petroleum producer with his Fahrenheit thermometer and it seems not only a great pity but an impossibility that their lines of endeavor did not lie in the same direction.

He devotes quite an amount of space to pyridine and in the reviewer's mind this is a useful contribution to the somewhat meager information that has been published on this subject.

He discusses at considerable length the manufacture of crude naphthalene and anthracene and this is also a contribution that should be of some benefit. It is a pity that he has not given more on anthracene, but he returns to the domain of the tar distiller for a considerable length of time.

There is, however, one very damaging statement in Chapter 16 which we feel he has made somewhat too lightly. He says pitch dust causes severe inflammation of the conjunctival membrane and cornea of the eye and may result in cancer. There has been considerable medical and scientific discussion of this feature and while he cites the monograph of John Murray, which was the result of the British Home Office inquiry into the subject, we do not feel that he has gone into sufficient detail and he may leave the wrong impression in the mind of the reader.

He goes into considerable detail with regard to the production

of creosote as well as giving some information on stripping gas for benzol and toluol. This shows the influence of the war in the chemistry of coal tar and while his information on the latter subject is fairly complete, it is not conceivable that the English manufacturer did not surpass the practice that he gives. It is entirely possible that they were in possession of additional information which did not reach the author in time for publication.

His chapter devoted to tarworks' tests, describing the various tests applied by the tar worker, is very good, but in the writer's opinion it should be much more complete as to detail.

Generally speaking, however, the book is of value and is well worth reading by people interested in the subject. The reviewer is somewhat inclined to think that the book is written more for the experienced hand than the person desiring information on the subject.

J. R. M. KLOTZ

The Flotation Process. By HERBERT A. MCGRAW. McGraw-Hill Book Company, Inc., New York City, 1918. Price, \$3.50 net.

Four entirely new chapters have expanded the 1918 edition from a previous 249 to 359 pages. The additional material, except for one chapter dealing with the use of petrography in flotation, is largely descriptive of late practice at various typical mills. In detail the chapters are altered as follows:

Chapter I, Concentration by Flotation, is unchanged except for minor additions.

Chapter II, The Patent Record of Flotation, is brought more nearly to date by a reproduction of the famous Minerals Separation Specification No. 835,120, while special headings for some of the minor processes make the chronology somewhat more clear.

Chapter III, The Theory of Flotation, contains considerable new matter on the rôle of films, inhibitory films, the mechanism of froth formation, and a discussion of the question of froth stability.

Chapter IV, Oils and Their Uses, has some new matter on the use of sagebrush oils, and on the quantity of oil required. An insertion of a tabulation of the practice in various cases, could it have been obtained, would no doubt be of considerable interest in this connection; in reality the qualitative aspects of the quantity of oils used are all that is given.

Chapter V, Flotation Processes and Apparatus, has several new pages devoted to Janney hydraulic, Rork-Sandberg machines, etc.

Chapter VI, Testing Ores of Flotation, is amplified by a discussion of the testing for the effect of pulp dilution, sand and slime, and handling coarse material.

Chapter VII, Testing at the Anaconda Mill, is identical except for the omission of several pages of tabulated test data.

Chapter VIII, The Use of Petrography in Flotation, is entirely new.

Chapters IX, X and XI, dealing with the Application of Flotation, Examples of Flotation Practice, and Flotation Operating Plants, have had practically no additions.

Chapter XII, Flotation of Arizona Copper Ores, is entirely new and discusses methods at Magma, Burro Mountain, Consolidated Arizona, etc., as well as dealing with sulfide filming, crushing and grinding, and improvements in flotation in relationship to the specific types of ores treated in the southwest.

Chapter XIII, Flotation of Miscellaneous Ores, is new and includes a discussion of flotation results on lead, silver, antimony, molybdenite, and complex ores.

Chapters XIV, XV, XVI, Description of Flotation Concen-

tration at Anaconda, Flotation Practice, and the Practice of Flotation are practically identical with the previous edition; one is inclined to wonder whether there have been no important changes in practice at the various mills discussed.

Chapter XVII, Flotation Development at the Inspiration Mill, is new in this edition, and gives adequate discussion of methods and results at this mill.

The Place of Flotation in Metallurgy, which closes the book in Chapter XVIII, has included some later discussion of the present changing attitude towards flotation, emphasizing the fact that while it has proved an exceedingly useful tool at certain mills, there are other places where it is not so glitteringly alluring from a business point of view.

In general, the introduction of new chapters describing with considerable detail the best practice in this country, has rounded out the balance of the new edition so as to enhance its value and usefulness not only to the general reader, but also the engineer in search of data.

CHARLES G. MAIER

Manual of the Chemical Analysis of Rocks. By HENRY S. WASHINGTON, Ph.D. 3rd Ed., Revised and Enlarged. 8vo. xii + 271 pp. John Wiley & Sons, Inc., New York. Price, \$2.50.

This excellent book is obviously written by one who takes pride in careful analytical work and who is interested in allied problems of geology and mineralogy. It is worthy of a place in the library of every analytical chemist. It does not attempt to supplant any of the well-known textbooks but is meant to be used with them also at hand.

In discussing errors that are likely to arise in the examination of rocks for scientific rather than practical purposes, Dr. Washington writes on page 4 as follows: "The analyst must rest content with reducing errors to a minimum by selecting methods which have been shown to be reliable. In this we cannot do better than follow the chemists of the U. S. Geological Survey whose experience is of the widest and who have set up a standard of analytical methods and practice for rocks and minerals that is beyond all others." Thus, frankly, does the author acknowledge that his methods are those published by W. F. Hillebrand in Bulletin 422 of the U. S. Geological Survey. It differs from the Bulletin, however, by describing the details of manipulation with greater care so that, on the whole, the book is more suitable for beginners. The methods described are applicable to the analysis of igneous rocks and may be regarded as standard for the determination of hydrogen, silicon, fluorine, ferrous and ferric iron, aluminum, calcium, magnesium, sodium, and potassium. It is assumed that there is one and only one right way to analyze a rock and that this way has been pointed out by F. W. Clarke and W. F. Hillebrand. There is practically no attempt to compare these methods with others that have been suggested. It is implied that a chemist by careful work should get values for Al_2O_3 , Na_2O , and K_2O within 0.05 per cent of the truth when less than 10 per cent of each constituent is present so that there appears to be little need of testing other methods. It may be said, however, that in the discussion of the elements which usually occur in small quantities in less igneous rocks, such as chromium, vanadium, boron, cerium, manganese, nickel, cobalt, copper, and phosphorus, the methods are not always entirely satisfactory and might, in some cases, lead to serious error if applied to ores rich in these substances. The book is not meant for the assay chemist who is daily called upon to make many determinations often of a single constituent.

"It may be said," writes Dr. Washington, "that the analysis of rocks would seem to be especially suitable for women, whose characteristics of neatness, patience, application, care and conscientiousness, and attention to detail would be most valuable in analytical work."

The general appearance of the book is excellent and it is remarkably free from typographical errors.

The chapter on apparatus and chemicals is distinctly improved in this edition. The danger of keeping ammonia solutions in glass vessels is emphasized strongly and the chemist is advised to redistill his ammonia as required and to keep it in ceresine bottles. Few realize how impure ammonia solutions often become on account of the solvent action on glass. The reviewer has known of an extremely careful analyst finding 103 per cent of iron in a sample of iron wire and the trouble was traced to the ammonia solution.

At the back of the book an analysis of a "gray porphyritic lava from Mt. Etna showing **** augite and olivine phenocrysts **** but more numerous crystals of plagioclase" is given and this furnishes an excuse for introducing, into this edition, an ancient print of Mt. Etna which represents, unfortunately, the only illustration in the book. The method of computing the analysis, which was made by Dr. Washington himself, is described with a fulness of detail seldom found outside a textbook on arithmetic. It is interesting to note that all the multiplications and divisions are carried out, not with the aid of logarithms or a slide rule, but in the orthodox manner, using in one case 69 digits in a problem that can be solved mentally. In the computation, 0.08616365 g. of Fe_2O_3 was found to be the equivalent of the FeO present and this was subtracted from the total iron content which corresponded to 0.11477193 g. of Fe_2O_3 . In the same sample, which weighed 1.0197 g., there was 0.00153600 g. of MnO . On page 241 a table of chemical factors is given and the values are rounded out to correspond to the quantities likely to be present in rocks. Thus the fraction of BaO in $BaSO_4$ is given as 0.66 and of P_2O_5 in $24 MoO_3 \cdot P_2O_5$ as 0.04. Logarithms are given of these values to five decimal places. It is astonishing that an author of such mineralogical, geological, and chemical erudition should be guilty of such mathematical indiscretion.

WILLIAM T. HALL

Beverages and Their Adulterations. By HARVEY W. WILEY, M.D. xv + 421 pp. P. Blakiston's Son & Co., Philadelphia, 1919. Price, \$3.50.

It may be said at the outset that this book is one written professedly for the interested public and not for the trained chemist. It is not in any sense a book of methods and should be read and discussed from a rather general point of view.

It is written in characteristic Wiley style, which means numerous plain-spoken truths couched in trenchant statements, curious delvings into the history of beverages, with occasional lapses into verse, and a decidedly dogmatic stand on certain disputed matters.

The book separates naturally into two general divisions, one relating to potable and mineral waters, soft drinks, tea and coffee, and the second portion devoted mainly to alcoholic beverages. The earlier part of the book does not seem so well written and the author does not appear entirely at home in treating the subject of potable water and its purification. In view of the numerous special treatises available in which this subject is presented with exactness it seems a pertinent inquiry whether this portion of the book would not be best confined to general statements, and the attempt to state precise chemical changes in terms intelligible to the non-scientific reader be omitted.

Several instances of this kind perhaps deserve notice that they may be changed in later editions. On page 3, by a careless sequence of English, radioactivity is given a place among the "bases." Temporary hardness of water is not usually ascribed to "sulfates of lime and magnesium," as the reader would surely infer from page 5. When soap is added to a hard water the fatty acid of the soap is not set free in an insoluble

state, page 6. In the experiment illustrated on page 16 it would puzzle even a chemist to understand how "it will be seen that the volume of the hydrogen collected is just double that of the oxygen," when both gases are collected in the same tube. "If water is colored, it is evidently due to contamination, which ought to be avoided," page 29, is a statement, which, if literally true, might well be disquieting to the millions of consumers of pure colored surface waters. The author is very much at sea in his description of the theory and functioning of a septic tank, page 44, and has evidently confused it with something entirely different.

One is inclined to wonder why cocoa and chocolate are given such inadequate treatment as compared with coffee and tea.

The portion of the book in which the alcoholic beverages are taken up certainly has a greater appeal than the earlier part. A wealth of detail is given in regard to the vineyards of the world and the characteristics of their products, the source, manufacture, and adulterations of brandy, whisky, and rum, even in details of mixing drinks, taken from the latest bartenders' guides. This is written in the most interesting manner and much of it in Dr. Wiley's happiest vein. A somewhat discordant note is found in the controversial manner in which much of the subject of whisky is discussed, although this is perhaps to be expected from the author's well-known views on the subject. There is certainly no sign of a let-down of that aggressive spirit to which is largely due whatever of teeth our national food laws possess.

A. G. WOODMAN

La Reorganisation de l'Industrie Chimique en France. By EUGÈNE GRANDMOUGIN, Ingenieur Chimiste (E.C.M.), AND PAUL GRANDMOUGIN, Administrateur Industriel. H. Dunod and E. Pinat, Paris, 1918.

The text of the book is rather broader than the title seems to indicate for it enters into general subjects of national reconstruction, including education, economics, politics, reform of the French press, the patent system, etc.

The book was written and published in the beginning of 1918, long before the signing of the armistice. Anybody touching upon such a broad subject at that time took the risk of having to change his opinion on account of subsequent events. In this case, however, the authors have shown such perspicacity that practically all they wrote more than a year ago can stand to-day. The advice and considerations show a broadness of view and a wide acquaintance with facts.

Although the book is written for the French and indicates their shortcoming in their political organization, as well as possible improvements in their educational system, similar advice would be just as useful for many other countries, not excluding the United States.

The book is very interesting reading, specially for a young chemist who is at the beginning of his career. There are large problems which seem to have little or no relation to chemistry or the chemical industry, and yet have an intense bearing on the work of every citizen, chemists included. To give an idea of the variety of subjects dealt with in this book, there is some advice to young chemists about marriage.

Considerable space has been given to the criticism of the French educational system, and particularly the time-honored tendency of some of the higher French engineering schools to give almost exclusive attention to mathematics. This has had the result that the few who managed to pass their examinations in such a school, for instance, as the École Polytechnique, can all make fully qualified professors of mathematics, but frequently are quite unprepared to grapple with practical engineering problems, where resourcefulness and modern practical knowledge are indispensable. The authors also bring out the fact that this exaggerated tendency to higher mathematics may have had some-

thing to do with the neglect of organic chemistry in France. They point out, with reason, that organic chemistry is a purely experimental science, where mathematics enters in very little, if at all.

They make a comparative description and criticism of the different patent systems. They explain the differences between the method of simple registration without examination as to patentability—also called the French system—and the system used in the United States, England, and Germany, where a patent is only granted after preliminary examination. To those in this country who might have some sympathy with the French system, the following sentence is significant: "Let us note, however, from now on, that the partisans of the non-examination system are becoming scarcer and scarcer and more timid." The American patent system is indicated as being the most liberal patent system in existence, which is truly the case.

In reading this book, one gains the impression that although the authors are pretty well acquainted with conditions in England and in Germany, as well as in their own country, they seem to be less well posted on what is going on in the United States. They refer to English and German periodicals, but they omit entirely mention of some of our excellent publications in the United States. I have met French chemists visiting the United States who seemed to be astonished when they learned of the existence of the AMERICAN CHEMICAL SOCIETY with over 13,000 members and three periodicals. Nor did they seem to realize what big strides chemistry had made in this country during the last twenty-five years.

L. H. BAEKELAND

Commercial Oils, Vegetable and Animal, with Special Reference to Oriental Oils. By I. F. LAUCKS. 1st Ed., 138 pp. John Wiley and Sons, Inc., New York, 1919. Price, \$1.25.

The preface states "this book is intended primarily for the non-technical man in the oil trade," and this intention seems to have been eminently successfully fulfilled.

The oils are defined and described, together with their preparation, properties, and uses, in a concise yet clear manner; a particularly valuable feature is the quoting of the specifications of and grading by various officially recognized associations, which are not readily accessible. Another useful feature is the listing of characteristics of the various oils coming to us from the Orient, and to be found nowhere else. These are, in some cases, quite different from those usually given, and will result in new standards being set for such oils. The chapter upon sampling is particularly good.

In conclusion, the book may be cheerfully recommended to the oil trade and the analyst.

A. H. GILL

Catalytic Hydrogenation and Reduction. By E. B. MAXTED. 104 pp. 12 illustrations. P. Blakiston's Son & Co., Philadelphia, Pa., 1919. Price, \$1.25 net.

This very readable little book meets the object of its author as stated in the preface, namely:

***** presenting in an easily accessible form the numerous examples of catalytic hydrogenation which have from time to time been published.

Special attention has been given to experimental methods and in addition to the simple hydrogenation of unsaturated linkages ***** various catalytic reductions of a less simple nature, usually involving the splitting off of water or of a halogen acid, have been included.

The book contains numerous references to patents and other literature, and gives a very good but brief survey of the whole subject of hydrogenation.

The volume has value chiefly from a theoretical and laboratory standpoint. Where it touches on chemical engineering ground, the information is very meager.

DAVID WESSON

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By CLARA M. GUPPY, Librarian Mellon Institute of Industrial Research, Pittsburgh

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MARKET REPORT—SEPTEMBER, 1919

WHOLESALE PRICES PREVAILING IN THE NEW YORK MARKET ON SEPTEMBER 15, 1919

INORGANIC CHEMICALS

Acetate of Lime, Basis 80%.....100 Lbs.	2.00	@	2.05
Alum. ammonia, lump, U. S. P.....100 Lbs.	4.25	@	4.50
Aluminum Sulfate, (iron free) Works.....Lb.	22 1/2	@	23 1/4
Ammonium Carbonate, domestic.....Lb.	13	@	13 1/4
Ammonium Chloride, white.....Lb.	19	@	20
Aqua Ammonia, 26%, drums.....Lb.	7 1/2	@	8
Arsenic, white.....Lb.	10 1/4	@	11
Barium Chloride.....Ton	65.00	@	85.00
Barium Nitrate.....Lb.	12	@	14
Barytes, prime white.....Ton	30.00	@	35.00
Bleaching Powder, 35 per cent, Works...100 Lbs.	2.00	@	2.50
Blue Vitriol.....Lb.	8 1/4	@	9 1/4
Borax, crystals, in bags.....Lb.	8 1/4	@	10 1/4
Boric Acid, powdered crystals.....Lb.	13 1/4	@	14
Brimstone, crude, domestic.....Long Ton	28.00	@	35.00
Bromine, technical, bulk.....Lb.	75	@	
Calcium Chloride, lump, 70 to 75% fused...Ton	20.00	@	24.00
Caustic Soda, 76 per cent, in bags.....100 Lbs.	3.25	@	3.50
Chalk, light precipitated.....Lb.	nominal		
China Clay, imported.....Ton	18.00	@	23.00
Feldspar.....Ton	8.00	@	15.00
Fuller's Earth, foreign, powdered.....Ton	nominal		
Fuller's Earth, domestic.....Ton	40.00	@	30.00
Glauber's Salt, in bbls.....100 Lbs.	1.50	@	2.10
Green Vitriol, bulk.....100 Lbs.	2.00	@	2.25
Hydrochloric Acid, commercial, C. P.....Lb.	8	@	8 1/4
Iodine, resublimed.....Lb.	4.50	@	4.55
Lead Acetate, white crystals.....Lb.	14	@	15
Lead Nitrate, C. P.....Lb.	85	@	
Litharge, American.....Lb.	9 1/4	@	10
Lithium Carbonate.....Lb.	1.50	@	
Magnesium Carbonate, U. S. P.....Lb.	21	@	22
Magnetite, "Calcined".....Ton	60.00	@	65.00
Nitric Acid, 40%.....Lb.	6.00	@	6.25
Nitric Acid, 42%.....Lb.	7.25	@	7.50
Phosphoric Acid, 48/50%.....Lb.	24	@	26
Phosphorus, yellow.....Lb.	35	@	40
Plaster of Paris.....100 Lbs.	2.00	@	2.50
Potassium Bichromate.....Lb.	27	@	28
Potassium Bromide, granular.....Lb.	1.25	@	1.30
Potassium Carbonate, calcined, 80 to 85%...Lb.	nominal		
Potassium Chlorate, crystals, spot.....Lb.	20c		
Potassium Cyanide, bulk, 98-99 per cent.....Lb.	nominal		
Potassium Hydroxide, 88 to 92%.....Lb.	30	@	33
Potassium Iodide, bulk.....Lb.	3.50	@	3.60
Potassium Nitrate.....Lb.	14	@	16
Potassium Permanganate, bulk, U. S. P.....Lb.	60	@	65
Quicksilver, flask.....75 Lbs.	105.00	@	
Red Lead American, dry.....100 Lbs.	10.88	@	13.00
Salt Cake glass makers'.....Ton	15.00	@	16.00
Silver Nitrate.....Oz.	72 1/2	@	73 1/2
Snapstone, in bags.....Ton	10.00	@	12.50
Soda Ash 58%, in bags.....100 Lbs.	1.90	@	2.10
Sodium Acetate, broken lump.....Lb.	6 1/4	@	7
Sodium Bicarbonate, domestic.....100 Lbs.	2.25	@	2.50
Sodium Bichromate.....Lb.	12	@	14
Sodium Chloride.....Lb.	12	@	15
Sodium Cyanide.....Lb.	29	@	30
Sodium Fluoride, commercial.....Lb.	13	@	14
Sodium Hyposulfite.....100 Lbs.	2.60	@	3.60
Sodium Nitrate, 95 per cent, spot.....100 Lbs.	2.88	@	2.90
Sodium Silicate, liquid, 40° Bé.....Lb.	2	@	2 1/4
Sodium Sulfide, 60%, fused in bbls.....Lb.	3	@	3 1/4
Sodium Bisulfite, powdered.....Lb.	5	@	7
Strontium Nitrate.....Lb.	25	@	30
Sulfur.....100 Lbs.	3.30	@	3.50
Sulfuric Acid, chamber 66° Bé.....Ton	16.50	@	18.50
Sulfuric Acid, oleum (fuming).....Ton	24.00	@	
Talc, American, white.....Ton	18.00	@	22.00
Terra Alba, American, No. 1.....100 Lbs.	1.25	@	
Tin Bichloride, 50%.....Lb.	18	@	20
Tin Oxide.....Lb.	60	@	63
Tin Oxide.....Lb.	8 1/4	@	9 1/4
White Lead American, dry.....Lb.	18	@	20
Zinc Carbonate.....Lb.	8	@	10
Zinc Chloride, commercial.....Lb.	8	@	10

ORGANIC CHEMICALS

Acetanilid, C. P., in bbls.....Lb.	46	@	47
Acetic Acid, 56 per cent, in bbls.....100 Lbs.	5.75	@	6.00
Acetic Acid, glacial, 99 1/2%.....100 Lbs.	12.00	@	12.50
Acetone, drums.....Lb.	13 1/4	@	14
Alcohol, denatured, 180 proof.....Gal.	52	@	56

Alcohol, Ethyl, non-beverage, 190 proof....Gal.	4.70	@	4.95
Alcohol, wood, 95 per cent, refined.....Gal.	1.30	@	1.35
Amyl Acetate.....Gal.	3.75	@	3.85
Aniline Oil, drums extra.....Lb.	33	@	34
Benzoic Acid, ex-toluol.....Lb.	90	@	1.00
Benzene, pure.....Gal.	33	@	
Camphor, refined in bulk, bbls.....Lb.	12	@	15
Carbolic Acid, U. S. P., crystals, drums.....Lb.	9	@	10
Carbon Bisulfide.....Lb.	10 1/2	@	11 1/2
Carbon Tetrachloride, drums, 100 gals.....Lb.	30	@	31
Chloroform, U. S. P.....Lb.	98	@	1.00
Citric Acid, domestic, crystals.....Lb.	2.00	@	2.10
Cresosote, beechwood.....Lb.	14 1/4	@	15 1/4
Cresol, U. S. P.....Lb.	7	@	8 1/4
Dextrine, corn (carloads, bags).....Lb.	nominal		
Dextrine, imported potato.....Lb.	19	@	24
Ether, U. S. P. 1900.....Lb.	23	@	25
Formaldehyde, 40 per cent.....Lb.	19	@	20
Glycerin, dynamite, drums extra.....Lb.	24	@	
Oxalic Acid, in casks.....Lb.	2.35	@	
Pyrogallallic Acid, resublimed, bulk.....Lb.	50	@	55
Salicylic Acid, U. S. P.....Lb.	5.50	@	5.70
Starch, corn (carloads, bags) pearl.....100 Lbs.	9	@	9 1/4
Starch, potato, Japanese.....Lb.	21	@	25
Starch, rice.....Lb.	7	@	8
Starch, sago flour.....Lb.	10	@	10 1/2
Starch, wheat.....Lb.	65	@	80
Tannic Acid, commercial.....Lb.	77	@	79
Tartaric Acid, crystals.....Lb.		@	

OILS, WAXES, ETC.

Beeswax, pure, white.....Lb.	62	@	63
Black Mineral Oil, 29 gravity.....Gal.	24	@	25
Castor Oil, No. 3.....Lb.	19 1/4	@	20
Ceresin, yellow.....Lb.	14	@	15
Corn Oil, crude.....100 Lbs.	24 1/4	@	
Cottonseed Oil, crude, f. o. b. mill.....Lb.	16.00	@	16.50
Cottonseed Oil, p. s. y. Oct. option.....100 Lbs.	21.00	@	
Menhaden Oil, crude (southern).....Gal.	1.10	@	
Neat's-foot Oil, 20°.....Gal.	2.25	@	
Paraffin, crude, 118 to 120 m. p.....Lb.	7 1/4	@	
Paraffin Oil, high viscosity.....Gal.	38	@	40
Rosin, "F" Grade, 280 lbs.....Bbl.	19.50	@	
Rosin Oil, first run.....Lb.	82	@	83
Shellac, T. N.....Lb.	nominal		
Spermaceti, cake.....Lb.	31	@	33
Sperm Oil, bleached winter, 38°.....Gal.	1.95	@	1.97
Spindle Oil, No. 200.....Gal.	38	@	40
Stearic Acid, double-pressed.....Lb.	18 1/4	@	19
Tallow, acidless.....Gal.	1.65	@	
Tar Oil, distilled.....Gal.	40	@	42
Turpentine, spirits of.....Gal.	1.12 1/4	@	

METALS

Aluminum, No. 1, ingots.....Lb.	33	@	
Antimony, ordinary.....100 Lbs.	8 1/4	@	8 1/4
Bismuth, N. Y.....Lb.	nominal		
Copper, electrolytic.....Lb.	21 1/4	@	23 1/4
Copper, lake.....Lb.	22	@	24
Lead, N. Y.....Lb.	6.05	@	
Nickel, electrolytic.....Lb.	55	@	56
Platinum, refined, soft.....Oz.	110.00	@	115.00
Silver.....Oz.	1.17	@	
Tin.....Lb.	70	@	
Tungsten (Wol).....Per Unit	6.75	@	7.25
Zinc, N. Y.....100 Lbs.	7.25	@	

FERTILIZER MATERIALS

Ammonium Sulfate.....100 Lbs.	3.75	@	
Blood, dried, f. o. b. New York.....Unit	7.25	@	
Bone, 3 and 50, ground, raw.....Ton	40.00	@	
Calcium Cyanamide.....Unit of Ammonia	5.15	@	10.00
Calcium Nitrate, Norwegian.....100 Lbs.	—	@	
Castor Meal.....Unit	—	@	
Fish Scrap, domestic, dried, f. o. b. works...Unit	6.60	@	10.00
Phosphate, acid, 16 per cent.....Ton	17.75	@	18.00
Phosphate Rock, f. o. b. mine.....Ton	nominal		
Florida land pebble, 68 per cent.....Ton	nominal		
Tennessee, 78-80 per cent.....Ton	11.00	@	11.50
Potassium "muriate," basis 80 per cent.....Ton	nominal		
Pyrites, furnace size, imported.....Unit	18 1/4	@	
Tankage, high-grade, f. o. b. Chicago.....Unit	6.75	@	10.00

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CHEMICALS DIVISION, WAR INDUSTRIES BOARD

By EDWARD R. WEIDLEIN, Mellon Institute of Industrial Research, Pittsburgh, Pa

The urgent need for a large production of chemicals and the establishment of close cooperation between the Government and the American chemical industry became exigent at the time the United States entered the war. One of the first steps which was taken for the purpose of coordinating the activities of the Government and the chemical industry was the formation of the Chemicals Committee of the Council of National Defense. The organization of this Committee was carried out admirably by Mr. Bernard M. Baruch, who was in active charge of raw materials for the Advisory Commission of the Council. This Committee, which was under the chairmanship of Dr. William H. Nichols, a distinguished chemical industrialist, was constituted as follows:

Chairman: Wm. H. Nichols, General Chemical Company
Assistant to Chairman: Maj. J. T. Crabbs, U. S. Army (Retired)
Ex-Officio: Van H. Manning, Director, Bureau of Mines, C. A. Richards, Department of Commerce; Marston T. Bogert, *Chairman*, Chemistry Committee, National Research Council
Acids: E. R. Grasselli, Grasselli Chemical Company
Alkalies: J. D. Pennock, Solvay Process Company
Coal-Tar By-Products: Wm. Hamlin Childs, The Barrett Company
Electrochemicals: John J. Riker, 19 Cedar St., New York City
Fertilizers: Horace Bowker, American Agricultural Chemical Company; Chas. H. MacDowell, Armour Fertilizer Works; Chas. G. Wilson, Virginia-Carolina Chemical Company
Miscellaneous Chemicals: Edward Mallinckrodt, Mallinckrodt Chemical Company
Pyrites: A. R. Ledoux, 15 William St., New York City
Secretary: J. D. Cameron Bradley, American Agricultural Chemical Company

The Subcommittees were as follows:

Acids Subcommittee: E. R. Grasselli, *Chairman*, Henry Howard, C. Wilbur Miller, J. Goetchius, W. H. Cocke, S. B. Fleming
Coal-Tar By-Products Subcommittee: W. H. Childs, *Chairman*, J. A. Topping, H. H. S. Handy, C. J. Ramsburg, W. H. Gartlen, W. R. Addicks
Synthetic Phenol Subcommittee: H. H. Dow, W. A. Bradford, W. E. McKay
Foreign Pyrites Subcommittee: A. R. Ledoux, *Chairman*, Horace Bowker, C. F. Burroughs, Henry Howard, F. H. Nichols
Domestic Pyrites Subcommittee: Chas. H. MacDowell, *Chairman*, A. R. Ledoux, N. P. Nash, William Mills
Electrochemical Subcommittee: J. J. Riker, *Chairman*, F. J. Tone, E. D. Kingsley, F. A. Lidbury
Fertilizer Subcommittee: Horace Bowker, *Chairman*, C. F. Burroughs, Porter Fleming, W. D. Huntington, C. H. MacDowell, William Prescott, Frederick Rayfield, C. G. Wilson, A. C. Read, S. B. Fleming
Miscellaneous Chemicals Subcommittee: Edward Mallinckrodt, Jr., *Chairman*, A. G. Rosengarten, G. P. Adamson
Alkali Subcommittee: J. D. Pennock, *Chairman*, C. H. MacDowell, E. E. Arnold, T. N. Hicks
Phosphate Rock Subcommittee: C. G. Memminger, *Chairman*

The Chemicals Committee, thus organized, made its headquarters at Washington, D. C. Regular meetings were held twice a month and material assistance, mainly of an advisory nature, was rendered to the Government during the summer and fall of 1917.

In October 1917 it became evident, however, that the general committee form of operation was somewhat cumbersome and that it was desirable, because of the pressure of work and the realization of the need for a prompt decision on all chemical matters, to establish an organization having a more direct relationship to the Government. The chemical and explosives work of the Raw Materials Section of the Council of National

Defense was, during the life of the Chemicals Committee, under the immediate supervision of Mr. Leland L. Summers. In October 1917, that Section secured the services of Mr. March F. Chase, a well-known chemical engineer, who had specialized in the development of the contact process for the manufacture of sulfuric acid, and early in November Mr. Chas. H. MacDowell, a prominent chemical industrialist and expert in fertilizer technology, was given control of the handling of nitrates and general chemicals. At that time the War Industries Board was a constituent part of the Council of National Defense and the division which had charge of chemicals was designated the Chemicals and Explosives Section. In December, Dr. Marston T. Bogert, Professor of Organic Chemistry in Columbia University and a member of the National Research Council, became associated with the Section as Technical Advisor, to be followed later by Dr. Herbert R. Moody, of the College of the City of New York, and by Dr. Samuel A. Tucker, of Columbia University. The membership of the Section was increased from time to time, but it soon became clear that a much larger organization must be perfected. Mr. MacDowell was entrusted with this important work and, by resolution of the War Industries Board, was appointed Director of the Chemicals Division.

In accordance with the administrative policy adopted, the various sections of the Chemicals Division operated in close collaboration with the Conservation Division in putting into effect conservation and substitution measures, and the Director of the Chemicals Division was a member of the Conservation Division.

From the inception of the work of the Chemicals Division, close contact was also maintained with the Priorities Board, to the end that all necessary industries could be kept running at full capacity. The highest type of cooperation was secured from the various army, navy and emergency fleet organizations through their representatives on the various sections and from the ranking officers of the several war-making bodies. A cordial cooperative relationship also existed with the Allied Purchasing Commission. It was necessary, from time to time, to enforce somewhat drastic regulations on various industries, even to the point of commandeering the entire productions of certain chemicals and raw materials, but nevertheless the heartiest concurrence was obtained from the industries affected. In all these cases the necessities for action were explained to the manufacturers involved and the cooperative response was without exception unanimous. The output of a number of industries was allocated by arrangement, notable instances being sulfur and pyrite, to permit of each consuming plant being supplied with a stock sufficient to maintain its full production without hoarding. The adoption of this plan eventuated in the operation of all sulfuric acid and munitions plants at full capacity. Wood distillation products, such as wood alcohol, acetates, etc., and also toluol, carbon tetrachloride, chlorine, platinum, etc., were commandeered or handled under mandatory orders and the outputs distributed. The prices under these commandeering orders were fixed thereby, through the Army Board of Appraisers. The Price Fixing Committee functioned on certain chemicals, such as sulfuric and nitric acids, making the same prices to the public as to the Government and the Allies. On numerous important raw materials distribution was effected through cooperation with the War Trade Board and the various war service committees, on the basis of a show-down of stocks, so that the imported materials could be equitably distributed. To illustrate, ferro-alloys and tanning materials were handled in this way.

¹ This summary report—a resumé of the activities of the Division—has been prepared at the suggestion of Mr. Chas. H. MacDowell. The writer is indebted to Mr. MacDowell for the privilege of presenting to the chemical profession this account of the organization and work so ably administered by Mr. MacDowell.

STAFF MEETINGS

For the purpose of coordinating properly the manifold activities of the different sections and of the Army and Navy, staff meetings were held twice a week and at these conferences progress reports were made by those interested. These meetings proved to be of great value.

The sectional membership was constituted by the Chief and his associates and representatives from the Army, Navy, Emergency Fleet, etc. The section members held meetings whenever necessary for the purpose of studying the problems of production, and there resulted therefrom the necessary recommendations regarding production and procurement. The work of the section members was of the same general nature as that usually conducted by the Board of Directors of a great corporation.

The Director of the Chemicals Division was, as mentioned, an ex-officio member of the Conservation Division; he also held membership in the Requirements Division.

WAR SERVICE COMMITTEE

Upon the dissolution of the Chemicals Committee its work was continued by the Chemical Alliance, Incorporated, as a war service committee, and it is appropriate to state here that the Alliance rendered valuable service to the Division in many ways. Other war service committees were formed in cases where the Chemical Alliance organization did not fit in with the work of the Division sections. A splendid spirit of cooperative effort existed and this same intensive collaboration was maintained between the sections of the Chemicals Division and the various industries which were interested in the activities of the Division.

FINAL ORGANIZATION OF THE DIVISION

The ultimate organization of the Chemicals Division, which, as explained, not only handled chemicals, but also raw materials for explosives manufacture, ferro-alloys, and other technological products, follows. There is included, under each Section, a brief resumé of the defined activities thereof, abstracted from the detailed sectional reports.

CHEMICALS DIVISION

CHAS. H. MACDOWELL, *Director*, Armour Fertilizer Works, Chicago.

As Director of the Chemicals Division, Mr. MacDowell had executive supervision over the work of the constituent sections thereof as listed below; in addition, he maintained an intimate familiarity with the operations of the Army and Navy and with the war preparation and was the official representative of the War Industries Board on various government committees. Combining the highest administrative skill with a rich experience in chemical industry, Mr. MacDowell's accomplishments elicited the very highest commendation from government officials and the admiration of his associates.

Acids and Heavy Chemicals Section: A. R. BRUNKE, *Chief*, The Liquid Carbonic Company, Chicago; H. E. FIELDS, *Associate*, Wheeling Mold and Foundry Company, Wheeling, W. Va.

This Section was concerned with the manufacture and availability as regards supply of mineral acids and heavy chemicals (soda ash and other sodium salts, etc.) used in the manufacture of other chemicals. It was, of course, principally concerned throughout the war with sulfuric acid, the most important reagent employed in chemical industry. At the time of the signing of the armistice, explosives and intermediates, including phenol, nitric acid, etc., were consuming 35 per cent of the total; the fertilizer industry consumed 27.8 per cent; oil refining, 11.2 per cent; chemicals and drugs, including acid manufacture, for purposes other than explosives, as well as ammonium sulfates, 9.6 per cent; steel pickling and galvanizing, 9.1 per cent; fabrics, textiles, tanning, rubber, paper, bleaching, 1.3 per cent; paints, lithopone, dyes, glue, glycerin, alcohol, 1.3 per cent; storage batteries, metallurgical work, including silver plating, 3.8 per cent; miscellaneous and unknown, 0.9 per cent. The monthly production so distributed exceeded 400,000 tons of 100 per cent acid. Because of the importance of these primary chemical products, because of the large and urgent demand caused by increased explosives production, and because of price equality to the Government and to all private consumers, much of the Section's effort was directed toward securing such a distribution of the acid available among the many requirements as would best meet the nation's varied needs.

Alkali and Chlorine Sections: H. G. CARRELL, *Chief*, Wing and Evans, 22 William St., New York City; J. F. T.M., *Associate*, Attorney-at-Law, Berger Building, Pittsburgh; Lt. E. A. Williams, *Associate*, Starkweather & Williams Co., Providence, R. I.

The important chemical problems handled by this Section were the alkalis, caustic soda and potash, soda ash, chlorine, and chlorine compounds. Additional commodities coming under its supervision were salt, sodium sulfide, chemical lime, and carbon disulfide. The work of the Section may be briefly illustrated by referring to one of the commodities handled, namely, caustic soda. The work on that product consisted in obtaining complete statistics of production, including monthly reports, compiling direct government requirements, and obtaining estimates on the quantity of caustic soda required to fill the many indirect military needs. The industrial requirements for all important consuming industries were also obtained. Further work pertained to the curtailment of the non-war consumption of caustic soda at points and in a manner least detrimental to industry. This procedure was adopted in the case of all other commodities, both in this Section and in the others listed below. In some instances requirements were met only by the enforcement of the most drastic measures.

Artificial Dyes and Intermediates Section: J. F. SCHOELLKOPF, Jr., *Chief*,¹ Buffalo, N. Y., succeeded by V. L. KING, *Chief*, Calco Chemical Co., Newark, N. J.

Through the cooperation of this Section the manufacturers of artificial dyes and intermediates built an industry that was in operation in time to save the entire textile manufacturing business of the country from the disastrous effect of an actual dye famine. As the requirements for explosives increased, it became necessary to restrict the use of the raw materials for the manufacture of certain classes of colors, with the results that the production of some dyes was practically prohibited. During this trying period, the Section was supported and aided most patriotically by all of the dye manufacturers. Following the signing of the armistice it became possible to remove the restrictions on basic raw materials and the dye manufacturer may now obtain his full supplies of toluol, xylol, etc.

Chemical Glass and Stoneware Section; also

Asbestos and Magnesia Section: R. M. TORRENCE, *Chief*, Highland Glass Company, Chicago, Ill.

This Section had to do with the glass and stoneware used in the chemical and metallurgical industries; it also concerned itself with mineral products of the type of asbestos, magnesia, etc. Through the loyal interest of glass industrialists during the war period, glass was substituted for many metals, taking the place of zinc, brass, and steel in some of their applications. The Section assisted glass manufacturers in securing fuel, transportation facilities, batch ingredients, and priorities certificates. In this way, the plants were kept in operation and met the demand for their products. The Section rendered similar assistance to the chemical stoneware industry, which also played an active part in insuring the success of some vitally important processes by furnishing under exact demands the needed stoneware equipment. The Section conducted the customary survey, securing requirements and keeping records for the information of the other sections and government bureaus interested in these supplies.

Creosote Section. I. C. DARLING, *Chief*, Bartholomay-Darling Company, Chicago, Ill.

In addition to its ordinary uses, creosote was essential to the war program of the Government, principally in the activities of the Emergency Fleet Corporation, the Railroad Administration, and the Army and Navy in overseas work. At the close of the war, the functions of the Creosote Section were devoted entirely to directing the production of the commodity to meet the needs of the Government; this supervisory work also included prompt delivery, thus entailing considerable diversion of shipments as the programs of various departments became altered. Through the efforts of this Section, the needs of the Government for creosote were cared for without any disturbance of business.

Electrodes and Abrasives Section: CAPT. H. C. DUBOIS, *Chief*, E. J. Lavino & Co., Philadelphia, Pa.

The industries which came under the jurisdiction of this Section were those which had as their products graphite, electrodes and abrasives. The Section went very thoroughly into the question of production and ascertained what could be done to provide for a substantial increase to meet the pressing needs of the manufacturers of munitions. The Section had before it, as a result of this investigation, a complete history of both pro-

¹ Mr. Schoellkopf resigned from the War Industries Board to enter the Motor Transport Service.

duction and consumption, so that it maintained at all times a clear understanding as to the requirements of the manufacturers and could, accordingly, make most radical changes in the shipping programs of the producers to the benefit of the users. Without this Section this could never have been accomplished, for the consumers absolutely refused in the case of electrodes, perhaps the most important commodity handled by the Section, to give the makers any reliable information respecting their stock on hand and other business details. As the result of representations made by this Section, the complete cooperation of the manufacturers of graphite, electrodes, and abrasives was obtained.

Sulfur and Pyrite Section; also

Ethyl Alcohol Section: WM. G. WOOLFOLK, *Chief*, Sanderson & Porter, 72 W. Adams St., Chicago; J. R. TOWNSEND, *Associate*, Sanderson & Porter, 72 W. Adams St., Chicago; A. E. WELLS, *Associate*, Bureau of Mines, Washington, D. C.

This Section concerned itself with conserving and utilizing to the best advantage all water- and rail-shipping facilities, by using material of the highest sulfur content; conserving transportation facilities through the use of sulfur materials available at the nearest point of consumption; increasing the production of properties deemed susceptible of dependable increased output; increasing the stocks at important government and private consumers' plants before winter weather interfered with transportation; stabilizing price conditions by putting all sulfur materials on a parity; and, in cooperation with the War Trade Board, controlling exports, thus conserving the nation's stocks. In collaboration with the Chemical Alliance Committee, plans were formulated and put into operation to handle these important problems, and the execution of these plans constituted the larger part of this Section's work. The output of sulfur was adequate for all requirements at the time of the signing of the armistice; but this gave rise to rather a serious problem upon stopping the manufacture of explosives, since many acid plants required little or no brimstone, because of the presence of heavy stocks. With the cooperation of the Government, the sulfur producers, and the consumers, this Section has been enabled to take care of these stocks in a manner which, it is believed, will eliminate the danger of heavy financial losses to the holders.

Ferro-Alloys Section: H. W. SANFORD, *Chief*, Sanford-Day Iron Works, Knoxville, Tenn.; C. D. TRIPP, *Associate*, Miami Metals Co., Chicago, Ill.

This Section handled minerals of tungsten, molybdenum, vanadium, zirconium, cobalt, titanium, chromium and manganese; also ferrosilicon and monazite sand. The alloy derivatives of the elements embraced were also within the jurisdiction of the Section. The manganese problem was of the most importance because it involved larger tonnages and because the steel industry of the United States had a production of about 2600 tons of high-grade ore; through the efforts of this Section, the output of ore has been so enlarged that there are being produced from American mines about 310,000 tons of high-grade ore and about 650,000 tons of low-grade ore. It would be possible, in fact, if absolutely necessary, to produce within the bounds of the United States all of the metallic manganese needed by this country.

Industrial Gases and Gas Products Section: MAJ. J. M. MOREHEAD, *Chief*, Rye, N. Y., People's Gas Co., Chicago, and Consulting Engineer, Union Carbide & Carbon Corporation.

This Section handled the following commodities: acetylene, carbolic acid, anhydrous ammonia, aqua ammonia, ammonium chloride, asphaltum, benzol, calcium carbide, carbonic acid gas, cyanamide, hydrogen, naphthalene, nitrogen, oxygen, rare gases, saccharin, solvent naphtha, toluol, and xylol. All of these chemical products entered to a greater or less extent into the military program, although the activities of the Section were confined principally to acetylene and calcium carbide, oxygen, saccharin, and toluol. The production of industrial gases and gas products was stimulated and increased to an enormous extent through the efforts of this Section.

Mica Section: C. K. LEITH, *Chief*, University of Wisconsin, Madison, Wis.

Upon the establishment of the Mica Section, the industry was in a chaotic condition, caused largely by the attempt on the part of certain consumers to beat the market, by the threatened shortage of supplies from abroad, and by the lack of information regarding requirements and specifications. A careful analysis of the situation showed that the shortage was not so acute as had been anticipated and that price regulation and close attention to future supplies of high-grade material were necessary. Results of value were obtained in consequence of the Section's

investigations, and the confidence and support of the producers were secured. A clear understanding of the domestic situation made possible definite conclusions as to the extent to which the material could be counted on to fill our war demands.

Miscellaneous Chemicals Section: A. G. ROSENGARTEN, *Chief*, Powers-Weightman-Rosengarten Co., Philadelphia.

This Section had charge of the miscellaneous inorganic and organic products not included in any of the other Sections, and also pyrotechnics. It was in close cooperation with the Technical and Consulting Staff of the Division and a large number of the commodities found falling within the scope of this Section were in charge of the Staff. The Section Chief was also a member of the Section of Medical Industry and attended all of the commodity and other meetings held by that Section.

Nitrate Section: CHAS. H. MACDOWELL, *Armour Fertilizer Works*, Chicago, Ill.; J. A. BECKER, *Associate*, *Armour Fertilizer Works*, Chicago, Ill.; H. RAY PAIGE, *Associate*, *H. Ray Paige & Co.*, New York City.

The principal functions of this Section were to arrange for keeping the Nitrate Executive, London, England, advised as to the general nitrate of soda conditions in the United States, such as requirements, shipments, stocks on hand, consumption, etc.; assigning vessels, allocated by the Shipping Control Committee, to the importers, based on their requirements of nitrate of soda for Army, Navy, and private uses; controlling the importation and distribution to consumers of nitrate in the United States; exercising control of the prices at which nitrate was sold to the consumer in the United States, viz., at the pool prices plus percentage of remuneration to the importers for handling; keeping the consumers of nitrate for the military program supplied with stock to prevent any shut-down or curtailment of production; assisting the United States exporters to secure promptly export licenses for coal, machinery, and other supplies for nitrate producers and railroads in Chile transporting nitrate; and assisting American exporters in securing priority certificates for machinery, railway supplies, etc., for the nitrate producers in Chile, as well as the railroads engaged in the transportation of nitrate to Chile. The Section reported stocks on hand, consumption for the preceding month, and estimated consumption for the ensuing month, which survey was compiled the first of each month.

Paint and Pigment Section: RUSSELL S. HUBBARD,¹ *Chief*, Philadelphia, Pa., deceased, succeeded by L. R. ATWOOD, *Chief*, Peaslee-Gaubert Co., Louisville, Ky.; J. E. PATTON, *Associate*, Pittsburgh Plate Glass Co., Pittsburgh; D. E. MAPOTHER, *Associate*, Real Estate, Louisville, Ky.

This Section had under control paints, varnishes, and the various raw materials entering into their manufacture. In general, the paint and varnish manufacturing capacity of the country was in excess of all requirements for war needs and industrial and civilian uses. But little shortage of raw material developed and where such shortage did occur it was due to the cutting-off or shutting-down of the importation of certain raw materials. Notwithstanding the difficulties thus encountered, the paint and varnish industry was able to supply promptly all needs and still leave a considerable quantity of its productive capacity unemployed. It is of interest to mention here that, on the suggestion of the Conservation Section, the Paint and Pigment Section took up with the manufacturers of paint and varnish a plan for the conservation of tin—by the elimination of certain sizes of cans, by the reduction of the number of colors, etc. The suggestions of this Section received the cheerful acquiescence of the manufacturers and the supervision of the operation of the plan was conducted by the Section. Suggestions for the conservation of various pigments and siccativ oils were also made by the Section to various government buying agencies.

Platinum Section; also

Wood Chemicals Section: C. H. CONNOR, *Chief*, Kissel, Kinnicut & Co., New York City; R. H. CARLTON, *Associate*, Blodgett & Co., New York City; C. E. DENIKE, *Associate*, Graves, Maulbert, George & Co., New York City; A. H. SMITH, *Associate*, W. S. Gray & Co., New York City.

As the result of the efforts of the War Industries Board, Chemicals Division, and the Equipment Division of the Signal Corps, wood chemicals (including acetate of lime, acetone, ketone, crude wood alcohol, and refined wood alcohol) were covered by a requisition and order dated December 24, 1917, signed by the Secretary of War. By the requisition and order, delivery of said supplies was to be made as directed by the War Industries Board. The requisition and order covering the plants producing wood chemicals was decided upon in order to avoid

¹ Mr. Hubbard took up the work knowing he was in ill health. He made the supreme sacrifice, as a result, in Atlantic City in October.

the dissipation of stocks in their hands and because of the vital importance of the same to the Signal Corps for the manufacture of cellulose acetate and other products and also to the Allies. On account of the large requirements of the Allies and our own Government, it was found necessary to restrict the use of acetate of lime in all industries where this was possible without seriously affecting them; as the result of these restrictions, 87 per cent of the acetate of lime produced went to the Allies and our own Government, the industry receiving only 13 per cent. The various trades and industries using acetic acid, which was produced from acetate of lime, were classified and placed on a basis where they were entitled to a certain percentage of their normal acetic acid requirements. Inventories were submitted every month from all manufacturers operating under the commandeering order and shipments were made of such quantities only of their products as were approved by the Wood Chemicals Section.

In July 1917 the War Industries Board, through the Chemicals Division, realizing the vital importance of platinum in the conduct of modern warfare, had taken the first steps toward conserving the supply through an order issued by the Secretary of the Treasury, withholding all platinum which passed into the United States mints. Mr. L. L. Summers did a large amount of preliminary work towards conserving the supply and in the fall of 1917, through his foresight, a large shipment of platinum from Russia was obtained for the United States Government at a favorable price. Early in March 1918 Mr. C. H. Connor was placed in charge of the Platinum Section. Mr. Connor ascertained through the various military departments what their requirements would be and also obtained accurate knowledge of the amounts of platinum required by the essential industries. He so administered this Section that all demands of an essential nature were met by the proper distribution of the supply. It is no exaggeration to state that without an adequate supply of platinum the winning of the war would have been vitally affected.

Refractories and Native Products Section: CHARLES CATLEY, Chief, Examiner of Mineral Properties, Staunton, Va.

The Refractories Section covered all those materials whose primary function is to withstand high temperatures. These materials include fire-clay brick and shapes, loose silica or ganister, dead-burned magnesite and dolomite, as well as brick made from the same, chrome ore, chrome brick, and special fire-resisting material made from bauxite, alundum, zirconia, and other special refractories. The Section also covered fluxes of all sorts, quicklime, fluorspar, fuller's earth, infusorial earth, bauxite, and the raw materials, mainly clays, quartz, and feldspar, used in the ceramic industry. It was disclosed that the great refractories industry was capable of meeting the calls upon it, providing it was properly protected in the way of classification on the preference list. Since any shortage in refractory material would immediately show itself in the reduction of the steel and coke output, intimate relations were established which resulted in the assurance of supplies of essential products.

Tanning Materials and Natural Dyes Section: E. J. HALEY, Chief, Haley-Hammond Co., New York City; E. A. PROSSER, Associate, Borne-Scrymser Co., New York City; H. G. WOOD, Associate, U. S. Forest Service, Washington, D. C.

The Tanning Materials Section was organized for the purpose of procuring and distributing tanning materials for the production of leather and leather goods required for governmental usage in the conduct of the war. The problem that presented itself at the inception of the Section's work was to secure the necessary quantities of tanning materials to carry out the government program on leather. A careful survey of the domestic production clearly indicated that very large quantities of imported materials must be immediately procured in order to assure the proper quality and quantity of leather set forth in the Government's requirements. The attention of the Section was especially directed to raw tanning materials and during the period of the war the American tanning industry was kept supplied with adequate quantities of imported commodities. It did not become necessary during the period of the functioning of this Section to establish maximum prices on any tanning materials, either imported or domestic. Moreover, the hearty cooperation and patriotic spirit governing the importers and manufacturers of tanning materials made it unnecessary for the Section to take drastic means to prevent profiteering.

In addition to the handling of vegetable tanning materials this Section also had charge of the distribution of mineral tanning materials, of which the principal one was chrome in its various commercial forms. It also attended to the supply of dyewood extracts, required in meeting the Government's demands for cloth for uniforms. Allocation of dyewoods was made and the Section had the constant cooperation of the Dyewood Extract Manufacturers' Committee.

Technical and Consulting Staff: DR. H. R. MOODY, College of the City of New York; E. R. WEIDLEIN, Mellon Institute of Industrial Research, Pittsburgh, Pa.; DR. T. P. MCCUTCHEON, University of Pennsylvania, Philadelphia; DR. H. F. STALEY (on ceramics), Bureau of Standards, Washington, D. C.; R. L. WOOD (Executive Assistant), Richard L. Wood Co., Buffalo, N. Y.; W. A. BARSH (Secretary to the Director), Armour Fertilizer Works, Chicago, Ill.

Widely varied material came before the Technical Consulting Section for consideration. In addition, this Section maintained close contact with the other Sections of the Division and with the various industries concerned, and it rendered service of prime importance in the investigation and solution of the numerous problems of procurement, production, and substitution.

It was for the handling of substances not previously considered to be "commodities" that the Technical Section was organized. From its inception this Section was composed of an "associate" staff. Dr. Marston T. Bogert first came, then Prof. Herbert R. Moody and Prof. Samuel A. Tucker, and finally Mr. E. R. Weidlein, Acting Director of the Mellon Institute of Industrial Research. When Dr. Bogert joined the Chemical Warfare Service, Professors Moody and Tucker were in regular charge, with the cooperation of Mr. Weidlein, partly in Washington but largely at the Mellon Institute at Pittsburgh. Professor Tucker was then commissioned in the Chemical Warfare Service and he was succeeded by Prof. Thos. P. McCutcheon, of the University of Pennsylvania. Closely associated with the Technical Section was the Fine Chemicals Section, the chief of which, Mr. A. G. Rosengarten, worked in intimate cooperation with the Technical Section. It is, in fact, difficult to discriminate between the lines of activity of each associate in the staffs of the Technical and Fine Chemicals Sections. The Technical Section maintained constant collaborative relationships with representatives of the Army, Navy, Emergency Fleet, etc.

Because of its widely varied activities, it is extremely difficult to summarize the work of the Technical Section or even to enumerate the many subjects investigated; the staff of this Section covered all industries and practically every phase of chemical endeavor, in addition to serving in an advisory or consultative capacity to the other sections of the Division and to the various bureaus of the Army, Navy, and Emergency Fleet. It may be stated, however, that the principal duties of the Technical Staff consisted in aiding chemical industrialists in overcoming the difficulties in manufacture due to the unusual economic conditions. The staff constantly encouraged, wherever advisable, the manufacture of substitutes and was effective in bringing together the chemical producer and user.

Joint Office on Chemical Statistics: CAPT. W. B. RICE, Army Representative, Associate Attorney, Duell, Warfield and Duell, New York City (transferred to Statistical Division, General Staff, October 25, 1918); ARTHUR P. MINNICK, W. I. B. Representative, U. S. Patent Office, Washington, D. C.; LT. R. P. DUNNING, Navy Representative, legal work in connection with engineering, Springfield, Mass.

One of the earliest and most important steps taken by the Division was the coordination of chemical information: this eventuated in the establishment of the Joint Office on Chemical Statistics. During 1917 and early in 1918 real annoyance to manufacturers was occasioned by the multiplicity of duplicate questionnaires originating in many departments of the Government, presenting intimate questions as to capacity, output, equipment, etc. To relieve the chemicals and explosives manufacturers of this embarrassment of interrogations and to standardize and simplify reports deemed necessary, the Chemicals and Explosives Section formed, with the War and Navy Departments, the Joint Office on Chemical Statistics. This Office was in the Chemicals Division. It received reports at regular intervals of production at manufacturing plants, capacities, needs for raw materials, and other essential data, and compiled monthly reports of the activities of the preceding month on different commodities as they related to war and civilian needs. Monthly graphs were prepared showing present and future plant capacities and actual performance against these capacities. Raw materials used in the manufacture of finished products were translated into percentage yields so that plant efficiencies could be checked. This Office eliminated many duplications in reports and did exceptionally good work in translating the figures received and in promptly preparing its reports.

THE MELLON INSTITUTE OF INDUSTRIAL RESEARCH

The research facilities of the Mellon Institute of Industrial Research, Pittsburgh, Pa., were at the disposal of the Division

and the industries handled by it. This relationship was established by the writer, then Acting Director of the Mellon Institute, who, as mentioned, served as a member of the Technical and Consulting Staff of the Division. The Mellon Institute through its Industrial Fellowship System is in close touch with industry in general and, as the result of this, possesses an immense storehouse of information on science and technology; all of this information, through the patriotic spirit of the donors of the Industrial Fellowships in operation, was made available to the Government. A number of important researches were carried out at the Institute under the auspices of the Division

and results were obtained which were of direct value to the Government during the crisis.

In addition to the Mellon Institute, several other industrial research laboratories extended cooperation and rendered material service to the Division.

THE CONCLUSION OF THE DIVISION'S WORK

The conclusion of the armistice upon November 11, 1918, caused the abrupt cessation of all new work of the Chemicals Division, and by January 1, 1919, the activities of the Division were practically completed and its affairs liquidated.

U. S. CHEMICAL PLANT FOR MANUFACTURING SODIUM CYANIDE, SALTVILLE, VIRGINIA¹

By CHAS. O. BROWN, Major, Ordnance Department, U. S. A.

Received July 25, 1919

The Bureau of Mines, in the early part of 1917, was the first to realize the importance to the War Department of an extensive chemical organization with adequate facilities for developing those materials necessary to the warfare program of the Army and Navy. Particularly, the toxic gas program needed far-reaching investigation, development, and production of large proportions. During this work it became apparent that sodium cyanide would be a necessity as a constituent in one or more of the toxic materials desired. Study of the classification of all raw materials in the country showed that sodium cyanide should, if possible, be produced by a nitrogen fixation method rather than by the sodamide-ammonia process. The destruction of ammonia to furnish the combined nitrogen was to be avoided by all means. This directed attention to the Bucher process for the production of sodium cyanide from soda ash, coke, and atmospheric nitrogen by the use of iron as a catalyst. This process was being developed by the Nitrogen Products Company, Providence, Rhode Island, and seemed to possess sufficient merit to justify the interest of the War Department.

In the latter part of December 1917, the War Department, acting on the recommendation of the Secretaries of War, Navy, Agriculture and Interior, requested the Bureau of Mines to develop a plant for producing 5 tons of sodium cyanide per day along the lines of the process of the Nitrogen Products Company. Owing to the progress of gas warfare, after the design was well along, the plant was increased to 10 tons per day. By special good fortune, the Bureau of Mines was able immediately to place this work under the direction of its chief chemist, Dr. Charles L. Parsons. An office was opened in the new Interior Building, with Dr. Parsons in charge of the project, and Major Chas. O. Brown, Ordnance Department, U. S. A., as commanding officer. Competent engineers, Capt. N. E. Holt, C. W. Marsh and others, were secured by the Bureau and immediately commenced the actual design.

The policy adopted in designing the plant was to adhere as closely as possible to the demonstrated design used by the Nitrogen Products Company. The equipment of this company, however, was not fully developed, and it was necessary to try to add such improvements as would insure and safeguard the success of a project of this size. A good deal of experimental work was done in a rapid but efficient manner during the design of the plant, to give the engineers the data necessary for some of the more radical decisions and changes. A complete unit with a horizontally tipped rotating retort for making cyanide was set up to determine if the stationary, vertical retort formerly used in this work should be abandoned. This work indicated

several slight advantages over the stationary retort, but the advantages were not so positive as to justify its use. The data on the stationary retort were quite extensive, and it seemed apparent that it would function in at least an acceptable manner. All suggestions for improvements in both design and methods of operation were carefully considered and will be described here as they come up, without special mention. A great deal of credit is due the consulting engineers, who rendered opinions on this phase of the work.

Before the design of the entire plant was completely finished the contract for construction was assigned to the Fraser-Brace Company of New York, who handled the work under the supervision of the Construction Division of the Army. Dr. Parsons was in active charge of the entire project until after its completion. After the more important parts of the design were finished, several of the engineering chemists in the Washington office assisted in the field to complete construction work.

As early as April 1, 1918, plans were made to secure the personnel to operate the plant. The reaction for producing cyanide is primarily a difficult one, and the undeveloped state of the art required that a maximum amount of care be used in selecting a personnel that would insure success. By good chance, unusual means were at the disposal of the Bureau of Mines for locating and obtaining chemists of the Junior Grade, and the War Department cooperated in placing these men in the organization at Saltville. A school for their systematic training and development was opened up, in charge of Lt. B. V. Reeves, under Capt. Norman E. Holt, who was then in charge of the field work in Saltville. This school was equipped in some cases with an actual unit of plant equipment and in other cases the equipment of the Nitrogen Product Company was utilized. The product worked upon in this training was supplied by the Company's experimental plant. As a result of this training, which was participated in by both officers and enlisted men, a nucleus of five officers and seventy-eight enlisted men was developed for the permanent organization. When the plant was ready for operation, a complete organization was ready, from guards to cost accountants, quartermaster to electrical engineer, firemen to shoemakers. The Post had a typical Post organization, modified sufficiently to allow the plant work, which was purely technical, to be conducted in three shifts of eight hours each.

The Post comprises approximately forty acres. The plant or process buildings are of substantial steel and concrete construction. The other eighty-odd buildings on the Post are semi-permanent wooden frame buildings. A filtration plant provides clear and sterile water for drinking and all domestic purposes. The larger bulk of water used in the process, as jacket water and condenser water, is settled to some extent by a reservoir back of a dam in the river, constructed to house the

¹ A part of the war program carried out under the direction of the Bureau of Mines. Published by permission of the Chief of Ordnance, U. S. A.



Withrow, Bristol, Va., Photographer

intakes for the water system. A boiler plant provides 1200 boiler horse power, furnishing steam for process requirements and steam to generate electric power sufficient to carry the entire plant load. The turbine room is equipped with three direct-connected turbo-generators. It was fortunate this provision was made because, owing to a burn-out in the high voltage transformers of the substation, the power plant of the Post was obliged to carry the plant load and furnish current for general uses for the entire period of Post activities.

The process is divided into three stages: (1) The mechanical preparation of the material treated in the retorts; (2) the treating of the briquetted soda ash-iron-coke mixture with nitrogen at 1000°C .; (3) the extracting of the cyanide as sodium cyanide from the cyanized briquettes produced in the preceding stage of the process. The barren briquettes, after recovery of the cyanide, are returned to the mechanical preparation building where they are reground, brought back to their original composition, and remade.

The mechanical preparation building was two stories high with a monitor permitting the installation of vertical dryers 55 ft. high. In this building the raw coke was crushed to pea size, fed to the tube mills (where it was mixed with a small amount of finely powdered iron) for further grinding in intimate mixture until both materials passed at least 150 to 200 mesh. The larger proportion of this mixture passed through 200 mesh and was conveyed to storage. From storage, a certain amount of this iron-coke material, with the proper percentage of soda ash, was dry mixed and then elevated to wet mixers for kneading into a doughy plastic mass, and the material extruded as briquettes while still hot. The briquettes were then dried by the exit flue gases from the retort furnaces.

In the retort department, in which the second stage of the process was carried out, there were 144 separate units consolidated into 8 banks of 18 units each. Two Morgan gas producers, located very close to the furnaces, supplied the fuel used. One main flue ran through the center of the retort building, a length of 180 ft. Four banks of furnaces were grouped on each side of, and drew gas from, this central flue. The retort furnaces were radically different in design and arrangement from any furnaces previously used, having been extensively modified with the object of increasing the life of the iron retorts used in the furnaces. The replacement of iron retorts had formerly been a source of heavy expense, each retort lasting only from 7 to 12 days. This objection was also met in another way, *viz.*, by the use of nichrome retorts. Much effort was devoted to those furnaces equipped with nichrome retorts, so that the actual increase in the life of iron retorts brought about by

this special furnace is uncertain. While no iron retorts actually failed in service, owing to the frequency of uncontrollable factors necessitating shut-downs for other reasons, indications pointed to a useful life of 11 to 14 days per retort in these furnaces. Convenient labor-saving devices were installed throughout the building for handling the feed to the retorts and disposing of the cyanized briquettes. After coming through the retorts, the briquettes passed through the feeder into a cooling can where the cold nitrogen was entered. The nitrogen passed up through the material in this cooling can into the retort where combination with the briquettes was effected. The carbon monoxide burned at the top of the retorts as in previous practice, no effort being made to utilize this heat beyond its usefulness as a pilot to indicate the behavior of the tube. Each furnace was separate in the bank, having an individual burner control apparatus, but one retort tube, an individual pyrometer and damper controlling the exit gas passage into a flue common to the entire bank of 18 furnaces. The pyrometers registering the heat conditions of the retorts were grouped in sets of nine and connected to an automatic recording instrument for permanent record. Accurate temperature control was very important to the successful operation of the retort. When a retort burned out the gas was cut off from the furnace and the work of putting in a new retort commenced. This work was completed with as little delay as possible to prevent the cooling-off of the furnace, but this depended on the nature of the break in the retort and the success attending the pulling of the retort from the furnace. It happened sometimes that a retort could be replaced by three men in four hours, while in other cases a day would be necessary to complete the job. Facilities for this work were developed by the engineer officers and the changing of retorts in this plant became a much smaller drawback.

In the recovery building in which the third stage of the process took place, the briquettes were dumped from an overhead mono-rail system into the leaching apparatus. Each unit of the lixiviating equipment held 1000 lbs. of cyanized briquettes, and when loaded the apparatus was closed and evacuated until all the entrained air possible of removal had been pumped out. The leaching of the cyanide was next accomplished by a process developed by the Nitrogen Products Company, using liquid anhydrous ammonia, which was pumped through the briquettes in three units on the countercurrent principle to extract the cyanide, while leaving the briquette structure substantially unimpaired. This permits complete extraction. On account of the vapor pressure of liquid ammonia, the entire system had to withstand 250 to 300 lbs. pressure. The ammonia saturated with cyanide passed into a header common to twelve units,

and from this header was distributed to anyone of six evaporators. The evaporators were steel, steam-jacketed cylinders placed horizontally and individually equipped with motor-driven agitators and extruders. The cyanide was thus produced in a powdered form and discharged mechanically, when dry, directly into the final shipping container. This procedure saved the workmen a great deal of handling and exposure to danger. The control of this entire operation just described lies in the evaporator and the steam jackets on both lixiviators and evaporators. When a lixiviator full of saturated ammonia was obtained, the first lixiviator of the three, now stripped of sodium cyanide, was cut out of the cycle, and the ammonia in it driven into the second unit by entering steam in the jacket. The surplus ammonia was driven out completely by the following procedure: The saturated ammonia solution was sent to an evaporator, heated by the steam jacket, and the rate of flow of the solution into the evaporator so regulated that the evaporated ammonia leaving the evaporator had accumulated several degrees of super heat, which was used by passing it up through the first lixiviator, in direct contact with the ammonia-wet briquettes, evaporating this entrained ammonia and leaving practically ammonia-free, cyanide-free material. The ammonia atmosphere remaining in the lixiviator was drawn out by passing air through the apparatus and then treatment of the air by scrubbing with water. The cyanide produced in the evaporator was stirred and heated until all ammonia was expelled and a vacuum would hold on the unit in question for five minutes. Then cooling water in the jacket reduced the temperature of the cyanide so that it could be packed. The leached briquettes were returned for use. This department was the most complex and received the largest amount of development by the chemical engineers. In spite of the many and grave uncertainties of this recovery, the equipment worked well, and costs and ammonia losses were much less than expected. Experience showed that 1 lb. of ammonia was lost mechanically for 50 lbs. of cyanide produced. The ammonia solution made in the scrubber was recovered and returned to the anhydrous ammonia storage. There were two 10-ton capacity refrigerating machines in the equipment but the most of the ammonia recovery was done by the absorption system. The design of all the equipment in this department was largely the work of the staff but especially was this true of the evaporators. They received considerable experimental attention before closing the design and in operation succeeded beautifully in producing powdered cyanide. The design of this evaporator, however, is open to still further improvement, as is also the case with the retort furnaces, but unquestionably this equipment offers an advance in the technique of the art.

The nitrogen for this process was obtained by the Claude process from the atmosphere. The nitrogen building contained two complete caustic scrubbers and compressors, either compressor, or both, supplying any one or more of the three Claude towers installed. This equipment made a consistent, uniform record for performance and produced pure, dry nitrogen with remarkable reliability. The method of analysis for nitrogen, to detect impurities of 0.01 per cent (not considering argon and other rare gases), was quite difficult and had to be executed with care, but by developing a special self-contained apparatus embodying all precautions for conditioning the gas sample, it was felt by the Research Director that reliance could be placed on the reported analyses, giving 99.99 per cent and 100 per cent as the usual purity of the nitrogen. The nitrogen columns proper functioned excellently, running as high as 45 days without trouble or deriming.

Owing to the happy termination of hostilities only a few days after the plant was ready to start operation, no attempt was made at capacity production. For the purpose of making justifiable reports on the equipment and securing such data as was possible regarding costs and defects in the plant as a whole,

one bank of furnaces, with an equivalent amount of equipment in the other departments, was operated. In general, the plant is well balanced, one department fitting very closely to other departments as to capacity and smoothness of operation. Development on this process, however, has never stopped, and will not stop with this plant, so that the flow sheet in a given department to-day may be warped and out of balance to-morrow.

During the short time of operating, many troubles were remedied and such cost data and technical data secured as was possible. In the mechanical preparation of the briquettes most of the troubles were of a minor sort and their correction easy. It was proposed to make up the carbon used in the process with a special pitch coke which contained practically no ash. It was desired to use the briquettes over and over again and this coke would permit such a practice, as the ash in the briquettes would not accumulate. But it was appreciated for the first time that some ash, 3 to 5 per cent, was beneficial to the porosity and hardness of the briquettes and that the original stock should be made from petroleum or foundry coke and then the accumulation of higher percentages of ash prevented by using pitch coke as a "make up" material. The briquettes were loaded on metal trays for drying, each tray containing about 60 lbs. of dried stock. This practice should be abandoned and a continuous conveyor dryer used. The up-keep and handling of the trays is prohibitive.

In the retort department several operating problems presented themselves and some serious defects in the design. The principle of the retort tube is bad from an engineering standpoint because it will not permit of reasonable sized units. The furnace equipment will accommodate only one retort, the troubles in feeding the material are uncertain and hard to correct, in the limited space of the retort, and finally there is too much investment per furnace for the amount of material produced per unit. These comments, of course, must not be considered as having any bearing on the work of the Bureau of Mines for the reason that the limitations of this type of furnace were well known to the engineers on starting the work. But there was no time to develop another type of furnace, although one profitable and quite extensive experiment was carried out during the early stage of the design. The fuel required for a retort amounted to over 70 lbs. of coal, as producer gas, per hour. Recommendations now on file, changing the furnaces still more, would reduce this to approximately 40 lbs. of coal on the same basis, but when it is possible to produce only 7.5 lbs. of cyanide during this hour, this cannot be considered economical heating. The cost of retorts per pound of cyanide is nearly 1.9 cents when using iron, and apparently nearly as much when using nichrome, although the true possibilities of cast nichrome are not unquestionably settled.

The hardness of the briquettes is an important point, because when dust-free (dust and fines are produced mostly by handling) the extraction is much easier and the mechanical ammonia loss much less. Experiments to control this factor resulted in an economical and most efficient binder, sodium aluminate; but unfortunately this material, even in the small amounts used, caused serious feeding difficulties. This was further shown when using a special retort that had been "calorized," a process impregnating the metal surface with aluminum. In this case continual feeding trouble was encountered. There was a shrinkage of the material during treatment in the retort of about 22 per cent. This was due to a change in specific volume and also in specific gravity of the material. The concentrations of sodium cyanide produced varied, but averaged 20 per cent. The amount of shrinkage of the briquettes altered this concentration figure. As high as 30 per cent sodium cyanide has been made, but when the original proportion of soda ash is sufficient to produce this concentration of cyanide, the briquettes are extremely hard to handle. It is also doubtful if actual economy, either in the

broad sense or from the standpoint of increased production alone, results from developing more than 20 per cent sodium cyanide.

In the recovery department the difficulties were largely mechanical and quite unimportant. The purity of the sodium cyanide produced averages 92 per cent but it is practically free from alkali, iron, and insoluble matter, the main impurity being cyanates. After the first lot produced, the material was nearly pure white, needing no purification before marketing.

COST PER POUND SODIUM CYANIDE

	Raw Materials Cents	All Other Charges Cents
Mechanical Preparation.....	2.32	3.41
Retort Department.....	2.39	8.85
Recovery Department.....	0.75	2.83
Laboratory.....		0.23
TOTALS.....	5.46	15.32
		5.46

GRAND TOTAL..... 20.78

ANALYSIS OF COST IN TERMS OF THE WORK PERFORMED

ITEM	Cost per Pound of NaCN	Per cent of Total Cost
Raw Materials.....	7.4982	37.30
Power.....	1.5986	7.95
Steam (not used as power)....	0.3038	1.51
Direct Labor.....	4.5410	22.59
Indirect Labor.....	0.4025	2.00
Retort Tubes.....	1.9300	9.60
Repairs.....	0.822	4.10
Depreciation.....	1.1800	5.87
Contingencies (10 per cent) ..	1.8260	9.08
TOTALS.....	20.1021	100.00

The cost of making cyanide, applied exclusively to this plant as operated with its military personnel and post organization, was roughly 20 cents per lb., calculated in the usual standard manner of cost accounting to include all charges except royalties and profits. This figure, however, would have no particular significance as to the cost of making cyanide at this plant if costs were reduced to a reasonable basis by virtue of constant operation at capacity. The nitrogen produced by the Claude process at about 25 cents per thousand cubic feet could be positively reduced to about 10 cents per thousand cubic feet if the capacity of the plant were required. The preceding brief tables show the cost in cents per pound of 100 per cent sodium cyanide by departments.

These two results are not derived from the same data but are independent observations and while disagreeing slightly, are still a notable check on 20 to 21 cents as the cost per pound.

At the conclusion of the project as far as described above the Bureau of Mines turned the property over to the Ordnance Department as originally planned. The personnel were released and steps taken to salvage the plant. The Bureau of Mines deserves great credit for efficient clean-cut handling of the project.

NITRATE DIVISION
ORDNANCE DEPARTMENT
WASHINGTON, D. C.

CONTRIBUTIONS FROM THE CHEMICAL WARFARE SERVICE, U. S. A.

A NEW ABSORBENT FOR AMMONIA RESPIRATORS¹

By G. ST. J. FERROTT, MAX VABLICK AND A. C. FIELDNER

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Protection from ammonia gas is needed by workmen in industries where refrigerating plants are used. Leaks often occur which develop concentrations of ammonia as high as 2 per cent. Protection against concentrations as high as 5 per cent is probably desirable, although this concentration can be endured only for a few minutes, due to the irritating effect of the gas on the skin. Loss of much time is avoided if workmen are provided with respirators which will enable them to make repairs in safety at any bearable concentration and at any degree of exertion.

Previously, protection from ammonia has been obtained by filtering the inhaled air through pumice stone impregnated with sulfuric acid. This absorbent has the disadvantages that at high concentrations and breathing rates (1) a great deal of heat is evolved, making the effluent air too hot to be breathed unless a cooling device is installed, said cooling device taking up practically as much volume as the absorbing material, (2) caustic fumes are produced which must be filtered out with a cotton or felt pad which increases the resistance to breathing, (3) the resistance, initially high, increases during absorption and becomes unbearable before the absorbent is exhausted, and (4) a specially designed canister to resist corrosion by the acid must be employed.

USE OF SALTS FORMING METAL-AMMONIA COMPOUNDS

We have found that certain salts which unite with ammonia to form metal-ammonia compounds provide

ideal absorbents for use in an ammonia respirator. These salts have great activity and capacity, the heat effect during absorption is negligible, no fumes are produced, the resistance increases very little during absorption, and no specially designed container is necessary. Among the best known of the metal-ammonia compounds are those containing trivalent cobalt, chromium, iridium, and rhodium, and divalent copper and zinc. Salts of iron, magnesium, strontium, barium, mercury, cadmium, calcium, and some other metals form similar compounds. Where anhydrous ammonia acts on the anhydrous salt, a compound of the general formula $MX_n(NH_3)_m$ is formed. When ammonia gas is passed over a salt hydrate a compound of the general formula $MX_n(NH_3)_{(m-x)} \cdot xH_2O$ may be formed, although in many cases it is probable that a mixture of basic salt, ammonium salt, and metal-ammonia salt is formed. Some of the metal-ammonia compounds have a considerable decomposition pressure of ammonia at room temperature and are not formed at all at the concentrations of ammonia in which we are interested; several others are stable at room temperature.

METHOD OF IMPREGNATING PUMICE STONE WITH THE SALT

In determining which of a number of salts was most efficient for our purpose, the following procedure was carried out:

Pumice stone, 8 to 14 mesh, was impregnated with about 70 per cent of its weight of salt. In carrying out the impregnation, pumice is mixed with salt in the ratio 60 per cent pumice by weight to 40 per cent salt and the whole covered with water. The solution is then boiled down with constant stirring until the salt has crystallized on the pumice and is almost dry. The

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material is then spread out and allowed to dry in the air, after which the fines are screened out on a 14 mesh sieve. This procedure gives us the salt in very fine crystals which have been found to be more active than larger crystals. The pumice base prevents increase of resistance during service due to the salt dissolving in the water evolved.

COMPARISON OF EFFICIENCY OF VARIOUS ABSORBENTS

The various absorbents were tested for efficiency in small scale tube tests. A 5 per cent ammonia-air mixture, dried over fused caustic, was passed through 5 in. of the material contained in a tube 1 in. in diameter, at a rate of 3 liters per min. Presence of ammonia in the effluent air was detected by smell. In this way the several salts were very quickly rated in order of efficiency. In order to get a rough idea of the capacity of the absorbent, the ammonia mixture was run through the absorbent for 30 min. to 1 hr. after the first trace of ammonia was detected in the effluent air, and the change in weight of the absorbent tube and the tube containing fused caustic noted. Obviously the algebraic sum of the gain in weight of the two tubes is equal to the amount of ammonia absorbed. In many cases it will be noticed that the salts lost slightly in weight, as is to be expected where ammonia is displacing water. With a few salts a slight gain in weight is noticed, due probably to the fact that all the water evolved had not been carried over into the caustic tube. The silica gel absorbs the ammonia with practically no evolution of water.

TABLE I.—TUBE TESTS COMPARING EFFICIENCY OF VARIOUS MATERIALS AS ABSORBENTS FOR AMMONIA

ABSORBENT	Initial Weight, Grams	Gain in Weight, Grams	Gain in Weight of NaOH Tube, Grams	Weight NH ₃ Absorbed, Grams	Wt. NH ₃ Absorbed		Time, hr. Qualitative	
					Wt. Absorbent	Wt. Salt	Test, Min.	Time, Run, Before Weighing, Min.
CoCl ₂ ·6H ₂ O	40.51	+0.04	4.01	4.05	10.0	25.0	12	75
CuSO ₄ ·5H ₂ O	39.47	+0.57	3.80	3.23	8.2	20.1	10	75
	39.12	+0.89	3.47	2.58	6.6	16.5	9	0
Silica gel	44.60	+2.35	0.07	3.42	7.7	19.1	6	60
	41.40	+0.07	1.45	1.38	3.3	8.3	5	00
Mg(NO ₃) ₂ ·6H ₂ O	41.44	+0.13	1.47	1.34	3.3	8.3	4	8
	41.10	+0.23	2.20	1.97	1.7	4.4	4	00
CoSO ₄ ·7H ₂ O	41.43	+0.89	2.74	1.85	2.4	6.1	4	00
	38.78	+1.20	0.57	1.57	3.7	9.2	4	00
Al ₂ (SO ₄) ₃ ·18H ₂ O	38.71	+0.95	1.24	3.4	8.5	4.0	—	—
	44.63	+0.16	1.13	1.17	4.8	12.0	1	30
ZnCl ₂	43.79	+0.12	2.32	2.20	5.0	12.5	2	30
FeSO ₄ ·7H ₂ O	34.79	+0.25	1.37	1.12	3.2	8.0	2	45
	40.50	+0.10	0.37	0.26	0.6	1.6	2	45
	42.40	+0.25	0.64	0.39	0.9	2.3	1	5
	39.76	+0.22	0.70	0.48	1.1	3.1	2	00
Citric acid	32.87	+0.08	0.45	0.37	1.1	2.8	1	5
Boric acid ¹	45.57	+0.45	2.75	2.30	5.0	6.7	8	00
K ₂ SO ₄ ·Al ₂ (SO ₄) ₃ ·24H ₂ O	29.86	+0.72	0.80	1.52	5.1	12.7	0	30
	29.52	+0.78	0.16	0.94	3.2	8.0	1	00
CO(NO ₂) ₂ ·6H ₂ O	37.91	+0.21	0.45	0.66	1.7	4.4	1	30
	38.71	+0.27	0.67	0.94	2.4	6.1	0	5
Cr ₂ (SO ₄) ₃	39.82	0.00	0.44	0.44	1.1	2.8	0	50
Ba(NO ₃) ₂	38.90	+0.02	0.06	0.04	0.1	0.3	0	30
CaCl ₂ ·2H ₂ O	37.01	0.00	0.05	0.05	0.1	0.3	0	30
Sr(NO ₃) ₂ ·4H ₂ O	41.92	+0.01	0.05	0.04	0.1	0.3	0	45
Cr ₂ (SO ₄) ₃ ·K ₂ SO ₄ ·24H ₂ O	37.52	+0.08	0.28	0.20	0.8	1.4	0	30
Co(NO ₂) ₂ ·4H ₂ O	40.11	+0.36	0.20	0.56	1.4	3.5	0	30
MnSO ₄ ·2H ₂ O	37.32	+0.58	0.06	0.64	1.7	4.3	0	20
Fe ₂ (SO ₄) ₃ ·9H ₂ O	42.55	+0.27	0.53	0.26	0.6	1.5	0	20

¹ Mixture of 35 parts kieselguhr and 100 parts boric acid (channelling).

Cobalt chloride appears to be the most efficient absorbent investigated. It let through no trace of ammonia for 12 min. and absorbed 25 per cent of its weight of ammonia, an amount corresponding to about 3.5

molecules of ammonia per molecule of cobalt chloride. Copper sulfate comes second, lasting about 10 min., and absorbing about 20 per cent of its weight of ammonia at equilibrium or 3 molecules of ammonia per molecule of salt. Silica gel absorbs nearly 20 per cent of its weight of ammonia at equilibrium, but has a considerable vapor pressure of ammonia before equilibrium is reached and hence is not as efficient for our purposes as the cobalt or copper salt. It has a use in the ammonia canister, however, which will be referred to later. Cobalt sulfate is not as good an absorbent as copper sulfate. Salts of magnesium, nickel, zinc, aluminum, ferrous iron, and boric acid also show considerable absorptive power.

The copper sulfate absorbent, which for reasons appearing later is believed to be the most satisfactory for our purpose, has been named kupramite.

MAN TESTS OF CANISTERS PACKED WITH VARIOUS ABSORBENTS

After the several salts had been rated by the tube test, some of the best of them were packed in canisters and subjected to actual man tests. Fig. 1 shows the

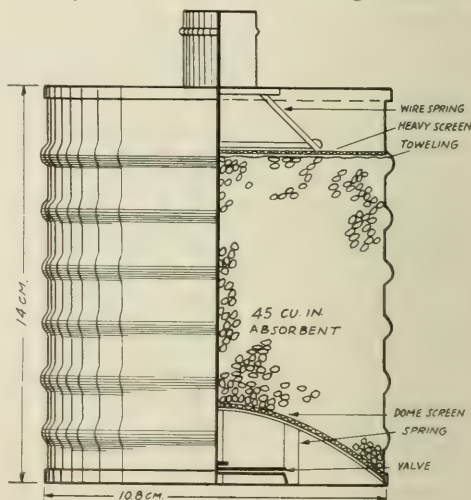


FIG. 1.—KUPRAMITE AMMONIA CANISTER

standard army canister used in this series of tests. It is an elliptical container of sheet metal with a capacity of about 45 cu. in. of material. This canister was employed in connection with the Tissot type mask shown in Fig. 2. In carrying out the man tests, a gas chamber of about 19,000 l. capacity was employed. Canisters were tested at concentrations varying from 2 to 5 per cent. It was found that concentrations of ammonia of 2 per cent could not be endured for longer periods than 15 min. due to the irritating effect of the gas upon the skin. The canisters were accordingly not run to break down with men inside the gas chamber. Tests to determine the total life of the canister were run with the canister inside the chamber and connected to the outside by a rubber tube. The observer was thus enabled

to wear the mask outside the chamber and to continue breathing until the absorbent was exhausted without the discomfort of being in the gas.

In the column under breathing rate (Table II) it will be noticed that this ran as high as 60 l. per min. These different breathing rates were brought about by having the men ride a bicycle ergometer with different currents flowing through the electromagnetic brake. The average man breathes about 8 l. per min. at rest, 32 l. per min. indicates moderately severe exercise and causes exhaustion in half an hour, at 60 l. per min. exhaustion occurs in about 5 min. The importance of testing the absorbents at high breathing rates is evident. An absorbent with a large capacity might offer no protection at all at high breathing rates due to the fact that it did not possess sufficient activity.

TABLE II—MAN TESTS OF CANISTERS PACKED WITH DIFFERENT ABSORBENTS

FILLING	Per cent Impregnation Concentration Per cent	Pressure Drop		Life in Min.	Approximate Breathing Rate Liters per min.
		Mm. H ₂ O at 85 l. per min.			
		Start	Finish		
CoCl ₂ ·6H ₂ O.....	50	50	60	192	8
	50	45	60	122	8
	50	45	58	13	32
	50	47	53	16	32
	50	34	38	4	60
CuSO ₄ ·5H ₂ O.....	50	45	58	240	8
	50	47	60	240	8
	50	54	58	120	8
	70	52	58	110	8
	70	45	53	184	8
FeSO ₄ ·7H ₂ O.....	50	42	60	166	8
	50	42	43	48	20
	70	48	61	26	32
	70	48	60	31	32
	70	64	70	5	60
Silicic acid.....	2	50	65	160	8
50 per cent boric acid, 50 per cent kieselguhr.....	2	50	58	120	8

The weight of the 45 cu. in. of impregnated pumice is between 500 and 550 g.

The three salts, copper sulfate, cobalt chloride, and ferrous sulfate were put on 8 to 14 mesh pumice in the manner previously described. Silicic acid was made by the decomposition of sodium silicate with acid and subsequent partial dehydration of the resulting product at a temperature of about 125° C., after the method of Patrick.¹ The figures under pressure drop show the resistances of the canister at the beginning and end of the test expressed in millimeters of water when an air flow of 85 l. per min. is passing through the canister.

Results of the man test show that either cobalt chloride or copper sulfate give an absorbent with a capacity more than adequate for any conditions which it is possible to conceive the canister might meet in service. For a man at rest the canister filled with either of these absorbents has a life of about 5 hrs. against 2 per cent ammonia, a concentration which is unbearable, due to skin irritation, for periods over 15 min. The canister has even longer life on an intermittent test. A canister filled with the copper sulfate absorbent was run on the regular man test against 2 per cent ammonia for 1 hr. a day on successive days until breakdown. The total service time of the canister under these conditions was 8 hrs. and 56 min. A canister filled with silicic acid and tested in a similar manner, lasted 4 hrs. and 8 min.

A defect of the metallic salt absorbents, which was at first noticed and has now been eliminated, was the tendency of the water given off during absorption to condense on the eyepieces of the mask and diminish the clearness of vision. To remedy this defect a 1-in. layer of silica gel or active charcoal is placed on top of the ammonia absorbent. This has been found to keep the humidity of the effluent air sufficiently below saturation to prevent condensation on the eyepieces.

POSSIBILITY OF DETERIORATION OF ABSORBENT WITH AGE

There is no reason to suppose that the absorbent will not retain its efficiency indefinitely. We have not yet had time to conduct any extensive series of aging tests; such tests are, however, under way. Canisters tested three weeks after packing have shown no apparent decrease in life.



FIG. 2—AMMONIA RESPIRATOR, SHOWING CANISTER CARRIED ON BACK

It has been found that the efficiency of the absorbent one day after preparation is somewhat greater than the efficiency a week after preparation. Further exposure does not cause any apparent decrease in life. If the absorbent is allowed to stand over 1 : 1 sulfuric acid for a week, the life is cut in half, while if the absorbent is allowed to stand over water for the same time the life is increased about 25 per cent. Evidently it is necessary that the copper sulfate be present in the form of the pentahydrate and undoubtedly a slight excess of water would aid in prolonging the life. It is possible that the addition of a small per cent of a deliquescent material to the original mix would prove of benefit. The whole question of increasing the life of the absorbent is being investigated in some detail. Very promising results have been obtained by making granules of a mixture of copper, sulfate, kieselguhr, and a cement. In this way an absorbent can be made which contains a very large proportion of the active material in a finely

¹ U. S. Patent 1,297,724.

divided state and a relatively small proportion of inert material.

RECOMMENDED CONSTRUCTION OF AMMONIA RESPIRATOR

PREPARATION OF ABSORBENT—Pumice stone, 8 to 14 mesh, and technical copper sulfate are placed in an evaporating pan in the ratio of one part by weight $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ to 1.5 parts pumice, and the whole is covered with sufficient water to dissolve the salt at boiling temperature. The mixture is then boiled down with constant stirring until crystallization takes place on the pumice and the crystals are nearly dry. The pumice thus treated is then removed from the dish, spread out and allowed to dry in the air. The fines are then screened out on a 14 mesh sieve. Care must be taken in the evaporating process that the absorbent is still slightly moist when taken from the pan.



FIG. 3.—AMMONIA RESPIRATOR, SHOWING RELATIVE SIZE OF CANISTER

PACKING OF THE CANISTER—Fig. 1 shows the standard army canister packed with kupramite. A layer of toweling is placed on top of the absorbent to filter out any fine particles which might be drawn up from the absorbent, and the whole is held in place by the usual heavy wire screen and spring. This method of packing is to be used with the present mouthpiece type of army mask described below. If the new Tissot type mask is used, a modification of the packing is desirable in order to eliminate the trouble due to moisture given off by the absorbent during service condensing on the

eyepieces of the mask and thus impairing the vision of the wearer. To remedy this defect a 1-in. layer of kupramite at the top of the canister is replaced by activated charcoal or silica gel, preferably silica gel. This decreases the humidity of the effluent air sufficiently to prevent dimming of the eyepieces. If charcoal is used, a 2-g. cotton pad (Eastern Star Furrier Co., Pawtucket, R. I.) is substituted for the toweling in order to remove charcoal dust. The canister complete weighs about 1.7 lbs.

TYPE OF FACEPIECE—The present standard type of army gas mask with mouthpiece and noseclip may be used, in which case no silica gel or charcoal need be placed in the canister. On the other hand the Tissot type facepiece shown in Figs. 2 and 3 is much more comfortable to wear because of the elimination of mouthpiece and noseclip; furthermore, the wearer has a larger range of vision and can work to better advantage. The photograph shows the canister carried on the back; the position on the chest as used by the Army is probably better for certain kinds of work. The complete respirator weighs about 3.5 lbs.

A simple mouthpiece and noseclip and separate goggles should never be used, as no goggles have yet been put on the market which will protect the eyes from ammonia in high concentration.

We wish to express our appreciation of the coöperation of Louis Jordy and O. P. Gephart in conducting the man tests, and of J. H. Yoe in conducting machine tests.

Acknowledgment is due to the Bureau of Mines and especially to the Director, Van H. Manning, for initiating the work on the industrial gas mask and for the valuable assistance of the Gas Investigations Laboratory of the Pittsburgh Station of the Bureau of Mines.

SUMMARY

Pumice stone impregnated with copper sulfate has been shown to have a large capacity for absorbing ammonia. A canister containing 45 cu. in. of this material will protect a man breathing at rest for at least 5 hrs. against 2 per cent ammonia and for $2\frac{1}{2}$ hrs. against 5 per cent ammonia. Tests at high breathing rates show that the canister affords ample protection even at severe exertion. Several other salts, and boric and silicic acids are also good absorbents. The advantages of the present absorbents are large capacity and activity, negligible heat of absorption, and cheapness.

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EFFECT OF MOISTURE CONTENT ON THE PERMEABILITY OF FABRICS TO MUSTARD GAS¹

By GEORGE H. CLOWES, G. ST. J. PERROTT, BENEDICT GORDON AND E. L. GREENSFELDER
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The purpose of this paper is to determine to what extent the permeability of various fabrics to mustard gas may be modified by the addition of varying proportions of moisture.

Since mustard gas is only slightly soluble in water, and in aqueous solution undergoes hydrolysis with

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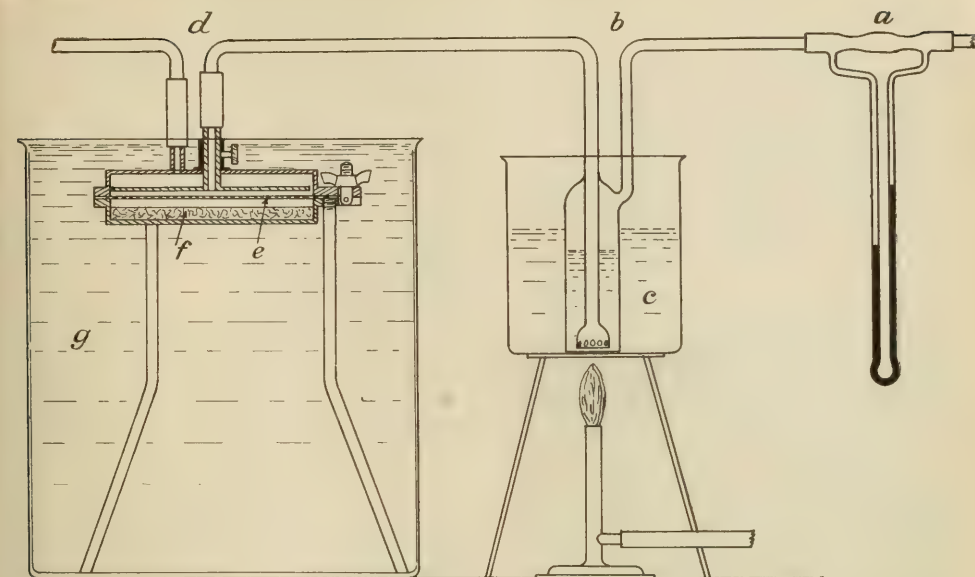


FIG. 1

a—Flow meter; b—Absorption tube; c—Water bath at 85° C.; d—Permeability apparatus; e—Fabric; f—Cotton wadding saturated with dichlorethylsulfide; g—Water bath at 20° C.

the production of hydrochloric acid and dihydroxyethylsulfide substances which exert little or no effect on the skin, it might be anticipated that water-soaked clothing would afford a barrier to the passage of mustard gas.

Field experiments indicate that heavy clothes saturated with water do in all probability offer resistance to the passage of mustard gas but that some of the fabrics specially prepared to resist mustard gas are lowered in their resistance by being wetted.

It has also been generally recognized that burns occur more commonly on those portions of the body which perspire most freely. That perspiration actually facilitates the passage of mustard into the skin has been demonstrated by moistening the skin with a water film and comparing the burn obtained on the moist and dry skin of the same subject after exactly equal exposures. It was found that in all cases the burns produced on the moistened surfaces were from two to three times as severe as those on the dry surface.¹

It has been demonstrated that in the case of the skin, surface adsorption plays a very considerable rôle and that difference in resistance of different individuals is to be attributed to the fact that the more resistant adsorb mustard gas more readily and in larger quantity than the more susceptible.¹

Since mustard gas probably passes from the skin surfaces into the underlying tissues through the sweat glands it is evident that a surface film of water might

aid this process by diminishing the amount of gas adsorbed by the skin surface and possibly also by facilitating capillary transportation on the surface of the water film.

The question arises whether similar conditions may not apply in the case of fabrics, all of which presumably adsorb mustard gas to a larger or smaller extent on the surface. A water film might be expected to diminish the surface adsorption of ordinary fabrics and facilitate the passage of mustard gas into the interstices or capillary spaces, and a surface film of water in the interstices or pores of the fabric might even facilitate the passage of mustard gas through the interstices along a water-air surface by capillarity.

On the other hand, if all the interstices were filled with water, if the mustard gas, which is very slightly soluble, had to dissolve in water and pass through the water by a slow process of diffusion, undergoing hydrolysis to a certain extent in the process, it might reasonably be anticipated that such a completely water soaked fabric would offer considerable resistance to mustard gas.

From this it is obvious that any intermediate range of permeability might be obtained, dependent upon the extent to which the interstices in question were filled with water.

It can thus be seen that the apparently conflicting reports regarding the influence exerted by water on the penetration of mustard gas may be reconcilable, on strictly theoretical grounds, and suitably constituted fabrics might be rendered more permeable to mustard gas by the addition of small amounts of water

¹ "On Dichlorethylsulfide (Mustard Gas) IV, The Mechanism of Absorption by the Skin," Homer W. Smith, George H. Clowes, and E. K. Marshall, *J. Pharmacology* (Future Publication).

and relatively impermeable by the addition of large amounts.

EXPERIMENTAL STUDIES

To investigate this question and to determine whether an optimum degree of penetration was actually associated with the addition of a small amount of water to a fabric, the following experiments were carried out:

A study was made of the effect of different percentages of moisture in several fabrics, namely, heavy, unbleached duck, cotton sheeting treated with a light impregnation of a special gelatin mixture, and a cotton sheeting impregnated with an oxidized linseed oil.

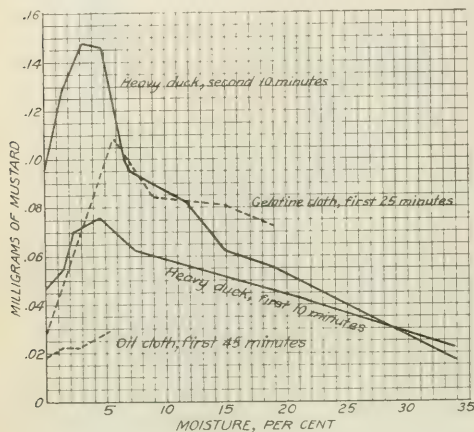


Fig. 2

The moist fabrics were prepared either by allowing circular discs of the material about 4 in. in diameter to remain for different periods of time in an atmosphere saturated with water vapor, whereby they absorbed different amounts of water vapor depending on the time of exposure, or in the case of the higher percentages by soaking the fabric in water and subsequently drying to the desired weight. The cloth discs were weighed to one-hundredth of a gram before and after water impregnation. The original weight of the duck was taken as the weight after drying in an oven at 100° C. for three hours and keeping over concentrated sulfuric acid to constant weight. Due to the nature of the gelatin and oil impregnated fabrics, the weight for zero per cent moisture was taken in the air-dried condition.

The water-saturated cloth discs so prepared were then set properly in the permeability apparatus shown in Fig. 1 over liquid mustard gas and kept throughout at a temperature of 20° C. by immersing the apparatus in a water bath. Air was then drawn over the top of the fabric at a rate of about 500 cc. per min. (measured by the flowmeter *a*) and through a solution of one per cent selenium dioxide in 1 : 1 sulfuric acid contained in a specially designed absorbing tube, *b*. The tube *b* is kept in a water bath at about 85° C. The air was sucked through the bubbler for periods of time depending on the permeability of

the fabric being tested; by this means any mustard vapor diffusing through the fabric was absorbed in the selenious acid solution. This solution is reduced to metallic selenium by traces of mustard gas. By nephelometric comparison of the suspensions thus formed with a standard suspension the amount of mustard gas absorbed can be calculated with a probable error of 0.002 mg. (for amounts between 0.10 and 0.01 mg.). The table shows the results obtained.

TABLE I—AMOUNTS OF MUSTARD GAS ABSORBED BY SELENIOUS ACID SOLUTION

HEAVY UNBLEACHED DUCK			GELATIN TREATED CLOTH	
Moisture Per cent	Mg. Mustard 1st 10 Min.	2nd 10 Min.	Moisture Per cent	Mg. Mustard 30 Min.
0.0	0.048	0.096	0.0	0.029
1.4	0.055	0.128	5.4	0.108
2.2	0.070	0.140	9.0	0.084
2.8	0.072	0.148	14.7	0.081
4.2	0.076	0.146	19.0	0.072
6.4	0.065	0.100	OXIDIZED OIL IMPREGNATED CLOTH	
7.0	0.062	0.096		
11.6	0.056	0.082	Moisture Per cent	Mg. Mustard 45 Min.
15.2	0.051	0.062	0.0	0.018
19.2	0.045	0.055	1.2	0.022
21.6	0.042	0.048	2.4	0.022
33.2	0.022	0.018	4.2	0.029

CONCLUSIONS

From the results obtained it is interesting to note that, whatever the cloth employed, the curve plotted is of the same general nature. The amount of mustard gas penetrating varies directly with increasing moisture up to a certain point, beyond which the amount decreases.

In the case of the oil impregnated cloth it was impossible to introduce more than 4.2 per cent moisture by the process employed in the other cases. This result might reasonably be anticipated owing to the difficulty of effecting contact between the oil and water phases. It is an interesting point that the oil impregnated cloth shows a slight but steady rise in permeability up to the point of maximum permeability of the other fabrics and then fails to take up additional water just at the point at which, according to our theory, water begins to fill the interstices. This difficulty might possibly be overcome by the use of soap solutions, etc., were it possible to continue the experiments.

It is important to note that in the case of the heavy duck, which affords the more uniform material, the addition of 30 per cent moisture reduces the permeability not only far below the optimum, but also far below that of the original dry material.

It is to be regretted that the data are somewhat incomplete, but owing to the suspension of experimental work following the armistice, it has been impossible to accumulate as much experimental evidence as appears desirable. Results do, however, afford considerable evidence that the permeation of fabrics by mustard gas is in a manner analogous to the action of mustard gas on the skin, and that surface adsorption and capillarity play a large part in determining the permeability of ordinary fabrics to mustard.

SUMMARY

I—The penetration of mustard gas through a heavy duck and a gelatin impregnated fabric was facilitated by the addition of from 4 per cent to 5 per cent of water

and partially inhibited by the addition of larger amounts of water.

II—The addition of water up to 4 per cent to an oil impregnated fabric caused a corresponding rise in permeability but of a smaller magnitude than in the case of the duck and gelatin treated cloth.

III—The probable explanation for this phenomenon is that at the point of maximum penetration a film of water covering the fabric interferes with surface adsorption of the mustard gas and possibly facilitates the passage of the gas along the surfaces by capillarity.

At higher water concentrations, as the interstices of the fabric are gradually filled with water, the passage of mustard gas would be first impeded and ultimately almost inhibited, since the speed of passage by solution in water and diffusion would necessarily be slow and associated with considerable hydrolysis.

IV—These results correspond with those observed regarding the influence exerted by a water film on the penetration of mustard gas into the skin.

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ORIGINAL PAPERS

THE PROXIMATE ANALYSIS OF COMMERCIAL CASEIN

By F. L. BROWNE

Received April 18, 1919

Although casein has had a fairly wide and growing application in many industries, it does not seem to have been customary to employ any comprehensive standard as the basis of specifications for its purchase. Since a large amount of casein was used in making waterproof glues for airplanes during the war, and since it was soon found that certain qualities of a commercial casein must be carefully considered in using it for glue making, it was found desirable to draw up specifications for casein for use in waterproof glues. This made necessary the adoption of methods of proximate analysis for casein.

Very little has been published in English concerning the proximate analysis of casein. A "borax solubility test"¹ and an "adhesiveness" test have been described and appear to have found some use in buying casein for making paper size, but the tests are rather crude and their value does not seem to be thoroughly established. Reuter² proposes a qualitative test for iron, a borax solubility test, and the examination of a water extract for acidity, metals, sulfates, and chlorides. This system of analysis is of doubtful value. Höpfner and Burmeister³ propose a system of analysis giving much more information. They determine moisture, fat, ash, nitrogen, and free acidity.

METHODS OF ANALYSIS

* The methods described by Höpfner and Burmeister were adopted, with some modification, for the work at the Forest Products Laboratory of the U. S. Forest Service at Madison, Wisconsin. They have been employed in the examination of over 300 samples of casein and have served as the basis for Bureau of Aircraft Production specifications for the purchase of casein to be used in making water-resistant glue. The methods as employed at this laboratory are given below.

SAMPLING FOR ANALYSIS—If the sample is gathered from bins at the creamery, portions should be taken systematically from all parts of the bin. These should all be ground together, if that has not been done previously. After the powder has been thoroughly

mixed, the final sample is taken out to be sent to the laboratory. A 100-g. sample will be found to be sufficient for the determinations described. The sample received at the laboratory should be thoroughly mixed, 50 g. set aside for the determination of fineness, and the remainder reduced to 60-mesh size.

COLOR—If possible, the color of the casein should be observed at the creamery as it is taken from the driers. Grinding makes the casein appear much lighter in color. Commercial casein may be obtained which is almost pure white, and the color need never be more than a pale yellow or cream.

ODOR—In spite of the rather widespread belief that, as one casein jobber expressed it, "casein has an odor all its own," commercial casein may be obtained which is entirely free from odor, or, at most, has an odor resembling that of sweet milk. The rancid odor frequently associated with casein is not due to the casein, but to impurities or decomposition products of casein. The odor is readily determined as follows: About 10 g. of the casein are soaked in about 10 cc. of water and an equal volume of a rather thick "milk of lime" added with stirring. After the mixture has stood a few moments the odor is noted.

FINENESS—A 50-g. sample is placed in a 60-mesh sieve, the sieve is held in one hand and moved horizontally back and forth at the rate of about 120 strokes per min., being allowed to strike at the end of each stroke against the palm of the other hand which is held stationary. The portion passing through in 10 min. is weighed, and reported as per cent passing 60 mesh.

MOISTURE—This is most accurately determined by weighing out a 3-g. sample in a glass-stoppered weighing bottle, heating to constant weight in a vacuum oven at 70° to 80° C., cooling in a desiccator, and weighing. For most purposes it is more convenient and sufficiently accurate to use a porcelain evaporating dish and make the determination by heating in a Freas oven at 98° C., and atmospheric pressure for 5 hrs. How nearly constant weight is obtained in 5 hrs. is shown in Table I.

The maximum difference obtained at this laboratory between determinations made at atmospheric pressure and *in vacuo* is 0.47 per cent higher *in vacuo*. In most cases the difference was much less.

¹ A. O. Dahlberg, "The Manufacture of Casein from Buttermilk or Skim Milk," U. S. Dept. of Agriculture, *Bulletin* 661.

² *Papier-Zig.*, [2] 32 (1907), 3374.

³ *Chem. Ztg.*, 36 (1912), 1053. See also Burr, *Milch. Zentr.*, 6 (1910), 385.

TABLE I—EFFECT OF TIME ON MOISTURE DETERMINATION
Temperature, 98° C.; Atmospheric Pressure

Time of Heating, Hours	Average Moisture Content, Per cent	
	Casein 1	Casein 2
1	8.89	5.78
2	9.49	6.36
3	9.92	6.46
4	10.07	6.63
5	10.18	6.67
22	10.41	6.74
44	10.46	6.71

FAT—The residue from the moisture determination is transferred to an extraction thimble and extracted for 16 hrs. with anhydrous, re-distilled ethyl ether in a Cauldwell or Soxhlet apparatus. The ether is evaporated from the extract, and the residue, corrected for the moisture content of the casein, is called fat.

In order to determine the time required for complete extraction, samples of a casein of unusually high fat content were extracted for varying lengths of time in a Cauldwell apparatus with the results shown in Table II.

TABLE II—EFFECT OF TIME ON FAT EXTRACTION

Time Extracted Hrs.	Fat (Moisture-free basis)		Remarks
	Per cent		
3	10.00	Sample "as received"	
6	10.45	Sample "as received"	
8	10.50	Sample "as received"	
16	10.54	Sample "as received"	
16	10.58	Residue from moisture determina- tion	

For practical purposes extraction is complete in 8 hrs., but it is customary and quite convenient to let the extraction run over night. It is important that the sample for the fat determination be finely ground.

ASH—A 3-g. sample is weighed out in a vitreosil dish and carefully charred over the low flame of a Bunsen burner. When completely carbonized, it is placed in an electric muffle furnace and heated at a dull red heat (not over 600° C.) until the ash is white, or at least light gray, and the weight is constant. A small amount of ammonium nitrate may be added to facilitate the combustion of the last traces of carbon. Care should be taken to avoid fusion of the ash if possible. Results are reported on a moisture-free basis.

The determination of the ash content of casein presents certain difficulties because of the presence of organic sulfur and phosphorus, alkali chlorides and phosphates, and alkaline-earth salts. With very low ash caseins, the phosphorus makes the use of platinum dishes dangerous; porcelain dishes cannot be used because the phosphoric acid resulting from the combustion of the organic phosphorus enters into combination with the porcelain, giving high results. Vitreosil dishes, however, have been found satisfactory at this laboratory.¹

A temperature in excess of a dull red heat (about 600° C.) should not be used because of danger of loss of alkali chlorides. With low ash caseins the phosphates present in the casein or formed during combustion sometimes give trouble by fusing over particles of unburned carbon, making it very difficult to obtain a white ash. In these cases warning is given during the preliminary charring of the sample by a very marked tendency of the casein to swell and overflow the dish. If the heating at this time is carried out at the lowest possible temperature so as to keep this

swelling down to a minimum, and if too high a temperature is not used in the muffle furnace, it will be found that a light-colored ash may be obtained, especially by using ammonium nitrate near the end of the ignition. With most technical caseins, however, there is enough calcium oxide present to combine with practically all the phosphoric acid formed, thus readily giving a white, skeleton ash.

TABLE III—COMPARISON OF ASH DETERMINATIONS IN PORCELAIN AND VITREOSIL

CASEIN No.	Per cent Ash, Straight Ignition In Porcelain	Per cent Ash, Straight Ignition In Vitreosil or Platinum	Per cent Ash, Calcium Acetate Added In Vitreosil
217	1.13	0.38	2.19
218	1.24	0.38	2.29
221	2.21	2.00	2.33
222	2.59	2.52	2.61

In Table III it will be seen that the values obtained in porcelain dishes are high, especially for caseins very low in ash. Caseins having much over 2 per cent ash, however, give values nearly the same in porcelain as in vitreosil, indicating that there is now enough lime present to "fix" all the organic phosphorus. To check this point, these caseins were ashed in the presence of a large excess of lime, added as calcium acetate, so as to retain as much of the organic phosphorus and sulfur as possible. The results are given in the last column of Table III. Porcelain dishes cannot be used for caseins containing less than 2 to 2.5 per cent ash, and vitreosil dishes are preferable at all times. Since nearly all commercial casein contains at least 2 per cent ash, very nearly all the organic phosphorus and sulfur are "fixed" in the ash.

The ash content of commercial caseins is, therefore, not a direct measure of the mineral impurities present, since the organic phosphorus and sulfur of the casein itself have been retained; but since in nearly all cases practically all this phosphorus has been "fixed," the ash is roughly proportional to the mineral impurities present. In this sense, then, the determination is empirical. Of course, a correction could be made by deducting from the ash value an amount corresponding to the organic phosphorus, but this would be extremely difficult to estimate correctly, and for the purpose of judging casein the uncorrected values are satisfactory.

In general, two methods of overcoming difficulties with fusible ashes have been proposed: (1) Leaching the charred material with water or acetic acid, completing the ashing of the residue, evaporating the leachings in the same dish, and finally heating to constant weight at dull redness,¹ and (2) adding basic materials such as calcium acetate,² or barium hydroxide,³ before ashing. The first of these is time-consuming for routine work. The second is objectionable because the heating must be prolonged to obtain constant weight or else the temperature raised to a point at which there is danger of loss of chlorides. For caseins containing less than 2 to 2.5 per cent ash, the second method gives higher results (see Table III) than straight ignition in vitreosil.

NITROGEN—A 1/2-g. sample is weighed out into an 800-cc. Kjeldahl flask, 20 cc. of concentrated sulfuric

¹ U. S. Department of Agriculture, Bureau of Chemistry, *Bulletin* 107, 38, 238.

² *Ibid.*, p. 21.

³ *Ann. Chem. Pharm.*, 73, 339, 74, 336.

¹ See also Höpfer and Burmeister.

acid, 10 g. of crystallized sodium sulfate, and a small crystal of copper sulfate are added, and the contents digested until a clear solution is obtained, and then for 30 min. longer. 300 cc. of distilled water, 50 cc. of a 1 : 1 solution of sodium hydroxide, and about $\frac{1}{4}$ g. of granulated zinc are added. About 250 cc. are then distilled over and caught in standard sulfuric or hydrochloric acid. (30 cc. of $N/5$ acid will be sufficient.) The excess acid is back-titrated with standard sodium hydroxide solution, methyl red being used as indicator. Since the nitrogen determination is made as a measure of the impurities other than moisture, fat, or ash, results are reported on a moisture-, fat-, and ash-free basis.

The nitrogen content of pure casein has been quite satisfactorily determined to be close to 15.67¹ and it is customary in the determination of casein in milk,² for example, to coagulate with acetic acid, determine the nitrogen in the coagulum by the Kjeldahl method, and multiply by 6.38 (100/15.67) to obtain the casein. The same method can be used for determining roughly the per cent "casein" in the sample by multiplying the nitrogen (on the basis of the sample "as received") by this factor. By comparing this with the moisture-, fat-, and ash-free material in the sample, we obtain a measure of the organic materials other than casein and fat present. There has been some discussion of this "nitrogen factor" in the literature.³ But since essentially the same information is given by observing how closely the nitrogen content computed on the moisture-, fat-, and ash-free basis approaches 15.67, and this method of calculation does not involve the use of any factor with its consequent multiplication of analytical errors, it is doubtless best to report only the nitrogen.

The use of the nitrogen content as a measure of the casein content is, of course, justifiable only if it is known that no other nitrogenous substances are present. Strictly speaking, this is not usually the case. The casein, unless very well washed, is contaminated with some whey protein which, as it has practically the same nitrogen content as casein, is thereby counted as casein. No other nitrogen-containing compounds are normally present.

ACIDITY—A 1-g. sample is placed in a flask and 25 cc. of $N/10$ sodium hydroxide solution run in from a pipette. During this addition the flask is gently agitated. The flask is then stoppered and the agitation continued until the solution is complete. This should require only 5 or 10 min. The stopper is then removed and the portion of solution wetting it washed into the flask with a stream of water from a wash bottle, 100 cc. of distilled water (neutral to phenolphthalein) are added, and the solution back titrated at once with $N/10$ acid, using 0.5 cc. of alcoholic phenolphthalein solution (1 g. per 100 cc.) as indicator. The acid is run in fairly rapidly with vigorous shaking of the flask so as to prevent precipitation of the casein locally. The number of cubic centimeters of $N/10$ alkali used

up by 1 g. of moisture-, fat-, and ash-free casein is called the "acidity" of the sample.

The following precautions must be observed if this method is to give concordant results: (1) The flask should be kept stoppered except when making additions or titrating; (2) the amount of indicator specified must be used and it must be adjusted with alkali so that one drop added to distilled water does not change its reaction; (3) local coagulation of casein during titration must be avoided; (4) the total time during which the casein is allowed to stand in contact with alkali must not exceed 30 min. at room temperature.

If trouble is experienced in obtaining complete solution in 5 to 10 min., the following procedure will give the same results: After addition of the alkali, the tightly stoppered flask is kept in an ice box at a temperature of about 10° C., for 4 hrs. and shaken vigorously once an hour. The dilution and titration are then made as before, except that the acid and alkali solutions should be standardized at the temperature of the ice-box.

Pure casein under these conditions is stated to combine with about 9.0 cc. of $N/10$ alkali per g.¹ Commercial casein may have a higher or lower acidity, depending upon the presence of free acids such as sulfuric or lactic on the one hand, or lime, etc., on the other.

Höpfner and Burmeister² determine acidity by the method of Lunge: 10 g. of the casein are shaken up with 100 cc. of water, filtered, and 50 cc. of the filtrate titrated with standard alkali solution. This method is supposed to give free acids directly, but fails because some casein goes into solution (even if the filtrate is perfectly clear) and uses up some alkali in the titration. To overcome this difficulty, one casein company suggests the following: 1 g. of casein is treated in a stoppered flask for 2 hrs. with 50 cc. of a 10 per cent solution of formaldehyde. It is then filtered, washed free from odor of formaldehyde, and the filtrate titrated with $N/10$ sodium hydroxide. From this reading is subtracted the amount of sodium hydroxide solution required to neutralize 50 cc. of the formaldehyde solution.

TABLE IV—METHODS FOR ACIDITY

CASEIN No.	Acidity as Determined by Complete Solution in NaOH—			Difference Between Complete Solution and CH_2O Methods Cc. $N/10$ Alk. per G.
	4 Hrs. Standing Cc. $N/10$ Alk. per G.	Dissolved at Once Cc. $N/10$ Alk. per G.	Formaldehyde Method Cc. $N/10$ Alk. per G.	
65	11.65	11.70	3.68	7.97
224	11.35	11.40	3.69	7.66
9	11.15	11.20	3.67	7.48
228	10.45	10.30	2.66	7.79
37	10.05	10.10	2.99	7.06
120	7.93	8.03	0.90	7.03
144	7.40	7.35	—0.17	7.57
143	6.95	6.90	—0.27	7.22
161	6.25	6.35	—0.90	7.15
123	5.65	5.70	—0.41	6.06

A comparison of the results obtained by the methods of complete solution of the casein and the formaldehyde leaching method is given in Table IV. The formalde-

¹ Thorpe, "Dictionary of Applied Chemistry" (9.0 cc.); Robertson, *J. Phys. Chem.*, **15** (1911), 178 (9.10 cc.); Robertson, "Physical Chemistry of the Proteins," **1913**, p. 90 (8.0 cc.); Long, *J. Am. Chem. Soc.*, **28** (1906), 372 (8.90 cc.); Van Slyke and Bosworth, *J. Biol. Chem.*, **17** (1913), 211 (9.00 cc.); Hart, *J. Biol. Chem.*, **5** (1909), 445 (9.26 cc.).

² Loc. cit.

¹ "Dairy Chemistry" (Richmond).

² Leach, "Food Inspection and Analysis."

³ *Z. Offent. Chem.*, **15**, 53.

TABLE V—COMPARISON OF ANALYSES OF PURE CASEIN WITH DEALERS' SAMPLES

TABLE V.—COMPARISON OF ANALYSES OF PURE CASEIN WITH DEALERS' SAMPLES												
CASEIN No.	Source	Maker No.	Color	Odor	Moisture Per cent	Fat Moisture-Free Per cent	Ash Moisture-Free Per cent	Nitrogen		"Casein" Per cent	Moisture, Fat, Ash-Free Material Per cent	Acidity Cc.
								Corrected Per cent	Not Corrected Per cent			
Dealers' Samples												
201	Domestic	10	Slight yellow	None	6.51	2.17	4.45	14.85	12.96	82.7	87.30	10.3
204	Domestic	14	White	Sour	6.39	0.16	5.68	14.48	12.76	81.4	88.14	7.6
1	Domestic	16	Very yellow	Sour	10.09	0.41	2.61	14.34	12.51	80.2	87.19	10.9
2	Domestic	16	Yellow	Sour	9.88	1.03	2.94	15.08	13.05	83.4	86.51	9.0
3	Domestic	20	White	Sour	8.17	2.82	4.74	15.15	12.73	81.3	83.98	11.7
5	Domestic	15	Slight yellow	Slightly sour	7.94	0.59	4.79	14.83	12.92	82.4	87.12	7.3
6	Domestic	15	Slight yellow	Slightly sour	9.29	0.33	5.13	15.04	12.90	82.4	85.76	7.5
7	Domestic	9	Yellow	Slightly sour	8.69	0.39	4.19	14.86	12.95	82.7	87.12	7.6
8	Domestic	9	White	Sour	7.25	0.78	4.90	14.97	13.10	83.7	87.50	7.4
9	Domestic	9	Slight yellow	Slightly sour	5.85	2.56	4.48	13.40	11.73	74.9	87.52	12.8
10	Domestic	9	White	Slightly sour	5.30	3.86	3.55	14.84	13.02	83.1	87.69	10.1
11	Domestic	9	Yellow	Slightly sour	6.30	2.17	3.93	13.84	12.18	77.8	87.99	10.4
18	Domestic	17	White	Sour	5.59	2.90	3.64	14.62	12.89	82.2	88.16	8.7
19	Domestic	5	Slight yellow	Slightly sour	8.03	2.57	3.78	14.84	12.78	81.6	86.14	8.7
21	Domestic	1	Yellow	Slightly sour	6.46	0.80	3.82	14.57	13.00	83.0	89.22	11.9
226	Domestic	4	Yellow	Slightly sour	7.25	0.74	3.19	14.44	12.85	82.0	89.09	11.7
227	Domestic	20	White	None	9.72	0.75	4.35	14.54	12.46	79.6	85.67	10.8
227	Domestic	20	White	None	8.85	0.92	4.41	14.65	12.65	80.7	86.29	11.4
228	Domestic	20	White	None	9.50	0.90	4.43	14.80	12.68	80.8	85.67	13.3
					Maximum,	10.09	3.86	5.68	15.04	13.10	.....	13.3
					Minimum,	5.30	0.33	2.61	13.40	11.73	.....	7.3
					Average,	7.74	1.41	4.15	14.63	12.74	.....	9.9
Pure Caseins												
171	Kahlbaum ¹	..	White	Sour	10.02	0.00	2.73	15.50	13.58	86.6	87.55	6.5
187	Kahlbaum ¹	..	White	Sour	7.42	0.22	0.95	15.58	14.26	91.0	91.30	8.46
216	Domestic ²	..	White	None	5.70	0.19	0.24	15.20	14.27	90.9	93.87	8.2
217	Domestic ²	..	White	Very sour	9.27	0.13	0.38	15.00	13.51	86.2	90.22	7.9
218	Domestic ²	..	White	Sour	9.41	1.66	0.38	15.33	13.59	86.8	88.55	8.1
					Maximum,	10.02	1.66	2.73	15.58	14.27	.....	8.46
					Minimum,	5.70	0.00	0.24	15.00	13.51	.....	6.5
					Average,	8.38	0.44	0.94	15.32	13.84	.....	7.8

¹ Hammarsten method. ² Van Slyke method.

TABLE VI—SUMMARY OF THE ANALYSES OF CASEINS MADE BY DIFFERENT METHODS

SOURCE OF CASEIN	Type of Casein	Number of Samples Averaged	Number of Makers Represented	Moisture			Fat (Moisture-Free)			Ash (Moisture-Free)			Nitrogen (Corrected)			Acidity		
				Maximum Per cent	Minimum Per cent	Average Per cent	Maximum Per cent	Minimum Per cent	Average Per cent	Maximum Per cent	Minimum Per cent	Average Per cent	Maximum Per cent	Minimum Per cent	Average Per cent	Maximum Cc.	Minimum Cc.	Average Cc.
				A—Caseins Bought on Market														
Domestic	Buttermilk	1	1	.....	.....	6.89	.....	.....	31.50 ¹	.....	.....	3.28	.....	.....	14.25	.....	.....	.....
	Grain curd	7	1	8.25	5.92	6.84	0.77	0.28	0.50	2.87	2.53	2.78	14.94	14.45	14.71	9.7	6.8	8.9
	Natural sour	12	5	9.78	6.21	7.70	1.44	0.21	0.88	3.38	2.93	3.46	14.89	13.62	14.38	12.5	5.1	9.7
	Sulfuric acid	23	7	10.18	6.23	7.97	2.48	0.15	1.41	3.34	2.62	3.92	15.32	13.22	14.42	13.9	5.7	10.4
	Acid, cooked curd	18	3	10.89	6.96	8.16	1.42	0.22	0.65	4.93	3.79	4.45	14.76	13.94	14.40	9.6	5.8	7.5
	Hydrochloric acid	14	6	8.60	4.86	7.37	1.15	0.00	0.56	6.10	3.14	4.52	14.98	13.83	14.39	10.7	6.7	8.7
	Rennet	3	3	10.32	5.54	8.29	0.83	0.39	0.63	8.39	7.18	7.97	15.10	13.82	14.41	11.3	5.5	9.9
India	Natural sour(?)	8	..	8.89	6.76	8.13	3.67	0.94	1.31	5.59	4.08	4.43	14.53	13.81	14.17	14.0	10.2	12.5
Argentine	Natural sour(?)	8	..	9.28	5.94	8.20	2.11	0.53	1.10	4.30	3.62	3.87	14.88	14.30	14.66	13.5	9.0	11.5
B—Caseins Made under Special Supervision																		
Domestic	Buttermilk	9	..	8.97	5.33	6.97	23.32	3.79	9.56	1.18	0.88	1.36	15.06 ¹	14.42 ¹	14.77 ¹	10.0 ¹	8.5 ¹	9.2 ¹
	Grain curd	11	1	11.10	8.50	9.48	0.31	0.10	0.33	2.76	1.08	1.65	15.25	14.37	14.84	11.7	6.1	9.9
	Natural sour (ejector)	18	1	9.44	6.70	7.87	0.94	0.00	0.27	2.62	1.33	2.15	15.40	14.54	14.84	10.7	7.4	8.7
	Sulfuric acid	34	1	9.63	4.15	7.81	1.05	0.35	3.36	3.02	1.50	1.50	15.00	13.50	14.46	10.8	6.2	7.6
	Natural acid, cooked curd	8	1	9.98	7.68	8.89	0.46	0.00	0.12	5.38	3.92	4.25	15.38	14.70	15.04	6.5	4.4	5.9
	Hydrochloric acid, cooked curd	8	1	11.08	8.82	9.44	0.33	0.05	0.18	5.09	4.14	4.71	15.51	14.61	15.03	6.5	4.2	5.2
	Hydrochloric acid	6	1	8.56	6.32	7.10	0.24	0.08	0.16	6.05	5.51	5.74	14.77	14.02	14.32	8.4	5.2	6.7

¹ Exceptionally high. Casein had a "greasy feeling" when rubbed between the fingers. ² Results based on three samples only.

hyde method is not as convenient as the method of solution in sodium hydroxide, requires more time, and it is not quite clear what the results indicate. It will be seen that negative values are often obtained, probably indicating some combination (either physical or chemical) between the casein and the formaldehyde.

SPECIFICATIONS

Government specifications¹ require that all casein used for making water-resistant glue for use in airplanes should pass the following tests:

Color: White or light cream
 Odor: Nearly odorless, with not more than a trace of sourness
 Moisture: Not more than 10.0 per cent
 Fat: Not more than 1.0 per cent
 Ash: Not more than 4.0 per cent
 Nitrogen: Not less than 14.25 per cent
 Acidity: Not more than 10.5 cc. N/10 alkali per g.

RESULTS OF ANALYSES

In Table V are given the results of the analyses of samples of casein bought from dealers in casein and

of five samples of pure casein made by the Hammarsten¹ and Van Slyke methods.² In Table VI-A is given a summary of the analyses of a much larger number of samples bought from makers of casein, classified according to the method of manufacture. In Table VI-B a summary will be found of the analyses of a large number of samples prepared in a commercial creamery by commercial methods, but under the supervision of an expert in dairy practice of the Dairy Division, Bureau of Animal Industry. In Table VIII the influence of certain factors in the manufacture of casein is shown. The same caseins furnish the data for Tables VI-B and VIII.

PURE CASEINS—It will be observed that the "pure" caseins in Table V are not entirely free from foreign substances. Most of them contain small amounts of fat (the high fat content of Casein 218 was due to insufficient washing with ether). The Hammarsten prep-

¹ Hammarsten, "A Text Book of Physiological Chemistry," translated by Mandel.² J. Biol. Chem., 38 (1918), 127.¹ Department of the Navy, Bureau of Construction and Repair, Aeronautical Specification 85, January 15, 1919.

arations are high in ash. It will be seen from the values for nitrogen or by comparing the "moisture-, fat-, ash-free material" with "caseins" that the samples contain appreciable amounts of organic impurities. The sour odor is due to this. Robertson¹ states that C. P. casein "nach Hammarsten" is contaminated by a small amount of an acid, water-soluble substance. The values for acidity are slightly low. The very low acidity value of Casein 171 is due probably to its high ash (CaO?) content.

TYPICAL COMMERCIAL CASEINS—The commercial caseins of Table V contain variable amounts of fat and ash. The fat in some cases is remarkably low.

TABLE VII

In Table VI-A	Per cent	In Table VI-B	Per cent
Grain curd ¹	2.66	Buttermilk.....	1.36
Buttermilk (one sample).....	3.38	Grain curd ¹	1.63
Natural sour.....	3.55	Natural sour (ejector) ¹	2.16
Sulfuric acid.....	3.94	Sulfuric acid.....	4.05
Acid, cooked curd.....	4.45	Sulfuric acid, cooked curd.....	4.25
Hydrochloric acid.....	4.56	Hydrochloric acid, cooked curd.....	4.71
Rennet.....	7.97	Hydrochloric acid.....	5.74

¹ The grain curd method of precipitating casein with hydrochloric acid, and the ejector method of natural souring have been developed by the Dairy Division of the Bureau of Animal Industry, and will be published within a short time.

The ash content averages about 4 per cent. The low nitrogen values indicate the presence of (1) mineral matter not volatile at 98° C. but volatile at the temperature of ashing, (2) nitrogenous organic matter other than fat or casein containing less nitrogen than casein, (3) non-nitrogenous organic matter. From an examination of the constituents of milk² it will be seen that neither of the first two should be present in appreciable amounts. Any whey protein present, since it has about the same nitrogen content as casein, would not influence the nitrogen content. Other organic matter normally present is non-nitrogenous, chiefly, lactose or its fermentation products. Comparison of "moisture-, fat-, ash-free material" with "casein" shows that the organic impurities other than fat vary from about 3 to about 12 per cent, being usually about 5 per cent. The acidity varies over a wide range, being frequently less than that of the pure caseins (due to the higher CaO content?) but usually considerably higher.

FAT—The fat content depends upon the raw material and its treatment before precipitation. Since the casein carries down the fat with it during precipitation, and since buttermilk usually contains more fat than skim milk, the fat content of the casein obtained therefrom is much higher than that of skim-milk casein. With skim-milk casein the fat content depends almost entirely upon the efficiency of the cream separator. With proper separation a fat content of less than 0.5 per cent can easily be insured.

ASH—The ash content is governed primarily by the acidity of the milk from which the curd is precipitated, and secondarily by the thoroughness with which the curd is washed. The formation of a large, chunky curd also seems to hinder removal of mineral matter by preventing the acid and later the wash water from coming thoroughly in contact with the casein inside the clots. Table VII condensed from Table VI shows the average ash contents observed in the different types of casein analyzed.

The tendency for the curd to form in large clots increases as we read down the lists of these precipitation methods. In Table VIII it will be seen that with the natural sour method, washing the curd after precipitation lowers the ash content, while it has little influence in the sulfuric acid method. This is due possibly to the fact that the different nature of the curd makes it less easy for the soluble mineral substances to be removed in the latter case.

Reference to Table VIII shows that the acidity of the milk from which the curd is precipitated has a decided influence on the ash content. The more acid used the lower is the ash content of the product. This is well shown in the cases of sulfuric-acid and sulfuric-acid cooked-curd caseins. With natural-sour caseins the ash content is lower than with corresponding amounts of mineral acids. This is doubtless due to the longer and more intimate contact of the curd with the acid. The development of the grain-curd method has shown that it is possible to get casein by mineral-acid precipitation with ash content even lower than in natural sour casein. In this method the aim is to add

TABLE VIII—INFLUENCE OF CERTAIN FACTORS IN MANUFACTURE ON ANALYSIS OF CASEIN

BASIS OF CLASSIFICATION	Natural Sour (Ejector)							Sulfuric Acid							Sulfuric-Acid Cooked Curd						
	No. of Samples	Acid ¹ Used for Pptn.	Times Curd Washed	Fat Per cent	Ash Per cent	Per cent N	Acidity Cc.	No. of Samples	Acid ¹ Used for Pptn.	Times Curd Washed	Fat Per cent	Ash Per cent	Per cent N	Acidity Cc.	No. of Samples	Acid ¹ Used for Pptn.	Fat Per cent	Ash Per cent	Per cent N	Acidity Cc.	
Washing of curd	13	0.92 Av. ²	2-4	0.25	1.86	15.04	8.5	12	0.65 Av.	2-3	0.15	4.51	14.60	7.4	.....	.....	.....	.....	.....	.....
Acid used for precipitating casein from milk	5	0.92 Av.	0	0.29	2.46	14.65	9.0	10	0.70 Av.	0	0.08	4.52	14.44	7.1	.....	.....	.....	.....	.....	.....
	7	1.01-1.1	2.3 Av.	0.40	1.95	14.85	8.7	9	0.65 Av.	0	0.42	4.47	14.16	8.0	.....	.....	.....	.....	.....	.....
	5	0.89-0.91	2.2 Av.	0.23	1.97	14.94	8.8	3	1.03	0 Av.	0.84	3.05	14.37	10.0	.....	.....	.....	.....	.....	.....
	5	0.72-0.85	2.2 Av.	0.15	2.10	15.03	8.6	7	0.73-0.84	1.3 Av.	0.20	3.51	14.67	7.5	.....	.....	.....	.....	.....	.....
								9	0.65-0.71	1.0 Av.	0.23	4.48	14.43	6.9	4	0.65-0.76	0.10	3.85	15.23	5.9	
								15	0.57-0.63	1.3 Av.	0.13	4.86	14.37	7.6	4	0.55-0.63	0.14	4.68	14.84	6.0	

¹ Amount of acid used to precipitate the casein from the milk expressed as 100 times the grams of acid hydrogen per cc. of milk; for natural-sour casein determined by titrating the milk before running through the ejector; for sulfuric-acid casein, the milk in nearly every case had an initial acidity of 0.0022 g. hydrogen per 100 cc. (0.2 per cent lactic acid), hence this amount is added to the grams of acid hydrogen added as sulfuric acid to get the figures given in the table.

² Where the abbreviation "Av." occurs, the figure is the average value for the number of samples being considered.

CAUSES OF VARIATIONS IN CASEIN

MOISTURE—The moisture content depends entirely upon the details of the drying process and is practically independent of the methods of precipitating the curd.

¹ T. B. Robertson, "The Physical Chemistry of the Proteins," 1918, p. 39.

² Leach, "Food Inspection and Analysis."

enough acid to give an acidity in the milk corresponding to the isoelectric point of the casein (which is also the point of minimum "solubility"), instead of limiting it to the least amount necessary to cause precipitation.

NITROGEN—The remarkably close agreement in the nitrogen contents of the domestic caseins in Table VI-A shows how little this value depends upon the

method of precipitating the curd. It is to be noted that the grain-curd caseins were all made by one creamery, which is employing the most modern methods. In Table VI-B the values for nitrogen are considerably higher with the grain-curd, ejector method of natural-sour, and cooked-curd caseins. This is probably due to the fact that in these cases the character of the curd is such as to permit of more thorough elimination of impurities during washing. In Table VIII it will be seen that washing the curd thoroughly after precipitation raises the nitrogen content, indicating a removal of such organic impurities as lactose. The acidity of the milk does not influence the nitrogen content.

ACIDITY—As is to be expected, there is a fairly close relation between the acidity and the ash content of the casein—the higher the ash, the lower the acidity, but this value is influenced also by other factors, such as the presence of some of the acid used for the precipitation. The acidity, therefore, is influenced first by the same factors as govern the ash content, namely, the acidity of the milk, and second, by the thoroughness of washing the curd. In this connection the change in acidity with ash content of the skim-milk caseins of Table VI-B is to be noted. The caseins of Table VI-A are not so well washed and hence this relation is more obscure. In Table VIII it will be seen that washing the curd thoroughly after precipitation tends to lower the acidity.

A comparison of A and B, Table VI, shows that the present commercial methods of making technical casein can be improved to a considerable extent. At present it does not seem to be the practice to wash the curd sufficiently after precipitation. The ejector method for natural-sour and the grain-curd method for acid casein seem to give the best results.

SUMMARY

1—A system for the proximate analysis of casein consisting of determinations of color, odor, moisture, fat, ash, nitrogen, and acidity is described.

2—The results of the analysis of some 200 samples of caseins of different types and methods of manufacture are reported.

3—The fat content of caseins depends upon the efficiency of the cream separation (for skim-milk casein) and is independent of the method of manufacture.

4—The ash content varies slightly with the thoroughness of the washing of the curd, but chiefly with the method of precipitation, the important factors being the amount of acid used and the length of time and intimacy of contact between curd and acid. The kind of acid seems to be immaterial, provided that different acids are used in equivalent amounts.

5—The nitrogen content depends chiefly on the thoroughness of the washing of the curd. It indicates the presence of 3 to 12 per cent of organic impurities (lactose, etc.).

6—The acidity in general increases as the ash content decreases, but is also largely influenced by the

amount of acid impurities present, which in turn varies with the thoroughness with which the curd is washed.

ACKNOWLEDGMENT

Experts of the Dairy Division, Bureau of Animal Industry, U. S. Department of Agriculture, the New York Agricultural Experiment Station, and the University of Wisconsin have given generously of their time and information to help in carrying out this work.

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A MODIFICATION OF THE PHENYLHYDRAZINE METHOD OF DETERMINING PENTOSANS

By PAUL MENAUL AND C. T. DOWELL

Received April 24, 1919

Everyone who has made determinations of pentosans by the phloroglucinol method realizes that a shorter and less expensive method is very much needed. This is especially true at this time when it is almost, if not impossible, to buy phloroglucinol even at the high price asked for it. Our purpose in this short investigation was to try to overcome this difficulty by modifying the phenylhydrazine method so as to make it shorter and at the same time obtain results by this method which would agree with the provisional phloroglucinol method.

Recent investigations make it more and more evident that many compounds other than the pentoses and pentosans give furfural when they are distilled with hydrochloric or sulfuric acid, and hence neither the phloroglucinol method nor any other method of determining the furfural coming from such a distillation will enable one to say definitely that the original substance contained a certain per cent of pentosans.

We thought it should be possible to precipitate the furfural with phenylhydrazine and determine the excess of phenylhydrazine in the filtrate by the use of some compound which would oxidize the phenylhydrazine. Tests were made using solutions of phenylhydrazine sulfate with iodine, potassium dichromate, ferric sulfate, sodium hypobromite, and Fehling's solution. With the iodine almost theoretical results were obtained when a large excess of it was used. The amount of ferrous salt found was always less than the theoretical. No better results were obtained with the other oxidizing agents. These results are in harmony with what Chattaway¹ found in his work on the hydrazines. R. Adan² found that the reaction between phenylhydrazine, zinc, and copper sulfate always gave less than the theoretical amount of nitrogen. He stated that secondary products such as chlorophenylhydrazine and diazo compounds were formed when hydrochloric acid was present. E. Ebler³ found that a quantitative yield of nitrogen was

¹ *J. Chem. Soc.*, **91** (1907), 1323; **95** (1909), 1065.

² *Bull. soc. chim. Belg.*, **21** (1907), 211; abstracted in *J. Chem. Soc.*, [II] **91** (1907), 657.

³ *Z. anorg. Chem.*, **47** (1905), 371; abstracted in *J. Chem. Soc.*, [II], **90** (1906), 53.

obtained in the reaction between an ammoniacal solution of copper sulfate and hydrazine. We thought that this reaction might be quantitative for phenylhydrazine also if no chloride or other halogen ion was present in the solution to cause the side reactions found by Adan. The distillation was, therefore, made using sulfuric instead of hydrochloric acid and using sodium sulfate instead of sodium chloride to lessen the solubility of the precipitate.¹ In the distillation the volume in the flask was kept practically constant by adding water as the distillation proceeded.

After the addition of the phenylhydrazine to an aliquot of the distillate the solution was stirred for the required time by bubbling carbon dioxide into it. An aliquot (50 cc.) of the filtrate from the hydrazone was put by means of a dropping funnel into a 250-cc. Fresenius nitrogen bulb,² which had been previously filled with a 10 per cent solution of ammoniacal copper sulfate and heated to expel the air. A 100-cc. burette was connected to the tube of the Fresenius bulb and a glass tube provided with a stopcock connected the neck of the bulb with a Schiff's nitrometer containing sulfuric acid. The aliquot of the filtrate was brought into the bulb through the dropping funnel by closing the cock leading to the nitrometer and lowering the burette. The bulb was then heated so as to keep the reaction mixture near the boiling point until the reaction was complete.

Results obtained using the above method to determine the pentosans in three samples of grain sorghum which were cut at different stages of growth, are given in the table below. Results obtained by Mr. Freidemann of this laboratory using the same samples and the phloroglucinol method are given for comparison. Neither Mr. Freidemann nor Mr. Menaul knew what results the other had obtained until the work had been finished.

TABLE SHOWING WEIGHTS OF PENTOSANS IN ONE GRAM OF SORGHUM

No.	Phloroglucinol Method Gram	Phenylhydrazine Method Gram
I.....	0.1790	0.1788
II.....	0.1523	0.1526
III.....	0.2149	0.2150

Other determinations showed that the addition of sodium sulfate to the distillate with the phenylhydrazine was not necessary. The same volume of nitrogen was obtained by taking two parts of the distillate to one of which sodium sulfate had been added and not to the other.

The time required to make a determination of the excess of phenylhydrazine in the filtrate is about 20 min. This method then makes it possible to use a much cheaper substance than phloroglucinol and to make a determination of pentosans in a much shorter time.

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STUDIES ON THE NITROTOLUENES. I—BINARY SYSTEMS OF A NITROTOLUENE AND SYMMETRICAL TRINITROMETOXYLENE^{1,2}

By JAMES M. BELL AND JAMES P. SAWYER

Received July 19, 1919

This paper records the freezing points of binary systems in which one component is 2,4,6-trinitroxylene and the second component is a nitrotoluene. Three nitrotoluenes have been used: *p*-mononitrotoluene, 1,2,4-dinitrotoluene, and 1,2,4,6-trinitrotoluene. We have also observed the ternary eutectic points when two of these nitrotoluenes and trinitro-*m*-xylene are the components.

PREPARATION AND PURIFICATION OF TRINITRO-M-XYLENE—Xylene, whose boiling point ranged between 139° and 139.8°, was nitrated with mixed nitric and sulfuric acids, the yield being about 80 per cent of the theoretical amount. Several crystallizations of the crude product from acetone gave crystals melting at 182°, and further crystallizations did not alter this temperature, which is the accepted melting point of the compound. We have also found that benzene is a good solvent for the recrystallization of this nitroxylene.

PURIFICATION OF THE NITROTOLUENES—All of the nitrotoluenes were purchased rather than prepared. The trinitrotoluene was recrystallized several times from a 2 : 1 mixture of 95 per cent alcohol and ether. The final product melts sharply at 80.5°, the accepted melting point. The mono- and dinitrotoluene had already been purified for another investigation, which will be reported later. The melting points, 51.2° and 69.4°, respectively, accord well with the accepted values.

METHOD OF DETERMINING MELTING POINTS OF BINARY MIXTURES—We have used the cooling curve method for the determination of freezing points. It is common experience that the true freezing point of mixtures is almost always difficult to read owing to supercooling. In a subsequent paper there will be a critical discussion of the proper interpretation of a cooling curve. Fig. 1 shows the triplicate cooling curves with a mixture of 65 per cent trinitro-*m*-xylene and 35 per cent trinitrotoluene. It will be noted that we have taken the intersection of the cooling curve for the liquid and of the cooling curve where trinitro-*m*-xylene is crystallizing out regularly, after the irregularity due to supercooling has passed. This point may be duplicated readily, whereas the temperature at which crystals first appear may vary, depending upon the degree of supercooling. In this instance three readings give a freezing point of 160.0° (uncorr.) or 162.8° (corr.). The cooling of the mixture for each curve lasted only about 5 or 6 min., the readings being taken at half-minute intervals. The apparatus consisted of a test tube containing 10 g. of the

¹ This paper is the first of a series dealing with the freezing points and thermal properties of the nitrotoluenes, the investigation having been undertaken at the request of the Division of Chemistry and Chemical Technology of the National Research Council.

² Presented to the faculty of the University of North Carolina by J. P. Sawyer in partial fulfillment of the requirements for the degree of Bachelor of Science in chemistry, June 1919.

¹ Recommended in U. S. Department of Agriculture, Bureau of Chemistry, *Bulletin* 49.

² See catalogue of Central Scientific Company, p. 371.

65% TNX-35% TNT

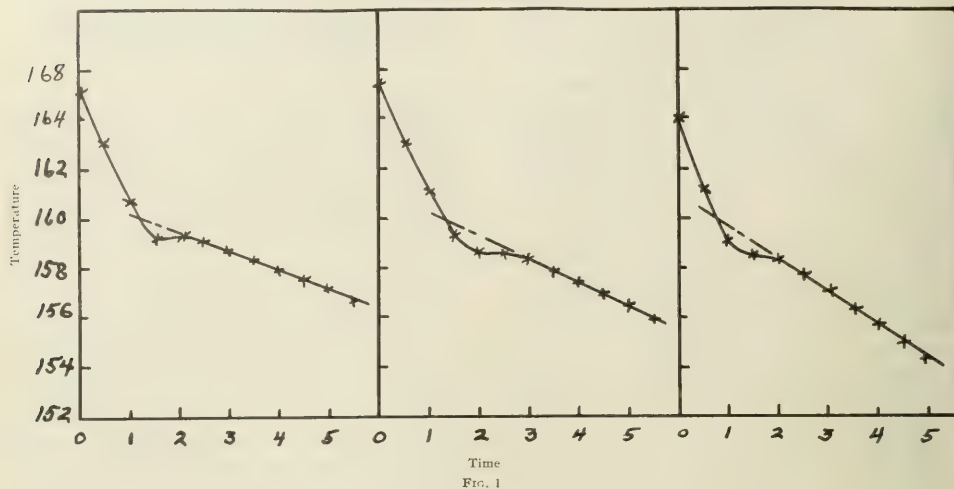


FIG. 1

melted sample and also a looped stirrer and a thermometer graduated to 0.1° . This test tube was jacketed by a larger test tube, which was placed in an oil bath maintained by heating coils about 5° below the freezing point of the mixture, which point had previously been approximately determined. Both the cooling mixture and the oil bath were stirred by an electric motor.

THE BINARY SYSTEM: TRINITRO-*m*-XYLENE-TRINITROTOLUENE—Freezing temperatures for mixtures of these two substances are given in Table I and Fig. 2.

Per cent Trinitro- <i>m</i> -xylene	Freezing Point		
By Weight	Molecular	Corr.	Calc.
100	100	182.0°	
80	79.0	172.0	171.6
65	63.6	162.8	162.6
50	48.5	152.0	151.8
35	33.7	138.1	
20	19.0	116.0	118.2
15	14.3	100.7	109.0
10	9.5	83.1	96.6
0	0.0	80.5	

The eutectic is at 74.8° , corresponding (by extrapolation) to 8 per cent of trinitro-*m*-xylene.

Per cent Trinitro- <i>m</i> -xylene	Freezing Point		
By Weight	Molecular	Corr.	Calc.
100	100.0	182.0°	
90	87.2	175.8	176.0
70	63.8	164.0	162.7
50	43.0	149.0	147.1
40	33.5	140.5	137.8
30	24.5	128.4	126.7
20	15.9	109.6	112.4
10	8.5	82.5	93.3
0	0.0	69.4	

The eutectic is at 67.7° , corresponding (by extrapolation) to 6 per cent of trinitro-*m*-xylene.

Per cent Trinitro- <i>m</i> -xylene	Freezing Point		
By Weight	Molecular	Corr.	Calc.
100	100.0	182.0°	
90	83.7	173.9	174.2
70	57.0	159.8	158.2
50	36.2	143.1	140.7
30	19.6	122.0	119.2
20	12.4	106.5	104.5
10	5.9	81.0	83.0
0	0.0	51.2	

The eutectic is at 50.5° , corresponding (by extrapolation) to 2 per cent of trinitro-*m*-xylene.

The composition of the mixture is given both in weight-per cents and in molecular-per cents, and the freezing point temperatures are corrected for the emergent stem of the thermometer.

TERNARY EUTECTIC TEMPERATURES—The binary eutectic temperature for mono- and dinitrotoluene, 26.4° , was lowered to 25.7° by additions of successive small quantities of trinitro-*m*-xylene; similarly that for mono- and trinitrotoluene, 33.8° , was lowered to 30.55° , and that for di- and trinitrotoluene, 45.1° , was lowered to 42.3° .

RELATION BETWEEN COMPOSITION AND MELTING POINT OF MIXTURES—In his paper on the general theory of solutions, Washburn¹ calls attention to an Amsterdam dissertation by Boldingh (1893) in which a relation was derived between the osmotic pressure and the concentration of a solution:

$$\pi = -\frac{RT}{V_0} \log_e x$$

in which terms involving the compressibility of the liquid are neglected. In this equation, π is the osmotic pressure, V_0 the molecular volume of the solvent, and x the mol. fraction of the solvent. This equation was combined by Washburn² with the thermodynamic relation connecting osmotic pressure and freezing point giving

$$dT = \frac{RT^2}{Q} \cdot \frac{dx}{x}$$

or

$$\frac{d \log_e x}{dT} = \frac{Q}{RT^2} \dots \dots \dots (1)$$

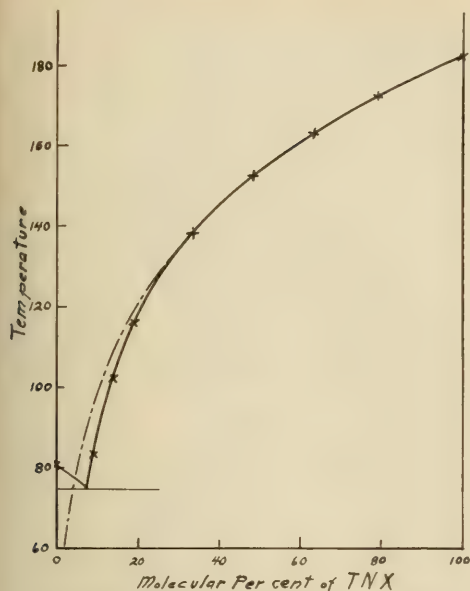
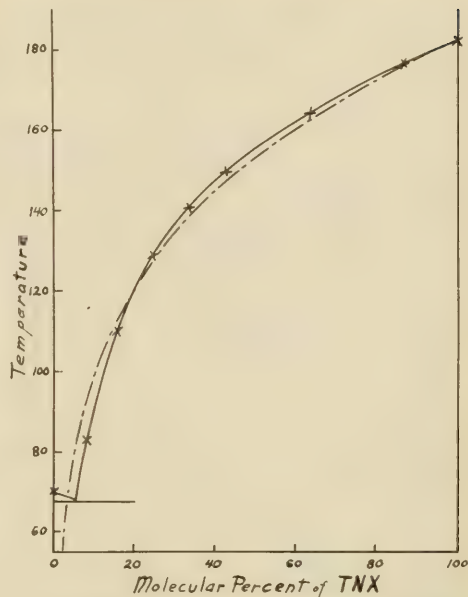
This same equation has also been derived by Schröder³ and LeChatelier.⁴ In this equation Q is the molecu-

¹ *J. Am. Chem. Soc.*, **32** (1910), 658.

² "Principles of Physical Chemistry," p. 168.

³ *Z. physik. Chem.*, **11** (1893), 449.

⁴ *Compt. rend.*, **118** (1894), 638.

FIG. 2—BINARY SYSTEM: TRINITRO-*m*-XYLENE-TRINITROTOLUENEFIG. 3—BINARY SYSTEM: TRINITRO-*m*-XYLENE-DINITROTOLUENE

lar heat of fusion of the solvent at the temperature T , and R is the constant of the gas equation. In deriving this formula, certain assumptions have been made, which should here be repeated. The components must form no compound or solid solution and must neither dissociate nor associate. It is further assumed that for such mixtures the laws of ideal solutions are valid. In order to test the validity of the formula for the lowering of the freezing point of trinitro-*m*-xylene by the nitrotoluenes, we should know how Q , the molecular heat of fusion, changes with the temperature. Let us consider only the conditions under which Q may be assumed as constant. This will be the case if the specific heats of the solid and of the liquid are equal. It was pointed out by van't Hoff that at the melting point the liquid has a greater specific heat. In his recent book on physical chemistry, Lewis¹ gives the specific heats of a few substances in both physical states. Two of these substances may be taken as probably typical of the behavior of trinitro-*m*-xylene. For benzene, the values are 0.43 and 0.35 cal. per g. and for naphthalene, 0.44 and 0.33 cal. per g. The differences are of the order 0.1 cal. per g. If we assume that this difference is fairly constant over moderate ranges in temperature, then it follows that

$$Q = Q_0 + \Delta c \cdot \Delta T \dots \dots \dots (2)$$

where Q is the heat of fusion at any temperature, Q_0 the heat of fusion at the melting point of pure component, Δc the difference in the molecular heats of liquid and solid, and ΔT the depression of freezing point due to the addition of the second component.

For benzene,¹ $Q_0 = 2370$, and $\Delta c = 6.2$, and consequently Q is constant (within 5 per cent) over a range of temperatures of 20°. For naphthalene, $Q_0 = 4560$, and $\Delta c = 14.1$, and consequently Q is constant (within 5 per cent) over a range of temperatures of 15°.

If we assume that Q is constant, the above differential equation may be integrated and becomes on integration

$$\log_e x = -\frac{Q(T_0 - T)}{RTT_0} \dots \dots \dots (3)$$

in which T_0 is the melting point of the pure substance, and T the melting point in the presence of a second component, x being the mol. fraction of the melting component. This formula is also given in another form by Baud and Gay,² who have verified the validity of the equation for binary mixtures of benzene and dichlorethylene by showing the constancy of k in the equation

$$\Delta T = -kT \log_{10} x \dots \dots \dots (4)$$

which becomes identical with Equation 3 above if

$$k = \frac{RT_0}{Q \log_{10} e} \dots \dots \dots (5)$$

Washburn³ has tested the validity of the formula by calculating the eutectic temperatures of binary mixtures of benzene, naphthalene and diphenyl, and has found close agreement with the observed eutectic temperatures.

As the literature presents no data on the value of Q for trinitro-*m*-xylene, we have employed a calculated

¹ Washburn, "A System of Physical Chemistry," 2, p. 172.

² Compt. rend., 150 (1910), 1687.

³ *Ibid.*, p. 169.

¹ "A System of Physical Chemistry," 2, p. 325.

value. Taking the point on the curve for trinitro-*m*-xylene and trinitrotoluene: $x = 0.337$ and $T = 138.1^\circ \text{C}$ or 411.1°A , and substituting in Equation 3 we get

$$\log_e 0.337 = - \frac{Q \times 43.9}{1.985 \times 411.1 \times 455} \dots (6)$$

and $Q = 9200 \text{ cal.}$, a value which has been employed in other calculations. When this value is substituted in Equation 3 we get

$$\log_e x = - \frac{9200 (T_0 - T)}{RTT_0} \dots (7)$$

and putting $T_0 = 455^\circ \text{A}$ we find

$$T = \frac{2012.7}{4.424 \log_{10} x} \dots (8)$$

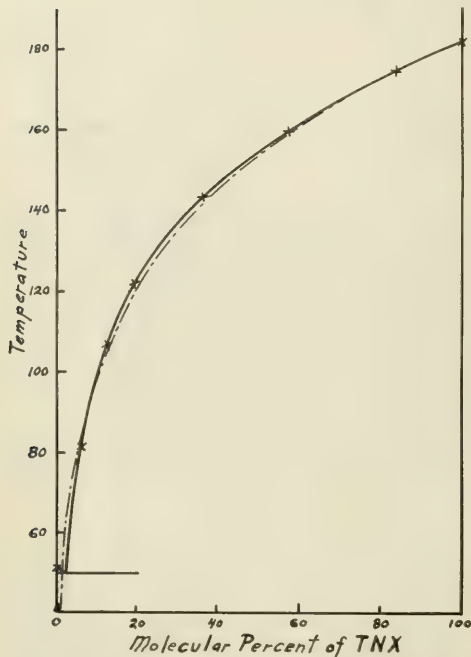


FIG. 4—BINARY SYSTEM TRINITRO-*m*-XYLENE-MONONITROTOLUENE

The freezing points for mixtures containing trinitro-*m*-xylene, calculated on the above basis, are shown in Table IV.

TABLE IV

Mol. Fraction of Trinitro- <i>m</i> -xylene	Freezing Point
1.00	182.0°
0.90	177.3
0.80	172.2
0.70	166.5
0.60	160.2
0.50	153.0
0.40	144.4
0.337	138.1
0.30	133.9
0.20	119.9
0.10	98.1
0.05	78.6

In Table IV the results of calculations of melting points are recorded, having given only the molecular heat of fusion and the mol. fraction of trinitro-*m*-

xylene. It should be emphasized that the results are not dependent upon the properties of the second component where the components are of sufficiently like chemical character. In other words, the same freezing point curve holds for these substances, when the concentrations are expressed in mol. fractions. From 100 per cent to 20 per cent of trinitro-*m*-xylene, the calculated and observed temperatures differ by less than 3° in every case. This is also shown on the diagrams where the observed and the calculated values are plotted, the two curves according well within the range mentioned above. For mononitrotoluene the agreement is excellent over the whole range of concentrations. For the other two substances there is considerable deviation from the eutectic mixtures up to about 20 per cent of trinitro-*m*-xylene. This may be attributed to the failure of some one of the original assumptions at these extreme concentrations.

SUMMARY

In this paper have been given the melting points of the binary mixtures of trinitro-*m*-xylene and a nitrotoluene. The ternary eutectic points for two nitrotoluenes and trinitro-*m*-xylene have also been recorded. Over wide ranges of concentration, the formula connecting heat of fusion, melting point and composition of ideal solutions holds for trinitro-*m*-xylene and is especially well followed where mononitrotoluene is the second component.

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STUDIES ON THE NITROTOLUENES. II—REFRACTIVE INDICES OF MIXTURES OF *p*-NITROTOLUENE, 1,2,4,6-DINITROTOLUENE AND 1,2,4,6-TRINITROTOLUENE^{1,2}

By JAMES M. BELL AND EDMUND O. CUMMINGS
Received July 19, 1919

In the course of a study of the ternary system of the 3 nitrotoluenes *p*-mononitrotoluene, 1,2,4 dinitrotoluene and 1,2,4,6-trinitrotoluene, it was found difficult to locate the position of the boundary curves on a triangular diagram, a difficulty due to the impossibility of direct analyses of the ternary mixtures. The results of the study of the ternary system will form the subject of a later paper of this series. The possibility of finding the composition of such mixtures by physical means was resorted to, and among other physical methods the refractive indices of many known mixtures were determined and charted in the hope of yielding data which would allow the determination of the composition of unknown mixtures. This phase of the investigation was discontinued however when a simpler method was discovered for finding the position of the boundary curves.

The results of this partial study are offered here as

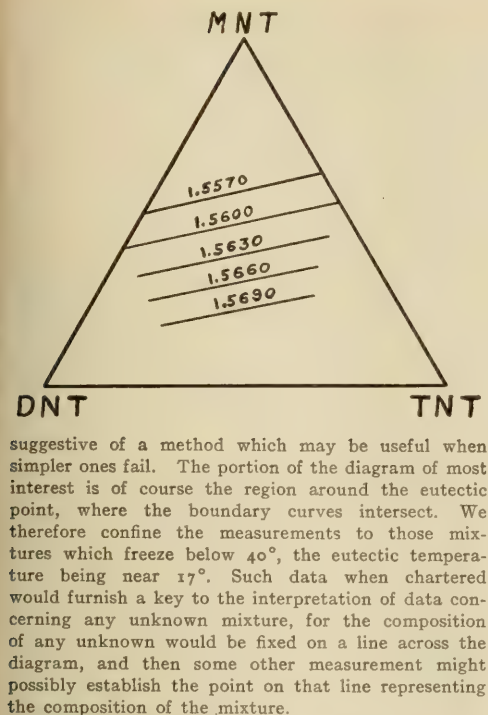
¹ This paper is the second of a series dealing with the freezing points and thermal properties of the nitrotoluenes, the investigation having been undertaken at the request of the Division of Chemistry and Chemical Technology of the National Research Council.

² Presented to the faculty of the University of North Carolina by E. O. Cummings in partial fulfillment of the requirement for the degree of Bachelor of Science in chemistry, June 1919.

MNT

DNT

TNT



COMPOSITION IN WEIGHT PER CENTS			REFRACTIVE INDEX		COMPOSITION IN WEIGHT PER CENTS			REFRACTIVE INDEX	
MNT	DNT	TNT	Observ.	Calc.	MNT	DNT	TNT	Observ.	Calc.
40	60	0	1.5599	1.5600	35	40	25	1.5631	1.5635
45	55	0	1.5580	1.5585	30	40	30	1.5657	1.5654
50	50	0	1.5568	1.5570	25	40	35	1.5678	1.5673
55	45	0	1.5557	1.5555	20	40	40	1.5695	1.5692
60	40	0	1.5539	1.5540	55	35	10	1.5557	1.5553
60	35	5	1.5541	1.5544	50	35	15	1.5577	1.5582
60	30	10	1.5548	1.5548	45	35	20	1.5594	1.5601
60	25	15	1.5556	1.5552	40	35	25	1.5614	1.5620
60	20	20	1.5564	1.5556	35	35	30	1.5636	1.5639
60	15	25	1.5554	1.5560	30	35	35	1.5658	1.5658
60	10	30	1.5564	1.5564	25	35	40	1.5675	1.5677
60	5	35	1.5568	1.5568	20	35	45	1.5699	1.5696
60	0	40	1.5572	1.5572	55	30	15	1.5565	1.5567
55	60	5	1.5621	1.5619	50	30	20	1.5583	1.5586
50	60	10	1.5634	1.5638	45	30	25	1.5601	1.5605
40	55	5	1.5605	1.5606	40	30	30	1.5620	1.5624
35	55	10	1.5623	1.5625	35	30	35	1.5638	1.5643
30	55	15	1.5644	1.5644	30	30	40	1.5664	1.5662
25	55	20	1.5664	1.5663	25	30	45	1.5682	1.5681
20	55	25	1.5685	1.5682	55	25	20	1.5568	1.5571
45	50	5	1.5585	1.5589	50	25	25	1.5585	1.5590
40	50	10	1.5602	1.5608	45	25	30	1.5606	1.5609
35	50	15	1.5622	1.5627	40	25	35	1.5626	1.5628
30	50	20	1.5643	1.5646	35	25	40	1.5650	1.5647
25	50	25	1.5668	1.5665	30	25	45	1.5668	1.5668
20	50	30	1.5682	1.5684	25	20	55	1.5676	1.5575
15	50	35	1.5700	1.5703	50	20	30	1.5592	1.5594
10	50	40	1.5725	1.5722	45	20	35	1.5610	1.5613
50	45	5	1.5570	1.5574	40	20	40	1.5628	1.5632
45	45	10	1.5589	1.5593	35	20	45	1.5656	1.5651
40	45	15	1.5608	1.5612	55	15	30	1.5579	1.5579
35	45	20	1.5630	1.5631	50	15	35	1.5596	1.5598
30	45	25	1.5645	1.5650	45	15	40	1.5622	1.5617
25	45	30	1.5669	1.5669	40	15	45	1.5636	1.5636
20	45	35	1.5686	1.5688	55	10	35	1.5582	1.5583
15	45	40	1.5710	1.5707	50	10	40	1.5597	1.5602
55	40	5	1.5557	1.5559	45	10	45	1.5620	1.5621
50	40	10	1.5574	1.5578	55	5	40	1.5586	1.5587
45	40	15	1.5594	1.5597	50	5	45	1.5606	1.5606
40	40	20	1.5612	1.5616	55	0	45	1.5592	1.5591

The apparatus used was an Abbé refractometer, through the prisms of which water circulated from a thermostat held at 38–39°. As the temperature coefficient is small, slight temperature variations were

allowed. The accompanying table records the results, and the triangular diagram shows the lines of equal refractive index.

These results accord, within the experimental error, in all but a few instances with calculated values in column 5, which have been obtained from the formula

$$n = 1.542m + 1.572d + 1.580t,$$

where m , d , and t are the fractions by weight of mono-, di- and trinitrotoluenes in the mixture. Thus, the refractive index of a mixture at 38–39° is an additive property, and may be expressed by a linear equation.

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SOME PROPERTIES OF COMMERCIAL SILICATE OF SODA¹

By JAMES G. VAH.

Received May 20, 1919

Sodium silicate is a name familiar to every chemist, but a somewhat extended experience and a search of the literature has led to the observation that the properties of commercial silicate of soda and the wide variety of physical characteristics which can be secured in its different types are often imperfectly understood. New uses for silicate of soda are continually being found, and it is thought that a more general knowledge of its properties may be helpful.

A definite compound of the formula Na_2SiO_3 is easily prepared in crystalline form from solutions containing sodium hydroxide and commercial sodium silicate. It crystallizes with 9 molecules of water. It melts in its water of crystallization at about 40° C. It is rapidly decomposed by the carbon dioxide of the air. As far as known, this product has no commercial significance, because it lacks those colloidal properties upon which practically all of the commercial applications of silicate of soda depend.

All the forms of sodium silicate in commercial use contain more silica than is indicated by the formula Na_2SiO_3 , one grade having about four times this amount. The ratio between sodium oxide, Na_2O , and silica, SiO_2 , may be varied between 1 to 4 and 2 to 3. Products more alkaline than the latter ratio are not made, on account of their tendency to form crystalline masses, which would interfere with their usefulness; and the practical limit in the other direction, namely, 1 to 4, is determined by the very low solubility of fused sodium silicate containing larger proportions of silica.

The fused masses resulting from the reaction between pure sand and sodium carbonate, or sulfate, have the physical appearance of glass, but are less permanent, and—especially the more alkaline types—effloresce in damp air in the course of a few weeks, so as to become practically opaque. The commercial grades are usually colored either greenish or yellow, due to the presence of small quantities of ferrous or ferric iron. Ferric iron is more frequently observed in the alkaline types, while those rich in silica usually

¹ Presented before the Division of Industrial and Engineering Chemistry at the Philadelphia Meeting of the American Chemical Society, September 2 to 6, 1919.

appear on the market as a greenish glass, not unlike window glass or green bottle-glass.

The solutions of these different silicates vary largely in their characteristics. To take the two extremes: that with a ratio of 1 to 4, as above, may be concentrated to about 37° Bé., which corresponds to about 34 per cent total solids. At this concentration its consistency is jelly-like, and masses of it may be picked up in the hand and shaken off without difficulty. If it is cooled to 5° C. it may be molded in the hand into balls which bounce very much like rubber balls, but which, if subjected to too much strain, will break with a clear vitreous fracture. The same result may be secured at ordinary temperatures by slightly increasing the concentration. Any forms molded from such a solution will slowly flatten out if left on a smooth surface, much after the manner of asphalt in warm weather. In contrast to this type, a silicate with a ratio of 2 to 3 is thinly fluid at 37° Bé., and may be concentrated to approximately 69° Bé., or about 62.5 per cent total solids. At this concentration its consistency is such that one may push a pencil into it with some difficulty. It flows slowly. A bubble in a tube of 2 in. in diameter will rise about 4 in. in 24 hrs. at 20° C. through such a solution. While the siliceous type breaks like a jelly, this type is very tough and may be drawn into long threads or "pulled" like molasses taffy until it becomes opaque and white. It is extremely sticky and dries much more slowly than the less alkaline forms. It will absorb moisture in damp weather.

Between these two extremes any intermediate grade can be produced; thus a considerable range of characteristics which are of importance in the adhesive uses of silicate of soda can be secured. As the proportion of alkali increases, the possible concentration increases, and there are in regular use different silicate solutions of 37°, 40°, 42°, 47°, 50°, 52°, 60°, and 69°, each adapted especially for some commercial use. Silicate is usually placed upon the market at a concentration near the practical limit, to avoid the expense of shipping unnecessary amounts of water. It is mostly sold in solution, however, on account of the difficult solubility of the anhydrous material.

The colloidal nature of silicate solutions is indicated by boiling points but little higher than the boiling point of water. This is true even in the case of the 69° solution which contains more than 62 per cent of solids. The freezing points also are but slightly depressed from that of water. The ordinary 40° silicate freezes at about -3° C. It becomes opaque and white. The freezing process is characterized by the rapid growth of long crystalline masses, which contain more water than the 40° solution. When such a solution is slightly warmed, the crystals tend to float, and it often happens that tank cars of 40° sodium silicate which have frozen and then thawed will contain a highly concentrated silicate at the bottom and a relatively dilute solution at the top. These are readily mixed together, and the solution thus secured is, as far as known, identical in properties with

the original. Solutions above 60° Bé. in concentration do not lose their transparency on freezing, but become progressively harder and finally brittle. They show no tendency to separate into concentrated and dilute portions when warmed to ordinary temperature.

Silicate of soda is precipitated by most salts of the heavy metals, and the precipitates are believed to contain free silicic acid along with metallic silicates. Precipitation is also effected by various liquids which tend to dehydrate the silicate solution. For instance, alcohol, glycerin, salt brine, and strong ammonia solutions will precipitate concentrated solutions of sodium silicate. Such precipitates may be redissolved, but the second solution has somewhat different characteristics from the original silicate solution, notably in respect to viscosity. An exact study of the nature of these precipitations would be an interesting field for research.

The viscosities of solutions of silicate of soda are of interest in connection with many of its uses. The forms rich in silica rise slowly in viscosity until the condition of jelly is approached, when they rise very sharply. This is true whether the rise in viscosity is due to decrease of alkalinity, decrease of temperature, or increase in concentration. To prepare a silicate adapted as a quick-setting adhesive, use is made of this fact. A change from a liquid to a solid condition may occur with the loss of as little as 10 per cent of moisture, this amount being very quickly absorbed into a layer of paper board when the silicate is thinly spread on its surface. Solutions adaptable for this sort of work do not air-dry below about 20 per cent moisture. If dried in mass to this condition, the solid solution has the appearance of glass, becomes hard enough to cut the hand, and is much more soluble than anhydrous silicate of the same relative composition. If suddenly exposed to a temperature above the boiling point of water, such a solution will expand into a mass of permanent bubbles of beautiful white appearance and apparent specific gravity as low as 0.01. Such a product is an excellent thermal insulator.

Silicate of soda is the most convenient source of gels of silicic acid which may be prepared with either alkaline or acid reaction by neutralizing more or less completely. Any mineral acid can be used for this purpose, and by varying concentrations of acid and of silicate solution, gels of a wide variety of physical characteristics can be secured. Strongly acid gels have been used to prevent the splashing of acid from storage batteries. Very hard neutral gels have been used for preparing material suitable for the adsorption of gases.

The strength of adhesives and cements produced from silicate of soda is very great. If pieces of hard wood are glued together, end to end, with a silicate solution containing slightly more than 3 molecules of silica (SiO_2) for each of sodium oxide (Na_2O), a tensile strength of 500 lbs. per sq. in. may be consistently secured. About 200 lbs. per sq. in. tensile strength is required to pull the fiber sidewise from

gum veneer, such as is ordinarily used in packing boxes, while 50 lbs. per sq. in. is sufficient to pull the fiber from any of the kinds of paper usually used for making built-up board for shipping containers and wall-board. The tensile strength of silicate of soda mixtures used for acid-proof cements is easily brought up to 1700 lbs. per sq. in. for air-dried briquettes, while the bond produced by baking silicate of soda and clay, as is the practice in the manufacture of abrasive wheels, easily yields a strength above 2,000 lbs. per sq. in.

To recount all the uses of silicate of soda and the properties on which they are based is beyond the scope of this article, but in spite of its diverse applications in the arts at this time it is plain to those who have worked with it that much remains to be learned. Studies are in progress which it is hoped may be useful.

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PHTHALIC ANHYDRIDE. I—INTRODUCTION

By H. D. GIBBS

Received August 19, 1919

Early in the year 1916 my attention was directed to the shortage of phthalic anhydride and its derivatives¹ and the difficulty attending the manufacture of this valuable intermediate for certain dyes and medicinals by the known processes. The best known and most economical process consisted in the oxidation of naphthalene by means of sulfuric acid in the presence of mercury compounds as catalyst.² An extensive study of this process on a laboratory scale was very disheartening and my experience in this regard was borne out by that of many other investigators. The yields were very erratic for unknown reasons, occasionally reaching 55 per cent of the theoretical, but averaging nearer 25 per cent. This line of investigation was discarded very early and experiments on the vapor phase oxidation of naphthalene in the presence of catalysts were begun with a view to paralleling a similar process for the production of benzaldehyde by the air oxidation of toluene.

The shortage of the supply of benzaldehyde for commercial uses had resulted in requests upon the Bureau of Chemistry for information concerning the best methods of manufacture and led to studies on the chlorination of toluene,³ since this process is generally regarded as the first step in the large-scale pro-

duction of benzaldehyde and some other valuable compounds. This laboratory was engaged in studies on malachite green and was therefore interested in the production of benzaldehyde. Very shortly afterwards I was impressed by the advantage of a direct oxidation process, if such could be devised, eliminating several troublesome steps in the introduction of the oxygen in the side chain of toluene.

Many methods have been proposed for oxidizing the methyl group of toluene in the wet way with solutions of various oxidizing substances, but these were not studied, being discarded in favor of vapor phase studies. Mixtures of oxygen and toluene, and later atmospheric air and toluene, were passed into contact with various substances at temperatures varying from the boiling point of toluene to 550°. Every substance tested by this method, and they were very numerous, catalyzed the reaction more or less, the valuable products being benzaldehyde and benzoic acid, the former predominating. Ultraviolet light was without effect. The oxides of the metals⁴ of the fifth and sixth groups of the periodic system were found to be most efficient, vanadium first and molybdenum second. I first gave a summary of this work at the Fifty-third Meeting of the AMERICAN CHEMICAL SOCIETY in New York, before the Division of Industrial Chemists and Chemical Engineers, September 27, 1916. A further account of the work was read at the Kansas City Meeting in April 1917.

Studies of the remarkable properties of the compounds of molybdenum and vanadium, both in a pure state and mixed with various other ingredients, in their power to catalyze other oxidation reactions were prosecuted and the next success was in producing phthalic anhydride from naphthalene.

The principal reactions that have been developed are: naphthalene to phthalic anhydride,² anthracene to anthraquinone,³ phenanthrene to phenanthraquinone.⁴ Others are under investigation. Methods for purification of phthalic anhydride have also been studied.⁵

The demand for phthalic anhydride being most acute, the naphthalene oxidation was the first that was carefully investigated, to determine the best conditions of temperature, gas mixture, time of contact, and condition of catalyst to produce the optimum yield. The best laboratory experiments gave a conversion equivalent to 82 per cent of the theoretical yield or about 95 g. of phthalic anhydride for each 100 g. of naphthalene. A small-scale factory unit was constructed in the laboratory and operated for one hour with the production of about 150 g. of phthalic anhydride. The operation was then discontinued because of evident defects in the construction.

The Department of Agriculture issued an announcement⁶ on June 16, 1917, offering cooperation with

¹ At this time very little phthalic anhydride or phthalic acid was made in this country and the little that was made was produced at great expense by the use of sulfuric acid as an oxidizing agent for naphthalene. Consequently there arose a shortage of phthalic anhydride derivatives and the prices were very high. The abnormal prices were about as follows: Phthalic anhydride, \$7.50, and small lots at \$14 per lb.; phenolphthalein, \$8 to \$20; rhodamine Bx, \$75; eosine, \$12 to \$15; erythrosine, \$24, and purified for food color \$30; rose bengale, \$50.

In 1917 (the Tariff Commission, Census of Dyes and Coal-Tar Chemicals 1917) small quantities of rhodamine B, uranine, phloxine P, and rose bengale B were manufactured and average prices for the following are reported: Phthalic anhydride, \$4.23 per lb.; phenolphthalein, \$9.65; eosine, \$8.58; and erythrosine, \$11.31.

² Levinstein, *J. Soc. Dyers Colorists*, [6] 17 (1901), 138; "Über Indigo-darstellung," *Chem.-Ztg.*, 32 (1908), 602.

³ Gibbs and Geiger, U. S. Pat. 1,246,739 (1917).

⁴ Gibbs, U. S. Pat. 1,284,887 (1918); application filed September 22, 1916.

⁵ Gibbs and Conover, U. S. Pat. 1,284,888 (1918) and 1,285,117 (1918).

⁶ Conover and Gibbs, U. S. Pat. 1,303,168 (1919).

⁷ Lewis and Gibbs, U. S. Pat. 1,288,431 (1918).

⁸ Conover and Gibbs, U. S. Pat. 1,301,388 (1919).

⁹ *THIS JOURNAL*, 9 (1917), 815; *Oil, Paint and Drug Reporter*, June 25, 1917, p. 16.

chemical manufacturers for the purpose of introducing the process into the plants on a commercial scale. Some months later all of the coöperation that could be handled advantageously was effected and the constantly increasing pressure of war problems employing the laboratories and personnel made it advisable to withdraw the offer, which was done on November 1, 1917.¹ Shortly after the signing of the armistice it was decided to reopen the offer of coöperation and an announcement to that effect was issued on March 17, 1919.² The reasons for this action were several.

First—The work upon war problems was practically over and men and funds were again available for the work for which this laboratory was planned.

Second—Several manufacturers stated that they could not enter into the coöperative agreement when first announced because at that time their entire staff was devoted to work on hand, but that now their resources were larger, war work was over, parts of the plant were idle, and they would like to be put in position to utilize the information originally given to other coöperators and upon the same terms.

Third—Publications of the completed work will not be ready for an indefinite period, since the scope of the investigations is undergoing great expansion, and it is considered desirable that the manufacturing process first be firmly established in this country. In the interim coöperators are furnished immediate reports on the latest developments.

Fourth—It seems desirable that a number of plants work upon the same problem in order that the best commercial installation be ultimately obtained.

Although the development was delayed somewhat by war conditions, the large-scale manufacture of phthalic anhydride is now proceeding in a satisfactory manner, and it is believed that eventually the details of the factory units will be so worked out that this process will be the most economical and practicable known for making phthalic anhydride. In fact, phthalic anhydride may become one of the cheapest organic compounds.

It is interesting to note that the phthalic anhydride produced by this process is of a remarkable degree of purity. Naturally it is free from chlorine or sulfur compounds, common impurities in phthalic anhydride as formerly found on the market.

Many data on the work have accumulated and new facts are continually being discovered. A series of papers descriptive of the work is now in preparation and will appear at intervals when the status of this and other investigations will permit.

COLOR LABORATORY
U. S. BUREAU OF CHEMISTRY
WASHINGTON, D. C.

HYGROSCOPIC PROPERTIES OF BLACK POWDER³

By G. B. TAYLOR
Received May 21, 1919

Among the questions referred to the Bureau of Mines by the military authorities during the war was

that of whether black powder in which a small part of the potassium nitrate had been replaced by potassium perchlorate was less resistant to moisture than straight black powder. This led to a brief study of the conditions under which black powder absorbed atmospheric moisture, the results of which are presented in this report. The fact that powder is more effective in the moisture-free condition is embodied in the old admonition to "keep your powder dry."

The methods followed were those of a previous investigation on moisture absorption by detonators.¹ The rate of moisture absorption in a saturated atmosphere was determined at 25° C. by exposing the material in shallow flat-bottom crucibles. Ordinary quart jars closing with glass tops and spring clamps were filled about an inch deep with distilled water; in each jar was placed a copper wire tripod for supporting one crucible. The jars were then closed and submerged completely in a large water thermostat electrically heated and stirred, and controlled by a toluene thermoregulator within $\pm 0.01^\circ$ of 25° C.

Two grams of the material whose rate of moisture absorption was to be determined were spread evenly over the bottom of the crucible (3.7 cm. in diameter), the crucible brought to 25°, and placed in one of the jars. After a certain number of hours the crucible was removed, placed in a weighing bottle, and weighed. Each result was obtained from a separate crucible, as it was found unsatisfactory to return the same crucible to the jar, on account of change in temperature of the crucible during weighing and slight losses in moisture while handling.

It was found in the previous investigation² that the moisture absorbed in a given time by pure salts under the conditions above outlined was independent of the weight of salt taken within certain limits (0.5 to 2.0 g.) and also independent of the degree of fineness to which the salt was ground. The relative rates of moisture absorption of different salts were found to be proportional to the difference between the vapor pressures of their saturated solutions and the partial pressure of water vapor in the surrounding atmosphere. It follows that when this difference is zero or when the partial pressure of water vapor in the surrounding atmosphere is less than the vapor pressure of the saturated solution of the salt no moisture will be absorbed. In the latter case a moist salt would dry out.

In American practice black powder is a mixture of 75 per cent potassium or sodium nitrate, 10 per cent sulfur, and 15 per cent charcoal. Moisture absorption is largely due to the nitrate or soluble constituents. Charcoal plays a small part.

EXPERIMENTAL

Two samples of black powder were submitted by the Ordnance Department for test. These were given the laboratory numbers M-2332 and M-2333. The size of grain appeared to be F. For comparison, the

¹ G. B. Taylor and W. C. Cope, "Hygroscopic Properties of Sodium, Potassium, and Ammonium Nitrates, Potassium Chlorate, and Mercury Fulminate," *Mel. & Chem. Eng.*, **15** (1916), 140.

² *Loc. cit.*

¹ THIS JOURNAL, **9** (1917), 1148.

² *Ibid.*, **11** (1919), 489.

³ Published by permission of Director, U. S. Bureau of Mines.

Bureau of Mines secured a sample of straight black powder, M-2334, size FF. The analyses follow:

TABLE I

	M-2332	M-2333	M-2334
KNO ₃	70.56	68.79	74.37
Sulfur.....	10.43	10.45	10.28
KClO ₄	2.91	4.80	
Charcoal.....	15.78	15.44	15.08
Moisture.....	0.32	0.52	0.27
	100.00	100.00	100.00

The rate of moisture absorption was determined on all these samples in a saturated atmosphere at 25° both as received and after crushing the grains to about 40 mesh. The results are given in Table II. Two-gram samples were weighed out in crucibles and desiccated over sulfuric acid several days previous to the tests.

TABLE II—RATE OF MOISTURE ABSORPTION IN A SATURATED ATMOSPHERE AT 25° C.

MATERIAL	HOURS	Moisture Absorbed Gram
M-2332, crushed grains (2.91 per cent KClO ₄).....	17 1/2	0.1665
	30 1/2	0.2354
	48 1/4	0.3803
M-2333, crushed grains (4.80 per cent KClO ₄).....	17 7/8	0.1649
	30	0.2482
	48	0.3844
M-2334, crushed grains.....	17 3/4	0.1420
	29 1/2	0.2174
	47 1/2	0.3595
M-2332, as received (2.91 per cent KClO ₄).....	7	0.0670
	16 1/2	0.1311
	30 1/2	0.2386
M-2333, as received (4.80 per cent KClO ₄).....	7	0.0607
	16 1/2	0.1248
	30 1/2	0.2173
M-2334, as received.....	7	0.0587
	16 1/2	0.1158
	30 1/2	0.2186
Potassium perchlorate.....	17	0.0070
	41 1/4	0.0191
	63	0.0238
Potassium perchlorate, 5 per cent }.....	61 1/2	0.0429
Potassium nitrate, 95 per cent... }	23 3/4	0.1582
	47 3/4	0.3012

For purposes of comparison the rates of moisture absorption of pure potassium perchlorate and a mixture of 5 per cent of this salt with 95 per cent pure potassium nitrate were determined. The results obtained are plotted in Fig. 1. When the increase in weight due to absorbed moisture is plotted against time, the points for pure salts lie on straight lines. In the figure the potassium chlorate, potassium nitrate, and sodium nitrate lines are taken from a former Bureau of Mines investigation.¹ To make sure that the conditions of experiment were the same, two points on the potassium nitrate line and one on the potassium chlorate were repeated. The new and old data were found to be in agreement.

Inspection of the figure shows that potassium perchlorate takes up moisture slowly from a saturated atmosphere, as might have been expected from its slight solubility. Calculation from its rate of moisture absorption shows that this salt is not hygroscopic unless the relative humidity exceeds 99 per cent at 25° C. Potassium nitrate absorbs moisture when the relative humidity exceeds 93 per cent, so that it was not to be expected that perchlorate would greatly influence the hygroscopicity of nitrate. The experimental results show that a mixture of 95 per cent potassium nitrate and 5 per cent potassium per-

chlorate absorbs moisture at practically the same rate as pure nitrate. It may be interesting to point out, however, that a mixture of 95 per cent perchlorate and 5 per cent chlorate absorbs moisture during the first 48 hrs. as fast as pure chlorate.

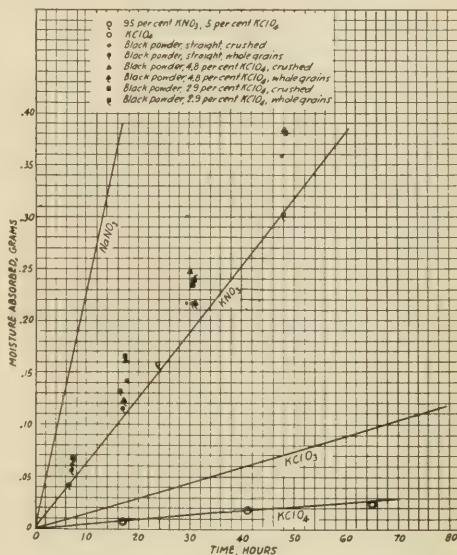


FIG. 1

The fact that a mixture of 5 per cent perchlorate with nitrate absorbs moisture at practically the same rate as pure nitrate would seem to indicate that the replacement of part of the nitrate in black powder by perchlorate does not increase its sensitiveness towards atmospheric moisture. Charcoal also absorbs moisture, which accounts for the deviation of black powder from the potassium nitrate line. In order to determine the order of magnitude of this effect, the soluble constituents of the powders were carefully washed out with water and the resulting charcoal-sulfur mixture dried and then exposed to a saturated atmosphere at 25° until equilibrium was reached. The results follow:

TABLE III

Weight of charcoal and sulfur mixture	GRAM OF MOISTURE ABSORBED AT EQUILIBRIUM AT 25° C.		
	M-2332	M-2333	M-2334
0.100	0.0190	0.0133	0.0153
0.250	0.0310	0.0252	0.0393

Equilibrium occurs in about 24 hrs. The results of the table were obtained from 48 hrs. exposure and it is seen that the moisture absorbed in proportion to weight within the experimental error. Two-gram samples containing 0.5 g. of charcoal-sulfur can absorb about 0.06 g. of water due to this mixture, which is about the maximum deviation of the powder samples from the potassium nitrate line.

The slightly greater affinity for atmospheric moisture of the samples containing perchlorate over the sample of straight black powder is of no practical im-

¹ Taylor and Cope, *Loc. cit.*

portance and may be accounted for by variations in structure or minor impurities. None of the samples gave a positive flame test for sodium.

SUMMARY

1—The relative rates of moisture absorption of three samples of black powder in a saturated atmosphere at 25° have been determined.

2—The presence of potassium perchlorate up to 5 per cent in mixtures with potassium nitrate has been shown to have only slight effect on the rate of moisture absorption.

3—Charcoal has been shown to contribute to the hygroscopic property of black powder but in much smaller degree than nitrate.

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THE COLOR CHANGES OF SUGAR-CANE JUICE AND THE NATURE OF CANE TANNIN¹

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Received May 2, 1919

A former article on this subject² dealt with the rôle of oxidases and of iron in the color changes of sugar-cane juice. The third factor known to be involved in the reactions is a water-soluble polyphenol which gives a green coloration with ferric salts. The previous literature regarding the whole subject was discussed in the paper referred to, but since its publication there has been noticed a very interesting and valuable contribution, overlooked before, on the oxidases of the sugar cane, by Ramji Narain.³ His studies were made more particularly from the standpoint of the plant physiologist, the principal object being the discovery of possible connections between oxidase activity and the formation of carbohydrates in the plant. He obtained positive reactions for a laccase and for peroxidase, but did not find tyrosinase, evidently because he did not employ the specific reagent consisting of *p*-cresol and glyocoll. Narain also reports some observations regarding the thermostability of cane oxidase. He found that his oxidase preparations could be boiled vigorously for 15 min. without the permanent loss of their effect. Their activity was found to be greatly impaired directly after boiling, but it reappeared almost undiminished after cooling. The boiling for 15 min. could even be repeated with the same effect as before. Like observations were made by him upon treating the oxidase preparations with hydrogen sulfide. Similar results had been previously obtained by Euler and Bolin, and by others, but it appears that the action of heat on oxidases depends largely on their state of purity. Narain draws the conclusion that oxidases can no longer be classed as enzymes, because they do not show the characteristic thermolability of these substances. Neither Browne nor Raciborski report the return of the activity of cane oxidase after boiling, and our own experiments did not confirm

Narain's results. But even if the oxidases were not permanently inactivated by boiling, the matter of their classification still depends entirely on the definition of "enzymes." Schmidt,⁴ Gramenitzki,⁵ Mellanby and Woolley,³ report that under certain conditions, trypsin, taka-diastase, and other enzymes can be boiled, and trypsin be heated in glycerol to 292°, without permanently losing their activity, and yet nobody has ceased to classify them as enzymes. If we accept the definition of Bayliss,⁴ who says that "Enzymes are merely a particular class of catalysts, considered for convenience apart, owing to the fact that they are produced by living organisms and are, for the most part, of unknown chemical constitution," then the resistance to heat is not a sure criterion for classification. It is true that oxidases differ from other enzymes also in not being specific, but even this is no reason for separate classification under Bayliss's definition.

Narain in the same paper also publishes some observations on the polyphenol of the cane. He states that on account of its behavior with lime water it must belong to the oak tannin group and not to the gallotannic acid group, but that some of its reactions resemble those of pyrogallol. He was unable to isolate pyrocatechin from the cane. This polyphenol, according to Miss Wheldale,⁵ is the cause of the guaiac reaction given by a number of plants. The author's experiments fully confirm Narain's claims on this point. Miss Wheldale's supposed pyrocatechin was most probably some other substance, because she reports finding it after treatment of the plant extract with chloroform, in which solvent pyrocatechin is appreciably soluble. Dekker⁶ also expresses serious doubts concerning the alleged occurrence of pyrocatechin in plants. The absence in sugar cane of pyrocatechin was proven by us by digesting sliced cane tops, which give a strong reaction with ferric salts, with benzene in a glass-stoppered bottle. The benzene extract was evaporated, the residue treated with water, filtered, and the filtrate tested for pyrocatechin. It did not even give the iron reaction.

In our further investigations on the nature of the cane polyphenol, we first tried to prepare extracts rich in this substance by dropping sliced cane tops, and eyes cut from the cane, into alcohol. This was done during the grinding season, and we hoped to work up these extracts after the end of the campaign. But it was found that, in spite of the high percentage of alcohol which was used to weaken enzyme activity, the extracts darkened very much while being kept, and we concluded that a large part of the polyphenol originally present must have been oxidized. After a number of unsuccessful attempts to prevent this oxidation, we finally adopted the method of slicing cane tops directly into boiling water, continuing the boiling for 5 to 10 min., and then pressing the juice out rapidly

¹ *Z. physiol. Chem.*, **67**, 314.

² *Ibid.*, **69**, 286.

³ Bayliss, "The Nature of Enzyme Action," 3rd Ed., p. 97.

⁴ *Loc. cit.*, pp. 11, 139.

⁵ *Proc. Roy. Soc.*, **84B** (1911), 121.

⁶ *De Looistoffen*, **1**, p. 209.

¹ Presented at the 56th Meeting of the American Chemical Society, Cleveland, Ohio, September 9 to 13, 1918.

² *This Journal*, **10** (1918), 814.

³ *Agr. J. India*, **1918**. Science Congress Number, 47.

in a fruit press. The extract had only a faint green color, from small quantities of iron dissolved from the press. The further treatment was based on the fact, ascertained by special tests, that the polyphenol is not precipitated by lead nitrate, but practically completely by neutral lead acetate. We, therefore, added at once, to the still hot extract a slight excess of lead nitrate solution. This caused a heavy precipitate which gave no reaction with ferric salts and consisted largely of lead sulfate, phosphate, organic lead salts, and other organic matter. The precipitate was filtered off, and the filtrate treated with neutral lead acetate solution in slight excess. The filtrate from this gave only a very faint iron reaction. The precipitate was suspended in water and decomposed with hydrogen sulfide. After filtering off the lead sulfide, the solution, which showed only a slight yellow color, was rapidly concentrated under diminished pressure, and finally brought to dryness in a vacuum desiccator over sulfuric acid. The residue was a buff-colored, amorphous mass and had an astringent, but at the same time very acid taste.

The product obtained was further purified by treating in an extraction apparatus for 12 hrs. with anhydrous ether, in which the polyphenol is almost insoluble. The ether extract, upon evaporation, left a considerable quantity of a crystalline substance which would have contained any pyrocatechin present in the crude product. It showed a slight iron reaction, and was, therefore, extracted with benzene. The benzene was evaporated off, and a water extract of the residue tested for polyphenols with iron solution. The result was absolutely negative, and the reaction obtained before with the ether extract must have been due to small quantities of the polyphenol itself, dissolved by ether.

That part of the ether-soluble material which was not dissolved by benzene was suspected to consist of aconitic acid. This acid had been previously found in cane juice by Behr¹ and Szymanski,² and was proven by Yoder³ to be the principal organic acid in sugar cane. Aconitic acid is precipitated by lead acetate, but not by lead nitrate. The crude acid obtained from the ether extract mentioned above was first converted into the acid ammonium salt, and this crystallized. The water solution of this salt was acidified, extracted with ether, and the ether evaporated. The acid was then once more recrystallized, and the resulting crystals showed under the microscope the characteristic appearance of aconitic acid. The melting point was found to be 178°, while the pure acid, made synthetically, melts at 191°. But Behr found for aconitic acid from cane a melting point of 171 to 173°, and Szymanski 167°. The acid was further identified by analysis of the silver salt, which contained 65.28 per cent silver, against 65.45 per cent calculated.

The polyphenol preparation, after the removal of ether-soluble substances, was digested with alcohol, and the insoluble gummy substances filtered off. The solution was again evaporated under diminished

pressure, and finally dried in a vacuum desiccator over sulfuric acid. The material obtained in this way was still amorphous, and had the same appearance as the original preparation before treatment with ether and alcohol. A number of tests were first made to see whether the polyphenol belonged to the tannins, or was of simpler constitution. It was found to be soluble in water, alcohol, acetone, and ethyl acetate, but practically insoluble in ether, benzene, and chloroform. A 1 per cent solution of the material gave a precipitate with acidified gelatin-salt solution. This reaction is generally considered characteristic of the tannins, and is not given by simpler polyphenols, except by gallic acid in the presence of gum arabic. The delicate reaction of Allen, with an ammoniacal solution of potassium ferricyanide, was also positive. Lime water gave at the first moment an olive coloration which quickly changed to yellowish brown. Upon standing, a brown precipitate settled out. Bromine water gave at once a yellow precipitate, which darkened and increased in quantity on standing. One per cent ferric alum solution gave a pure green color, which on careful addition of sodium bicarbonate solution first darkened, then changed to bluish purple, and finally to purple-red. Ferric chloride and sodium acetate also gave a green color, but upon slowly adding dilute bicarbonate solution, the color first changed to greenish blue, and then through purple to purplish red. The exact color obtained depends entirely on the hydrogen ion concentration, and this shows that the differentiation between tannins on the basis of their iron reaction is quite arbitrary, because the color may be green or blue according to the reaction. Sodium nitrite plus a few drops of *N*/10 hydrochloric acid produced a reddish brown color, which did not change further. One per cent copper sulfate solution gave a precipitate which dissolved in ammonia with an olive color. Stannous chloride in concentrated hydrochloric acid developed on standing a pink coloration. With solid sodium sulfite no reaction was obtained, and pine wood moistened with hydrochloric acid gave only a faint bluish green color.

This behavior towards reagents would make it appear that the cane polyphenol belongs to Class 1a in Proctor's classification.¹

For the purpose of further identification the effect of heat, of dilute acids, and of potash fusion on the polyphenol was investigated.

ACTION OF HEAT—One-half gram of the polyphenol preparation in 5 cc. of glycerol was gradually heated to 200°, and the heating continued at this temperature for 25 min. After cooling, the mixture was diluted with water and shaken out several times with ether. The residue left after evaporating the ether was found to be soluble in benzene. It gave a fine green color with ferric chloride, changing to purple and red upon addition of sodium bicarbonate, and a pine splinter moistened with hydrochloric acid developed a bluish green color. No characteristic reaction was obtained with lime water. The melting point was found to be

¹ *Ber.*, **1** (1877), 351.

² *Ber. Versuchsst. West-Java*, **2** (1896), 25.

³ *This Journal*, **3** (1911), 640.

¹ *J. Soc. Chem. Ind.*, **13** (1894), 487.

98°. It was, therefore, pyrocatechin, and pyrogallol was evidently not formed by heating the raw material.

EFFECT OF ACIDS—This was investigated by heating 2 g. of the original polyphenol preparation with 100 cc. of 2 per cent hydrochloric acid under reflux for 2½ hrs. in a vigorously boiling water bath. Upon cooling, a small quantity of a reddish precipitate settled out, which was filtered off. It dissolved readily in cold alcohol, and was reprecipitated from the solution by adding water acidulated with hydrochloric acid. It was, therefore, a phlobaphene, no ellagic acid being formed. The filtrate from the phlobaphene was shaken out several times with ether, and the ether evaporated. A considerable residue remained which was insoluble in benzene. It was taken up in water and the solution filtered. It gave a precipitate with neutral lead acetate, soluble in acetic acid. The filtrate from the lead precipitate gave no precipitate with lead subacetate. Ferric alum solution produced a pure green color, which, on addition of sodium bicarbonate, first changed to blue and then to a beautiful purplish red. Ferrous sulfate in neutral solution gave a fine violet color. Silver nitrate solution was reduced on warming, and ammoniacal silver solution in the cold. Pine wood moistened with hydrochloric acid was colored bluish green. These reactions show that protocathechuic acid was formed, and not gallic acid. This was further confirmed by the fact that the characteristic reaction of gallic acid with lime water, white precipitate quickly changing to blue, could not be obtained. Instead, lime water produced a beautiful purple color, which was, however, not due to pyrogallol, because it was quite permanent, while the similar color produced by pyrogallol quickly changes to brown. We are unable to say what this substance, produced in addition to protocathechuic acid, consisted of. The melting point of the protocathechuic acid was 183°, against 199° for the pure substance. A larger and purer sample of this acid was produced in the potash fusion described below.

The acid solution remaining after treatment of the tannin with hydrochloric acid and after extraction with ether was neutralized with sodium carbonate, and purified by precipitation with lead subacetate. The lead in the filtrate was removed with sulfuric acid, the excess acid neutralized with sodium carbonate, and the resulting liquid tested with Fehling's solution. A precipitate of cuprous oxide was obtained which would point to the glucoside nature of the tannin. But in the author's opinion this is no positive proof, because glucose may be present in the form of an adsorption compound, and the glucoside nature of the tannin could only be definitely proven if the tannin were crystalline and contained glucose in definite proportions.

ACTION OF ALKALI—This was tested by first boiling 5 g. of the tannin for 2½ hrs. with 100 cc. potassium hydroxide solution, 1.2 sp. gr. The product obtained did not give any reaction for caffeic acid, with ferric salts or phloroglucin-hydrochloric acid. The alkaline solution was evaporated to dryness in a copper beaker and then heated to fusion. The resulting mass was dissolved in water, the solution acidified with dilute

sulfuric acid and filtered from the potassium sulfate, which crystallized out on standing. The liquid was almost neutralized with sodium bicarbonate, shaken out several times with ether, the ether evaporated, and the residue redissolved in water. The product was further purified by precipitating with neutral lead acetate, decomposing the precipitate with hydrogen sulfide, filtering off the lead sulfide, and evaporating the solution. In this way a mass of fine, silky needles was obtained, slightly tinged with brown. They were soluble in water, alcohol, and ether, but not in benzene. They gave all the characteristic reactions of protocathechuic acid described above, and the melting point was found to be 194°.

The filtrate from the lead acetate precipitate was freed from lead and then tested for phloroglucin, but none could be found. The test with pine wood and hydrochloric acid produced a bluish green color, due evidently to some protocathechuic acid, which had not been precipitated by the lead acetate.

The original product resulting after the potash fusion, when acidified with sulfuric acid, developed a strong odor of acetic acid. A part of the liquid was, therefore, distilled with steam, and a silver salt prepared from the distillate. Evidently small quantities of a phenolic substance had also distilled over, as part of the silver nitrate added was reduced to metallic silver. The solution was heated, the metallic silver filtered off, and upon cooling, the silver salt crystallized out in the form of the characteristic nacreous laminae of silver acetate. This salt was found to contain 65.10 per cent of silver, against 64.63 per cent calculated. It was, therefore, free from propionic acid or other homologues.

The results obtained show that the tannin of the sugar cane is a pyrocatechin derivative, closely resembling the oak tannins investigated by Trimble.¹ However, it is not precipitated by Stiasny's reagent,² formaldehyde and hydrochloric acid.

SUMMARY

The polyphenol of the sugar cane giving a green color with ferric salts is not pyrocatechin. It is a true tannin, giving a precipitate with gelatin, and is, like the oak tannins, derived from pyrocatechin, not from pyrogallol. Heat alone produces pyrocatechin, and no pyrogallol; dilute acids give rise to a phlobaphene and protocathechuic acid, but not ellagic or gallic acids; potash fusion yields protocathechuic and acetic acids, but no gallic acid or phloroglucin.

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LOW TEMPERATURE-VACUUM FOOD DEHYDRATION

By K. GEORGE FALK, EDWARD M. FRANKEL AND RALPH H. MCKEE

Received June 18, 1919

INTRODUCTION

In connection with the work of the Division of Food and Nutrition, Medical Department, U. S. Army, Major (later Lieutenant Colonel) John R. Murlin

¹ "The Tannins," 2, p. 90.

² Chem. Zentr., 2 (1908), 1832.

requested the study of methods for preserving meat as part of the investigation of meat spoilage which was being carried on. It soon developed that dehydration processes offered the most promising outlook. At the time, special attention was paid to meat, but the broader aspects of dehydration as applicable to all food products were kept constantly in view.

Two of the important problems of the then existing emergency with regard to foods involved transportation and the safety factor of food handling, transportation, and storage. A satisfactory method of dehydration would help to solve both problems, making shipping simple and inexpensive and spoilage insignificant. It is not necessary at this time to discuss the general importance of food dehydration processes, as Prof. S. C. Prescott has lately given an excellent presentation¹ of this subject.

PRINCIPLES INVOLVED

In the dehydration of meat, the following seem to be the important factors: (1) The temperature of dehydration must be kept below the point at which the proteins coagulate, and the fats melt; (2) with too low a temperature the process of dehydration will be unnecessarily prolonged with the result that often spoilage will occur and the overhead cost will be greatly increased; (3) if the removal of water takes place exclusively from the outer surface, as in the use of a stream of heated air, a cornified layer is likely to form, thereby preventing evaporation of moisture from the inner parts and resulting ultimately in spoilage of the product; (4) the fats in the meat must not be allowed to become rancid as by oxidation; (5) a sufficient quantity of heat must be supplied to evaporate the large percentage of water present. Briefly, the conditions to be met include a suitable temperature, absence of air, and the addition of the needed calories of heat energy.

These conditions were first worked out with a small sized vacuum chamber, suitably modified, loaned by Professors H. C. Sherman and T. B. Freas, of Columbia University. The process was then carried over to the commercial size vacuum dryer in the chemical engineering laboratories of Columbia University.²

The solution of the problem involves heating the meat (or other food product) cut in pieces of suitable size to a temperature below that at which cooking or appreciable changes in the meat take place; continuously maintaining a degree of vacuum such that the vapor pressure of water at the temperature employed is greater than the pressure within the vacuum dryer, thus causing boiling and evaporation of the water from the inner parts of the meat as well as from the surface; and introducing a sufficient quantity of heat to enable the large amount of water to be evaporated by taking up the requisite number of calories of heat energy to overcome the latent heat of vaporization of water.

The commercial vacuum shelf dryer used was one permitting hot water or low-pressure (sub-atmospheric) steam to circulate through the shelves. The meat or material to be dried was placed on galvanized iron wire-gauze trays which could readily be run into the dryer onto the shelves and which gave metallic conduction from the heating surface to the substance to be dried. At the same time, the gauze trays carrying the material being dehydrated permit of evaporation of the water downwards as well as upwards. Such trays also can be readily cleaned.

DEHYDRATION OF MEAT

The method of dehydrating meat is as follows: The bones and most of the fat are removed at the time of slaughtering the animal, the meat cut into pieces of suitable size (cubes, steak or hash) and introduced into the vacuum dryer. If the dehydrating plant and the slaughter house are within a short distance of each other, the living animal heat can be retained in the meat. The vacuum pump is started and at the same time the hot water or low-pressure steam is circulated through the shelves. The process is interrupted from time to time and the trays containing the meat removed, weighed, and the loss of water controlled. The vacuum to be maintained corresponds to a pressure of about 2 in. of mercury. It is not necessary to have the dryer closed off entirely, but a "cracked" vacuum in which a small current of air is allowed to pass through the dryer is permissible and sometimes desirable, although the pressure must not be allowed to rise above that indicated. The temperature of the circulating fluid is kept at about 70° C. At first, when the meat contains most water and is most sensitive to changes due to heat and other causes, it is probable that its temperature does not rise above 50° because of the large amount of water being evaporated. As the meat becomes more dehydrated, and the rate of evaporation of the water decreases, the meat becomes correspondingly warmer, until toward the end, when danger of decomposition by heat is least, the temperature approaches that of the shelves.

The time of dehydration will vary with the size of the individual pieces of meat used. With steaks 1/4 in. thick, dehydration has been completed in 2 to 3 hrs. There is not much difference in the time for pieces of stew size and ground for hash for the same quantities per square foot of pan surface. Stew-size pieces after dehydration can readily be ground to the hash form by passage through a suitable meat grinder.

Beef contains on the average 75 per cent of its weight as water. With a shelf dryer having about 50 sq. ft. of pan surface and holding 100 lbs. of meat cut in pieces of stew size (1 in. cubes), working as indicated, the loss of weight in an 8-hr. run was in the neighborhood of 65 per cent. The most rapid loss in weight occurred during the first third of the time. A further loss in weight can be brought about by additional time in the vacuum dryer, but a more economical method of working is possible. Beef which has lost about two-thirds of its weight in water, when exposed to the atmosphere does not take up water again, but on the contrary loses additional water and becomes

¹ "Relation of Dehydration to Agriculture," U. S. Dept. Agr., Circular 126, January 25, 1919.

² U. S. Patent 1,309,357 of July 1919, and foreign patents.

dehydrated further. By exposing the dehydrated meat from the vacuum dryer to the atmosphere for two or three days, further decrease in weight takes place until the meat weighs in the neighborhood of 28 per cent of its original weight. Under these conditions it contains approximately 10 per cent of its final weight as water. Certain precautions must be exercised with regard to this supplemental air-drying. If the meat is not dehydrated sufficiently in the vacuum dryer, in the process of air-drying a dry mold may appear on some of the pieces. This mold is harmless and does not spread after the meat is dehydrated satisfactorily, but it does not look well and can readily be completely avoided by paying attention to the first, main part of the dehydration.

PROPERTIES OF DEHYDRATED MEAT

The dehydrated beef in stew size or as steaks is reddish brown to brown in color. Its volume is about one-half of that of the fresh beef. After grinding to hash form, the product is grayish brown in color. It can be compressed readily to smaller bulk. Exposed to ordinary atmospheric conditions for a year no perceptible change occurred. In a closed container saturated completely with water vapor, moisture was taken up very gradually and after four or five days at room temperatures molds began to appear on the meat. If the meat were taken out of the container at any time before the molds appeared and exposed to the atmosphere, reversion to the original dehydrated condition occurred. It is important to mention that the fat in the meat did not turn rancid on keeping under ordinary conditions.

TABLE I—ANALYSES OF MEAT BEFORE AND AFTER DEHYDRATION

	Fresh Meat		Dehydrated Meat, May 9—		Dehydrated Meat, May 9—	
	Apr. 18	Apr. 20	Room Exposed	Room Jar	Incubator Exposed	Incubator Jar
	Per cent of Meat					
Total nitrogen ¹	3.26	.....	9.83	9.87	10.4	9.92
NH ₃ nitrogen ¹	0.016	0.045	0.053	0.055	0.045	0.062
N. P. N.	0.329	0.975	1.139	1.056	1.115	1.095
N. P. N. minus NH ₃ -N	0.309	0.919	1.095	1.008	1.074	1.042
NH ₃ nitrogen.....	0.020	0.056	0.044	0.048	0.041	0.053
K ₂ + K ₂ nitrogen.....	0.124	0.360	0.360	0.358	0.364	0.360
Purine nitrogen.....	0.022	0.064	0.080	0.080	0.082	0.077
Residual N. P. N.	0.163	0.495	0.635	0.570	0.628	0.605
	Per cent of Total Nitrogen					
NH ₃ nitrogen ¹	0.49	.....	0.54	0.56	0.43	0.63
N. P. N.	10.1	.....	11.6	10.7	10.7	11.0
NH ₃ nitrogen.....	0.61	.....	0.45	0.49	0.40	0.53
K ₂ + K ₂ nitrogen.....	3.8	.....	3.66	3.62	3.50	3.62
Purine nitrogen.....	0.66	.....	0.82	0.81	0.79	0.78
Residual N. P. N.	50.0	.....	66.6	57.7	60.4	61.0

¹ Determined directly on meat; results not marked are on N. P. N. Filtrate.

² K₂ + K₂ = creatine plus creatinine.

The dehydrated meat contained on the average 10 per cent of its weight as moisture. Chemical analyses of the meat before dehydration, immediately after dehydration, and at intervals thereafter up to four months were made. The constituents determined included ammonia, non-protein nitrogen, creatine plus creatinine, and purines. The methods used have been described in detail elsewhere.¹ The only additional points which need be mentioned are that the sample was obtained as uniform as possible by carefully grinding and mixing, and that for each analysis 70 g. were used, soaked in water for half an hour, and

then treated in the customary way. The results are given in Tables I and II. These experiments were carried out by Miss Grace McGuire and Dr. Emil J. Baumann.

Table I shows the results of one series of experiments. The chilled fresh beef (48 hrs. after slaughtering) was analyzed April 18, dehydrated, and the dehydrated meat analyzed April 20. It was then ground to a powder, divided into four portions, kept under different conditions and analyzed again May 9, after 19 days. Two portions were kept at room temperature (15–20° C.), one exposed to the air, the other in a tightly closed jar; and two portions were kept similarly at incubator temperature (37° C.).

The results show that the meat was dehydrated to about one-third of its original weight. After dehydration there was very little change. The part of the table in which results are given as percentages of total nitrogen brings this out more satisfactorily. The constancy of the ammonia results is noteworthy, as any decomposition would greatly increase the ammonia content.

Table II gives the results over a longer period of time. The four different ways of keeping the dehydrated meat were the same as before.

The results in this table show the composition of the fresh meat, of the meat immediately after dehydration, and after standing 12, 32, and 121 days under the different conditions. The appearance of the meat kept at the ordinary temperature was unchanged after the four months. In the incubator at 37° in this length of time, the meat took on a slightly cooked appearance. There was no odor of any sort noticeable and no signs of the growth of molds or bacteria.

The chemical analyses show no essential change in the meat when the difficulty of accurate sampling is taken into account. Whatever slight changes appear to occur are apparently negligible and cannot be expected to change the properties of the meat. This is evident especially when comparing these results with the results obtained with meat undergoing decomposition, as, for example, in the ammonia content.¹

Several series of bacteriological tests were carried out with the dehydrated meat by Dr. F. Hulton-Frankel. One gram samples of the meat were carefully washed with ether to remove surface contamination, placed in sterile saline solution over night in the incubator, and the saline extract cultured on agar plates. No organisms were found in several series of experiments. The dehydrated meat after removal of surface contamination is therefore sterile.

The rate of taking up of water by the dehydrated meat preliminary to its preparation for use depends to a great extent upon its state of division. A large number of recipes have been developed but it will be necessary to give only some of the general principles here. With the hash form, enough water to form a paste is added, the mixture allowed to stand for 10 min., and then prepared as when using fresh meat. The pieces of stew size or the steaks must be

¹ K. G. Falk, E. J. Baumann and G. McGuire, *J. Biol. Chem.*, **37** (1919), 525. For purine method, cf. also I. Greenwald, *J. Biol. Chem.*, **25** (1916), 224.

¹ K. G. Falk and G. McGuire, *J. Biol. Chem.*, **37** (1919), 547.

TABLE II—ANALYSES OF DEHYDRATED MEAT AT VARYING INTERVALS AND CONDITIONS

	Fresh Feb. 20	Dehy- drated Feb. 21	Dehydrated Meat—												Incubator Jar		
			Room Exposed			Room Jar			Incubator Exposed			Incubator Exposed			Mar. 4 Mar. 24 June 21		
			Mar. 4	Mar. 24	June 21	Mar. 4	Mar. 24	June 21	Mar. 4	Mar. 24	June 21	Mar. 4	Mar. 24	June 21	Mar. 4	Mar. 24	June 21
			Per cent of Meat														
Total nitrogen ¹	3.52	9.60	11.0	12.2	9.79	10.25	11.7	9.87	12.2	11.0	10.11	11.0	10.7	10.00			
NH ₃ nitrogen ¹	0.010	0.043	0.045	0.032	0.047	0.051	0.050	0.055	0.056	0.090	0.047	0.083	0.055	0.058			
N. P. N. ¹	0.288	0.894	1.500	1.345	1.010	1.685	1.372	1.075	1.395	1.405	1.085	1.430	1.178	1.010			
NH ₃ nitrogen.....	0.011	0.033	0.022	0.026	0.042	0.049	0.042	0.054	0.021	0.074	0.042	0.074	0.045	0.058			
K ₁ + K ₂ nitrogen.....	0.13	0.37	0.44	0.51	0.388	0.40	0.51	0.39	0.46	0.48	0.40	0.42	0.45	0.39			
Purine nitrogen.....	0.017	0.072	0.083	0.084	0.074	0.079	0.084	0.079	0.077	0.078	0.081	0.078	0.079	0.082			
Residual N. P. N. ¹	0.130	0.419	0.955	0.725	0.516	1.057	0.736	0.554	0.837	0.773	0.561	0.858	0.604	0.482			
			Per cent Total Nitrogen														
NH ₃ nitrogen ¹	0.28	0.45	0.41	0.26	0.48	0.49	0.43	0.56	0.46	0.82	0.46	0.75	0.51	0.58			
N. P. N. ¹	8.19	9.32	13.6	11.0	10.3	16.5	11.8	10.9	11.3	13.2	10.7	13.0	11.0	10.1			
K ₁ + K ₂ nitrogen.....	3.7	3.9	4.0	4.2	3.87	3.9	4.4	3.93	3.8	4.4	3.96	3.8	4.2	3.9			
Purine nitrogen.....	0.48	0.75	0.75	0.69	0.756	0.77	0.72	0.801	0.63	0.71	0.800	0.71	0.74	0.08			
Residual N. P. N. ¹	3.69	4.36	8.68	5.95	5.27	10.3	6.29	5.61	6.86	7.03	5.55	5.32	5.64	4.82			
Ammonia nitrogen.....	0.31	0.34	0.20	0.21	0.43	0.48	0.36	0.53	0.172	0.67	0.41	0.67	0.42	0.575			

¹ Determinations made directly upon meat extract; results not so marked determined on non-protein nitrogen filtrates.

² K₁ + K₂ = creatine plus creatinine.

treated with water for longer periods of time, 8 to 12 hrs. In general, times of cooking should be slightly longer than with fresh meat.

The dehydrated meat has been used by a number of individuals, by the dietitians of several hospitals, and in an army camp. About 500 lbs. were shipped to Asia Minor for the American Committee for Relief in the Near East, and another considerable shipment has just been dehydrated for use in a South American exploration expedition.

DEHYDRATION OF FISH

The dehydration of fish is carried out in the same way as the dehydration of beef. The fish is either split and the bones removed, or steaks or slices cut. The product is satisfactory in every respect. Dehydrated salmon retains its color and flavor unchanged. Oysters and clams were also dehydrated without difficulty by the new process.

DEHYDRATION OF VEGETABLES

The new vacuum dehydration process has also been applied to a large variety of vegetables. The method of carrying out the dehydration was the same as with meat, except that in a number of instances the time required was considerably less. The appearance of the products was satisfactory in every case. Chemical analyses of the products (nitrogen and ash determinations) show no facts of interest. The moisture content varied from 5 to 20 per cent, depending upon the vegetable and length of time of dehydration.

With potatoes the procedure is as follows: No preliminary cooking or steaming is necessary. The potatoes are peeled, sliced into cold water, and then placed on the trays. Slicing into water keeps them from turning dark before putting them into the dryer. The dehydrated product is white in color and remains so.

Enzyme studies were carried out on vegetables dehydrated by the vacuum and air-blast processes and compared with the enzyme content of the fresh vegetables.¹ In general, vacuum dehydration caused considerably less destruction of enzyme action than did the air-blast dehydration.

The physiologic actions of some of these dehydrated products are being studied by Dr. Maurice H. Givens, of the University of Rochester, and by Dr. K. Sugiura,

of the General Memorial Hospital, New York, by the former in connection with the antiscorbutic property toward guinea pigs, by the latter in connection with the growth hormone toward rats. Their results will be communicated later elsewhere.

DEHYDRATION OF FRUITS

Very little need be added in connection with the dehydration of fruits by the vacuum process. Of special interest is the fact that some can be dehydrated to form white products, for example, apples, without treatment with sulfur dioxide. The method is excellent for the drying of coconut for the production of copra. No marked loss of flavor is noted in vacuum-dried fruits. It would seem that the low temperatures used prevent the volatilization of the essential oils so that on rehydration the fruit has its original flavor.

ADVANTAGES OF THE NEW PROCESS

The advantages in food preservation, including the obvious saving of space, weight, and refrigeration, are indicated in Prof. S. C. Prescott's publication already referred to.

The specific advantages of the new vacuum dehydration process as compared with the hitherto used method of dehydration by means of a current of heated air may be mentioned briefly as follows:

1—More economical operation. Only one-fourth of the fuel required by the heated air method.

2—Shorter time required, hence permitting products sensitive to spoilage to be handled.

3—Applicability to such products as meat and fish.

4—Smaller chemical changes produced, *e. g.*, fats not becoming rancid, etc.

5—In general, a more satisfactory character of product. Unoxidized, structure open (permitting ready hydration), less change in enzymes and hormones, and in case of fruits sulfur dioxide treatment not required to keep original color.

A disadvantage of the process is the initial cost of the apparatus. This cost is several times that of the apparatus used when drying is carried out with a current of hot air. The interest on plant investment in any dehydration process is, however, a very minor part of the cost of operation.

ACKNOWLEDGMENT

In conclusion the writers wish to express their thanks to those who have aided them in various ways to

¹ K. G. Falk, G. McGuire and E. Blount, *J. Biol. Chem.*, **38** (1919), 229.

develop this process, but especially to Mr. Herbert Eckweiler who carried out many of the experimental and technical operations necessary to this investigation.

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SOIL ACIDITY—THE RESULTANT OF CHEMICAL PHENOMENA¹

By H. A. NOYES

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That condition of soils known as acid is not confined to any one soil type. The major portion of the soils of the eastern half of the United States are acid in the sense that they will grow better crops when treated with agricultural lime. Many of these soils were acid in their virgin state and the majority have or are becoming more acid through the loss of metals in drainage waters and crops. The number of years required to bring about an acid condition varies with the soil. The composition, origin, natural fertility, system of cropping, and cultural practices followed all bear on the acidity. Nitrogen, phosphorus, and potassium have been the three elements considered essential in fertilization practices. Calcium (in agricultural lime), though not usually classed as a plant food, is occupying as important a place in soil fertility investigations as either nitrogen or potassium.

In an article entitled "Carbonic Acid Gas in Relation to Soil Acidity Changes," the writer made the following statement: "The changed reactions of this soil toward a neutral salt of a strong base and a strong acid (KNO_3) after subjection to the varied conditions of the experiments at least suggests that soil acidity is largely the result of hydrolytic mass action phenomena." The present paper gives some of the reactions between water and soil constituents in relation to soil acidity results and additional experimental data in support of the statement just quoted.

Investigators have looked to the following substances and phenomena for the explanation of soil acidity: the presence of mineral acids, the presence of organic acids, free hydrogen ions, colloidal material, absorption and adsorption, and the presence of specific compounds.

The methods used and in use for making soil acidity determinations are many. The methods include the treatment of soils with substances of both low and high solubilities.

Salts of strong acids and strong bases, of strong

¹ The experimental work covered by this paper was done while the author was employed as research associate in chemistry and bacteriology at the Purdue University Agricultural Experiment Station.

The author wishes to make acknowledgment to Mr. Lester Yoder for assistance in laboratory work, as well as to Dr. C. A. Peters, of the Massachusetts Agricultural College, Mr. W. H. Beal, Chief of Publications, State Relations Service, and Mr. W. A. Hamor, Assistant Director of the Mellon Institute of Industrial Research, for criticisms and suggestions in the preparation of the manuscript.

acids and weak bases, of weak acids and strong bases, of weak acids and weak bases, calcium hydroxide, the lowering of the freezing point of the soil, the catalysis of esters, and the hydrogen ion concentration have all been used in studying soil acidity. The results obtained by different methods have differed so widely with the same sample of soil that statements similar to the following are quite common: "Calcium acetate results are mainly due to 'organic' acidity, potassium nitrate results give mainly the 'inorganic' acidity, and the Veitch lime-water method gives the calcium-fixing power of the soil."

To point out some of the reasons for variations in results obtained by the different methods and to show the method of attack used in carrying out the investigations reported in this paper, the constitution of soils is considered in connection with some of the fundamental teachings of physical chemistry. The condition of a soil, at any time, can be considered as a stage in its progress towards a constantly changing equilibrium in accordance with the principle of LeChatelier.

Metals enter into reactions dependent on their places in the electromotive series, each one replacing (until an equilibrium is reached) any one occurring later in the series. The order of the metals in the electromotive series is *potassium, sodium, barium, strontium, calcium, magnesium, aluminum, manganese, zinc, chromium, cadmium, iron, cobalt, nickel, tin, etc.* Those italicized are present in arable soils and stand well up in the series. To avoid a rather common misconception, it must be noted that the electromotive series cannot be used to explain the tendency of one radical to dislodge another in double decompositions. The influences which determine decomposition are the solubilities and ionizations of the compounds concerned. The law of mass action states that the velocity of a chemical reaction is proportional to the masses of the substances reacting, or, in other words, is equal to the product of the masses of the reacting substances times a constant. This means that where the constituents of a slightly ionized substance are present, that substance will form at the expense of other substances that are more highly ionized.

Table I gives the solubilities of some of the salts of those metals regularly found in soils and shows that the inorganic sodium and potassium compounds that occur in soil are all more or less soluble, that calcium, magnesium, and manganese compounds are less soluble, and that iron and aluminum compounds are still less soluble.

The ionization theory makes it necessary to consider that chemical reactions take place between ions. If a sufficient quantity of any compound found in soils is put by itself with water and no reactions take place between it and the distilled water, there are present at equilibrium the following ions from the salt, the dissolved salt, and the crystalline undissolved salt. This condition is dependent on the laws of chemical and physical equilibrium and can be illustrated by sodium nitrate.

TABLE I—SOLUBILITIES OF DIFFERENT SALTS IN WATER

	POTASSIUM	SODIUM	CALCIUM	MAGNESIUM	MANGANESE	ALUMINUM	IRON
Acetate.....	188.0 ⁹⁰	26.0 ⁹⁰	39.29 ⁰	Soluble	2.34	Soluble	Soluble
Carbonate.....	53.21 ⁹⁰	17.61 ⁹⁰	0.00031 ⁹⁰	0.0971 ¹⁰	0.013	.....	.....
Bicarbonate.....	24.95 ⁹⁰	8.81 ⁹⁰	.....	42.71 ⁹⁰	.....	.....	.....
Chloride.....	25.51 ⁹⁰	26.41 ⁹⁰	.....	35.21 ⁹⁰	43.61 ⁹⁰	41.11 ⁹⁰	47.91 ⁹⁰
Hydride.....	53.41 ⁹⁰	51.71 ⁹⁰	0.00031 ⁹⁰	0.00081 ⁹⁰	0.00021 ⁹⁰	Insol.	Insol.
Nitrate.....	24.01 ⁹⁰	46.81 ⁹⁰	54.81 ⁹⁰	43.11 ⁹⁰	62.41 ⁹⁰	V. soluble	V. soluble
Phosphate, Mono.....	25.01 ⁹⁰	V. soluble	1.81 ⁹⁰	.....	.....	.....	.....
Phosphate, Di.....	V. soluble	8.51 ⁹⁰	0.021 ⁹⁰	Sl. soluble	.....	.....	.....
Phosphate, Tri.....	Sl. soluble	11.31 ⁹⁰	0.021 ⁹⁰	.....	.....	Insol.	Insol.
Sulfate.....	10.11 ⁹⁰	16.21 ⁹⁰	0.2021 ⁹⁰	26.21 ⁹⁰	38.61 ⁹⁰	26.61 ⁹⁰	Sl. soluble

Those figures italicized are from Landolt-Börnstein, *Physikalisch-Chemische Tabellen*, 1912 edition, and are percentages of anhydrous material in saturated solutions at the temperatures specified. Other notes are from Van Nostrand's "Chemical Annual for 1913," but calculated to anhydrous salt per 10 cc. water for saturated solutions.

By the law of physical equilibrium, we have

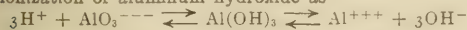
$$(1) \frac{\text{Concn. NaNO}_3 \text{ (diss.)}}{\text{Concn. NaNO}_3 \text{ (solid)}} = K$$

and by the law chemical equilibrium, we have

$$(2) \frac{\text{Concn. Na ions} \times \text{Concn. NO}_3 \text{ ions}}{\text{Concn. NaNO}_3 \text{ (diss.)}} = K'$$

The numerator of (1) is the denominator of (2), so the denominator of (2) is a constant, therefore, the $\text{Concn. Na}^+ \times \text{Concn. NO}_3^- = K$ times $\text{Concn. solid NaNO}_3 \times K'$, for in a saturated solution of sodium nitrate the product of the concentration of the two ions is a constant number. Soils contain many compounds of different solubilities and the solubilities of many of these compounds are so low that the soil solution must always be approximately saturated with them. According to the law of chemical equilibrium, the concentration of the product of the ions of a substance divided by the amount of substance dissolved is a constant. This means that common ions affect the solubilities of other substances. From this it is easy to see that the whole system can be changed by the addition of an outside substance, which brings about the whole or partial precipitation of one kind of ion present in solution. The taking up of soil constituents by plants and the constant movement of soil moisture make it certain that the soil solution is constantly changing. Substances kept out of solution by other substances and substances in solution because of the presence of certain other substances are constantly being allowed to dissolve or are forced out of solution by the changing phenomena in connection with changes in soil moisture. Reversible reactions must play important rôles in the soil solution, for changes in soil moisture cause the active masses of the substances to change.¹

Neutralization is the combining of a hydrogen ion with an hydroxyl ion to form undissociated water. Water, aluminum hydroxide, and certain other soil constituents are amphoteric, *i. e.*, they act as acids under specific conditions and as bases under other specific conditions. For example, we may express the ionization of aluminum hydroxide as



The mass action formula applied to water gives

$$\frac{\text{H}^+ \times \text{OH}^-}{\text{H}_2\text{O (sol.)}} = K$$

The denominator must be a constant; therefore the ionization constant for pure water is $\text{Concn. H}^+ \times \text{Concn. OH}^- = K$. Any substance which on reaction with water would remove either H^+ or OH^- ions would make the solution either acid or alkaline, for

pure water is the standard for neutrality and a solution is only neutral when the concentration of the H^+ ions is equal to the concentration of the OH^- ions. From the results of reaction between water and substances, we are led to conclude that water can act either as an acid or a base, depending on the conditions present. Water on reacting with metallic oxides may be considered a base, for in such cases the action depends on the formation of OH^- ions. $\text{CaO} + \text{H}^+ + \text{OH}^- \rightarrow \text{Ca(OH)}_2$. Water acts as an acid in that hydrogen is set free from water by potassium and sodium in the same manner that it is set free from hydrochloric acid by zinc. A type of reaction which takes place on extracting soils is the following:

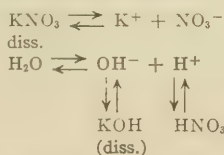


and H_2CO_3 can be considered a hydrogen salt according to the same principle that NaHCO_3 is a sodium salt.

The variations of the compounds present in soil as to quantities, solubilities, and their inter-reactions attendant upon variations in the moisture content and cropping phenomena show that water must play the important rôle in the constitution and reaction of soils. A recent investigation, as well as the present, gives evidence that the readily changing substances in the soil belong to those classes of compounds that hydrolyze readily. First, the work reported in this paper, and, second, the evidence obtained by Conner¹ show wide variations in soil acidity as the result of keeping soils at different moisture contents for one year. Silicates have also been found by Conner¹ to show increased reactions with normal potassium nitrate solutions in proportion as the water of constitution is increased.

The reactions between water and the salts commonly used for estimating so-called soil acidity illustrates the hydrolysis of all classes of salts but show that data so obtained are indicative of the nature of many substances that have to do with the reaction of soils.

Potassium nitrate in normal solution is the salt used in the Hopkins potassium nitrate method.² Potassium nitrate when dissolved in water is highly ionized, while water is only slightly ionized.

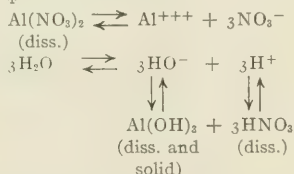


¹ THIS JOURNAL, 8² (1916), 35.

² H. W. Wiley, Bureau of Chemistry, *Bulletin* 107, p. 20.

¹ S. I. Conner, *J. Agr. Res.*, 15 (1918), 321.

Small amounts of molecular potassium hydroxide and nitric acid must be formed because potassium hydroxide and nitric acid have ionization constants. The net result is no appreciable hydrolysis, for both potassium hydroxide and nitric acid are almost completely ionized and the concentration of either H^+ or OH^- ions is not appreciably affected. When soils that give an acid reaction by the potassium nitrate method are treated with the potassium nitrate solution, the results must be due to reactions between the potassium nitrate and weaker salts. Potassium forms soluble salts and stands at the head of the electromotive series of metals; thus at equilibrium any metal replaced by potassium will have a soluble nitrate ion to combine with, for all metallic nitrates are soluble. Many workers have shown that the potassium nitrate extract of acid soils contains considerable aluminum and some iron. That these results (the so-called acidity) were due to hydrolysis and attendant reactions is supported by the way aluminum nitrate and similar compounds react with water.

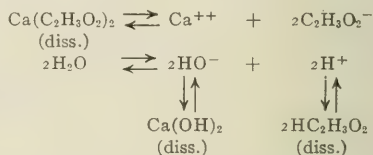


Aluminum hydroxide is a weak base and in addition is difficultly soluble. Nitric acid is highly ionized and the solution of aluminum nitrate in water is acid in reaction due to the OH^- ions of water being removed in molecular aluminum hydroxide. From the type of hydrolysis typified by the above and recognized in soils by Veitch¹ in 1904, it is evident that soil extracts may contain an excess of hydrogen ions when treated with normal potassium nitrate solution. The writer² has observed that the aluminum and iron present in the potassium nitrate extracts did not correlate with the titrations. This is to be expected, for through plant nutrition, draining, and chemical reactions the more soluble and stronger metals are being removed from the soil solution, thus allowing it to contain an excess of hydrogen ions under field conditions.

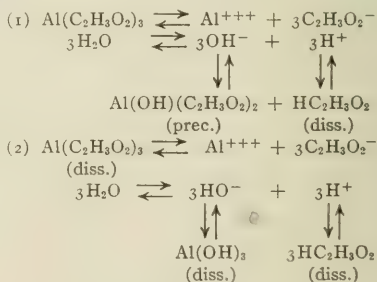
Gillespie³ tested twenty-two soils of various types with the hydrogen electrode and found hydrogen ion exponents ranging from 4.6 to 8.6. No excess of hydrogen or hydroxyl ions would have given a hydrogen ion exponent of 7.0, and thus these soils under conditions tested ranged from acid to alkaline in reaction. Sharp and Hoagland,⁴ as the result of quite extensive studies on soils with the hydrogen electrode, conclude that they have evidence "confirmatory of the view that soil acidity is fundamentally dependent on the equilibria of reactions yielding an excess of hydrogen ions." Conner,⁵ through the hydrolysis of esters,

has also proved the presence of hydrogen ions in water and soil mixtures. The autocatalysis observed by Conner¹ shows that slight changes in the active masses of the soil constituents may have considerable effect on the rate of those reactions which have to do with soil acidity. The fact that autocatalysis increases the hydrolysis of an ester would indicate that autocatalysis may play an important part in increasing soil acidity. The part that catalyzers play in changing the velocity of soil reactions has been attributed to various things.³

Calcium acetate is the salt used in the C. H. Jones³ acidity method. The reactions of calcium acetate with water illustrate the hydrolysis of the salt of a strong base and a weak acid and help in explaining the differences obtained for this and the potassium nitrate method.



Traces of molecular calcium hydroxide would be formed but this compound, though slightly soluble, is a strong base (highly ionized), and the hydroxylion concentration of the system would not be appreciably changed until calcium hydroxide was precipitated. Molecular acetic acid would be formed, for acetic acid is not highly ionized and some hydrogen ions would thus be removed from the system. In contact with the soil, calcium acetate would cause the solution to become acid in reaction, since calcium (strong base) would tend to replace iron and aluminum in the soil constituents (silicates). The effect of water on aluminum acetate illustrates that the solutions titrated in the determination of acidity by the Jones method contain free acetic acid.



The chemical reagents used by Truog are calcium chloride (very similar in its reactions to potassium nitrate) and zinc sulfide, which illustrate another type of hydrolysis (that of a salt of a weak base and a weak acid).

¹ *J. Am. Chem. Soc.*, **26** (1904), 637.

² H. A. Noyes and Lester Yoder, *Soil Science*, **5** (1918), 151.

³ *J. Wash. Acad. Sci.*, **6** (1916), 7.

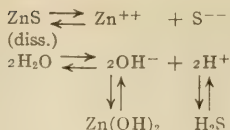
⁴ *J. Agr. Res.*, **7** (1916), 123.

⁵ *Loc. cit.*

¹ *Loc. cit.*

² G. Bertrand, *Ann. inst. Pasteur*, **26**, 852.

³ *Proc. Assoc. Off. Agr. Chem.*, **1914**.



Zinc hydroxide is a very weak base and difficultly soluble. Hydrogen sulfide is a very weak acid, largely un-ionized, and a gas. The hydrolysis of the zinc sulfide will be almost complete but the solution will be neither strongly basic nor acid, due to the zinc sulfide, because of the weakness of the resultant products of hydrolysis. The results of the Truog test then are due to the calcium chloride. The acidity is the result of the replacement of aluminum, iron, etc., by calcium. The hydrolysis of the chlorides gives hydrogen ions which allow hydrogen sulfide to be boiled off.

Many organic compounds are present in soils. A study of the works of Gortner,¹ Jodidi and Wells,² Potter and Snyder,³ and Robinson and Miller⁴ shows that soil organic matter hydrolyzes readily. It has been found that calcium hydroxide will remove, by precipitation, much of the water-soluble organic matter in soil extracts, and it is well known that magnesium hydroxide will decompose soil organic matter yielding ammonia. The influence of double salts and the formation of complex ions must be considered in connection with the soil extract. The trivalency of the phosphate radical and especially the ability of sodium and potassium to enter into combination with other substances in forming soluble phosphates and silicates must have effects on the solubilities and dissociations of substances in the soil solution. Organic matter combines with metallic elements in such a way that the metallic elements are not readily precipitable. This probably has been one of the facts underlying much of the so-called absorption and adsorption data. To illustrate—many compounds such as sugar, glycerin, tartrates, and citrates are known to interfere with the precipitation of some metals. When a copper sulfate solution is mixed with glycerin, no precipitate of copper hydroxide is formed on the addition of sodium hydroxide. This behavior is made use of in Fehling's and Haines' solutions in testing for sugar.

A theory of how organic matter interferes with the tests for the metals is that it has in it hydroxyl groups with which the metallic hydroxides combine to form complex ions. Certain organic acids, which contain no hydroxyl groups, are capable of forming complexes with metallic ions. All of these complex ions are decomposed, rather readily, by the addition of strong acids whose hydrogen ion breaks up the complex ions by suppressing the anions of the weaker organic acids. In soil acidity determinations no opportunity is given for these complexes to be broken up. Acid as well as alkaline soils have an acid neutralizing

power which has to be considered in determining available phosphoric acid by the *N/5* hydrochloric acid method.¹

Recent data of Gillespie and Wise² substantiate the statements made in the paragraph just previous concerning the hydrolysis of organic compounds. The following quotation from the contribution of Gillespie and Wise is given as showing that one can look to the regular working of fundamental physico-chemical laws rather than to the more hypothetical adsorption and colloidal activity theorems, as accounting for what is spoken of in the literature as soil acidity.

There seems to be no reason to doubt that the large decrease of potential seen when potassium chloride is added to humus is due to a large increase of hydrogen-ion concentration, which, in turn, is due mainly to a reaction between the potassium chloride and the humus. The action of salts on the hydrogen-ion activity of true solutions and the uncertainties due to diffusion potentials make it difficult to draw any conclusions as to the mechanism of the reaction between salts and humus.

The mechanism of the reaction between soils and neutral salts is in dispute. Harris maintains that when a portion of soil is repeatedly extracted with saline solution, the total acid substance yielded by sodium chloride or potassium nitrate is very much less than that yielded by sodium acetate.

He mentions a difference in the total acid yielded by potassium nitrate and sodium chloride (this difference is small compared with the difference seen by him in the action of ether and sodium acetate), and points out that it is difficult to account for the liberation of so much acid on the assumption that the reaction is purely chemical and insists that it is a case of adsorption, following the typical adsorption curve. It is fair to point out that the fact that sodium acetate reacts so much more extensively with soil than does potassium nitrate or sodium chloride (in a single treatment) may well be due to the buffer action of sodium acetate, which permits the liberation of a considerable quantity of acetic acid without too high a hydrogen-ion concentration resulting. We also appreciate the difficulty of accounting for the large apparent increase of hydrogen-ion concentration occurring when humus is treated with potassium chloride, on the assumption that the process is purely chemical, but we do not seek to draw a sharp line between chemical and adsorptive processes.

If instead of looking upon certain substances as colloids, we consider that specific conditions allow some substances to go into what is termed the colloidal state we have the following definition: "In the colloidal state a substance does not diffuse through parchment membranes; does not show more than slight osmotic pressures; and is non-crystalline." The solution and suspension theories of colloids have brought it about that we attribute the very marked differences in the physical properties of the various classes of solutions as being due to the differences in the size of the particles present. In considering the results to be obtained by any method of soil extraction, it is undoubtedly necessary to fully realize that soils contain ions ensuing from compounds of low conductivities which allow the presence of colloidal bodies. Methods for the preparation of colloids that would apply to those in soils are (1) that illustrated by the

¹ *Soil Science*, 2 (1916), 395.

² Iowa Experiment Station, *Research Bulletin* 3.

³ *J. Am. Chem. Soc.*, 37 (1915), 2219.

⁴ Michigan Agricultural Experiment Station, *Technical Bulletin* 35.

¹ Arthur Goss, in Wiley's "Principles and Practice of Agricultural Analysis," 1, 465.

² *J. Am. Chem. Soc.*, 40 (1918), 796.

preparation of colloidal ferric hydroxide and colloidal silicic acid, namely, dialysis, and (2) that illustrated by the production of colloidal matter from a normally difficultly soluble substance, in the absence of an electrolyte. Is it not reasonable to presume that carbon dioxide produced slowly through bacterial and root respirations might be the cause of the formation of some colloidal iron and aluminum compounds from dissolved salts of these metals present in a weak ionic solution in the soil interspaces to and from which water is continually moving? This reaction would apparently be quite similar to those taking place when ammonium carbonate is added to ferric chloride until a precipitate begins to form and then the mixture is dialyzed with water. A soil containing an excess of free carbon dioxide gas and water probably yields some colloidal silicic acid by forming soluble hydrated silicates in much the same way that colloidal silicic acid is prepared in the laboratory by adding a solution of sodium silicate to water containing a slight excess of hydrochloric acid. From the study of the action of water on various salts presented to illustrate hydrolysis, colloidal solutions may also be found in certain soils due to the formation of insoluble substances by soil reaction in the presence of small amounts of electrolytes. The formation of colloidal bodies in the soil solution is thus dependent on hydrolytic mass action phenomena, and any soil acidity which might be attributed to the presence of colloidal matter thus is primarily due to the workings of the mass law rather than to the presence of the colloidal bodies. The constancy of the soil moisture must determine largely the colloidal possibilities of the soil solution and the results already referred to, where Conner¹ got wide variations in soil acidity by several methods, due to keeping soils at different moisture content, rather goes against the belief that soil colloids could be more than slightly responsible for the acidity results obtained.

PLAN OF INVESTIGATIONS

Paraffined Wagner pots, filled with equal weights of soil to which the various applications of calcium carbonate and fertilizing materials had been added, were used for all experiments. The soil was kept one-half saturated with water throughout the investigation from February 4 to December 5, 1916. Each experiment except 5A (which contained only three pots) was made up of nine pots each carrying four plants of *Capsicum*, *annuum*, *abbreviatum* (*Celestial*). Three pots received no carbon dioxide gas additions, three received carbon dioxide gas at the rate of 650 cc. per pot per hr. from 8.00 A.M. to 4.00 P.M. each day commencing April 16, while the other three received the carbon dioxide gas treatment constantly from April 16 to the close of the experiments. The system of treatment, the description of the Wagner pot, and method of applying gas additions are given in the previous article.

THE SOIL USED

The soil used was a brown silt loam classified by the Bureau of Soils as Sioux Silt Loam. The acidity

of this soil when taken from the field containing 18.0 per cent of moisture was 1540 parts calcium carbonate per million pounds of dry soil by the Veitch method and 233 parts by the Hopkins potassium nitrate method. The analysis of the soil is given in Table II.

TABLE II—ANALYSIS OF SOIL¹

	Per cent
Insoluble residue ²	82.05
K ₂ O ²	0.31
Na ₂ O ²	0.36
CaO ²	0.44
MgO ²	0.79
Fe ₂ O ₃	4.35
Al ₂ O ₃	3.65
P ₂ O ₅	0.13
Mn ₂ O ₃	0.18
SO ₂	0.52
Water, hygroscopic ³	2.31
Volatile matter ⁴	5.76
Nitrogen ⁵	0.19
Total carbon ⁶	2.12
Inorganic carbon ⁷	0.03

¹ From preliminary paper, *Loc. cit.*

² Solution and residue made by extracting soil on steam bath with hydrochloric acid (sp. gr. 1.115) for 10 hrs. Solution analyzed by usual procedures.

³ Determined volumetrically from acid solution with hydrogen sulfide as reducing agent.

⁴ Method of Goss.

⁵ Five-gram aliquot used and both determinations made on same aliquots.

⁶ Regular Kjeldahl.

⁷ Method of Ames and Gaither as modified by Schollenberger.

⁸ Method of Marr with dilute acid and vacuum as recommended by Ames of Ohio.

TABLE III—CHANGES IN ACIDITY DUE TO EXTRACTING VARIOUSLY TREATED ACID SOIL, WITH CARBON DIOXIDE-FREE DISTILLED WATER

	CO ₂ Treatment per Day Hours	CaCO ₃ Added	Acidity at Close of Water Inves- after Ex- traction ⁸	Change Due to Ex- traction
Experiment 1				
Acid soil, with crop	0	0 ¹ 592 ¹	534 ¹	— 58
	8	0 716	648	— 68
	24	0 881	791	— 90
Experiment 2				
Acid soil, with crop, and single ap- plication of CaCO ₃	0	0 770	362	378 + 16
	8	0 770	644	516 + 128
	24	0 770	736	585 + 151
Experiment 3				
Acid soil, with crop, and double ap- plication of CaCO ₃	0	0 1540	353	378 + 25
	8	0 1540	449	479 + 30
	24	0 1540	510	516 + 6
Experiment 4 ⁸				
Acid soil, with crop, with triple ap- plication of CaCO ₃ and single ap- plication of phosphorus Banner bone ⁹ (dicalcium phosphate)	0	0 2310	242	265 + 23
	8	0 2310	350	365 + 15
	24	0 2310	333	302 + 31
Acid phosphate ⁸	0	0 2310	324	234 — 90
	8	0 2310	456	353 — 103
	24	0 2310	416	315 — 101
Experiment 5 ⁸				
Acid soil, with crop, with triple ap- plication of CaCO ₃ and approxi- mately one-half application of nitrogen in form of sodium nitrate ⁷	0	0 2310	315—	232 — 83
	8	0 2310	397	275 — 122
	24	0 2310	454	338 — 116
Sodium nitrate ⁷	0	0 2310	321	176 — 145
	8	0 2310	321	231 — 90
	24	0 2310	475	323 — 152
Experiment 5A ⁸				
Acid soil, with crop, with triple ap- plication of CaCO ₃ and approxi- mately one-half application of nitrogen in form of sodium nitrate	0	0 2310	227	202 — 25
	8	0 2310	318	277 — 79
	24	0 2310	365	277 — 88

¹ Figures express parts per million parts of soil.

² Single application of lime equals 770 parts calcium carbonate per million of dry soil.

³ Single application of phosphorus equals 501.5 parts per million of dry soil.

⁴ Single application of nitrogen equals 235.6 parts per million of dry soil.

⁵ In Expts. 4 and 5 comparisons were made between different carriers of phosphorus and nitrogen.

⁶ Two pots in each set of three received Banner Bone and one acid phosphate in Expt. 4.

⁷ Two pots in each set of three received dried blood and one sodium nitrate in Expt. 5.

⁸ Carbon dioxide treatment started 20 wks. later in Expt. 5A than in other experiments.

⁹ The extraction tube was weighed at the start and after the 500 cc. of extract had been obtained. The wet soil was removed and 62.5 cc. of 2 N potassium nitrate solution were added, together with enough water to make 125 cc. per 50 g. of dry soil. The figures for acidity after extraction were obtained in this manner in all cases.

At the close of the investigation the soil in each pot was emptied out in turn into a large pan and thoroughly

mixed. Samples of the mixed soil were taken to the laboratory, air-dried, and preserved for chemical analysis. Acidity determinations were made on these air-dry samples both before and after extraction with carbon dioxide-free distilled water by the Hopkins normal potassium nitrate method. The results are given in Table III.

EXTRACTION APPARATUS USED

Fig. 1 shows the extraction apparatus used. A graduated cylinder was fitted with a two-holed rubber stopper. One hole was used to make connections with the suction line and the other to connect with the extraction tube. The cylindrical part of the extraction tube was 12 in. long and had an internal diameter of about $\frac{1}{2}$ in. The lower part of the extraction tube was drawn out and fused to a small glass tube. A perforated porcelain disc covered with a mat of pulped ashless filter paper forms the filter.

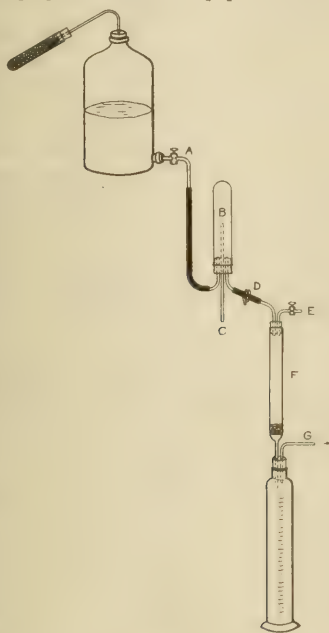


FIG. 1

The upper end of the extraction tube is closed with a two-holed rubber stopper carrying connections to the outside air and the overflow trap (which keeps water head constant). The properly protected supply of carbon dioxide-free distilled water and pinchcocks make the apparatus complete.

Fifty grams of the prepared air-dry soil are weighed out and slid into an extraction tube in which a filter has just been prepared. The soil is compacted slightly by tapping the extraction tube, held upright, on the bench a prescribed number of times. The extraction tube is put in place. The stopcock A is opened and the constant level tube B is filled; A is then closed

down until the water overflows slowly (drop by drop) at C. Pinchcock D is opened, and then pinchcock E is held open until a layer of water about 1 in. deep covers the surface of the soil in F. Stopcock A is adjusted to supply water as fast as it moves out of B into the extraction tube. When water begins to come through into the cylinder G the rate of flow is adjusted by raising or lowering B. In some cases it is advisable to apply suction at G rather than to increase the water head.

PRINCIPLE OF EXTRACTOR

In our extractions the following points were taken into consideration. Solubilities due to added carbonic acid in the water used for extraction were eliminated since the carbon dioxide factor was already included in the experiments. Carbon dioxide-free distilled water moving down slowly through the soil was expected to deplete the different soil layers successively of their water-soluble material and of the materials gradually brought into solution by changing the mass action relations. Substances having high solubility and high ionization (slightly hydrolyzed) constants were undoubtedly removed first. Each new layer of water bore a different relation to the soil it came in contact with and dissolved out substances under different conditions, since substances already removed gave possibilities of different solubilities and hydrolysis, and the active masses of the soil constituents were constantly changing. The effects of specific mineral radicals on the solubilities of other radicals changed constantly. The amount of solution (extract) obtained, 500 cc., and the rate at which it was obtained, 50 cc. per day, was such that the first 350 cc. removed most of the readily soluble material (the last three 50 cc. portions were found by test to contain little soluble material). Undoubtedly the greater portion of the dissolved material, the readily water-soluble material and material resulting from hydrolytic decompositions were in the extract. Small amounts (constant) of soluble material from substances of slight solubility and the soluble products of slow hydrolysis could have been obtained almost indefinitely.

The acidity determinations made on the soil both before and after extraction are given in Table III. The possibilities of hydrolysis of the reagent used in making acidities when it is dissolved in water made it seem advisable to use the potassium nitrate method for the determinations. The facts that the salts of potassium are soluble and that the nitrates of any metals replaced by potassium would be soluble were advantageous in studying whether the extraction of the soils with water had removed from them the substances responsible for the reactions obtained previous to extraction.

Table III brings out the following:

(1) Carbon dioxide gas, added to the soil, has, in every case, increased soil acidity as determined by the potassium nitrate method. The average results of all experiments expressed in terms of calcium carbonate follow. Before extraction, zero hours carbon dioxide treatment gave an acidity of 342 lbs. per

million; 8 hrs. carbon dioxide per day, 456 lbs. per million; and 24 hrs. carbon dioxide per day, 521 lbs. per million. After extraction, zero hours carbon dioxide treatment gave an acidity of 300 lbs. per million; 8 hrs. carbon dioxide per day, 388 lbs. per million; and 24 hrs. carbon dioxide per day, 431 lbs. per million.

(2) Carbon dioxide gas added to the soil has changed the constitution of the soil, in that the reactions of the soil with potassium nitrate were changed.

(3) Calcium carbonate additions to the soil decreased the acidity of the soil but not in proportion to the amounts added, showing that this compound has made other chemical combinations besides those which decrease the acidity measured by the potassium nitrate method.

(4) Calcium carbonate has also produced changes in the soil as shown by the differences in acidity before and after extraction with carbon dioxide-free water. There is a 58 lb. decrease due to extraction where no lime was added, an increase of 16 lbs. on extraction when a single application of lime was applied, and an increase of 25 lbs. with the double application of calcium carbonate.

(5) Carbon dioxide applications with calcium carbonate have generally effected changes in the soil shown in the differences between acidity determinations before and after extraction.

(6) Calcium from calcium carbonate has replaced acid-reacting substances soluble in normal potassium nitrate solution.

(7) The form in which the phosphorus was applied and both the form and the amounts in which the nitrogen was applied effected changes in the soil which are apparent when the soil is treated with a normal potassium nitrate solution.

(8) Acid phosphate when applied with calcium carbonate did not decrease the acidity of the unextracted soil to the same extent that dicalcium phosphate and an equal quantity of calcium carbonate did. This failure to decrease the acidity may be due to the fact that water-soluble calcium sulfate (CaSO_4) reacted with the soluble phosphate to form aluminum compounds that were easily hydrolyzed by water.

Table IV gives the weights of material precipitated by ammonium hydroxide from potassium nitrate extracts of the variously treated soils. The differences are evidence that the results reported in Table III are due to changes in the substances making up the soil.

Table IV shows:

(1) Carbon dioxide gas additions to the soil have both increased and decreased the amount of substances precipitable by ammonium hydroxide which are extracted by a normal potassium nitrate solution.

(2) Calcium carbonate additions to the soil did not decrease the weights of ammonium hydroxide-precipitable material in proportion to the amount added. Calcium will replace aluminum and the results of such a reaction are apparent in the increased weight of precipitates from the potassium nitrate extract of the soil receiving double application of calcium carbonate.

(3) The form in which the phosphorus and nitrogen were applied was the cause of reactions which influenced the amount of material extracted by the normal potassium nitrate solution. The increased amounts of substances obtained after extraction are evidence that the fertilizing materials were the cause of soil solutions of different composition which in turn affected the solubility of aluminum-containing compounds in the soil. Acid phosphate and sodium nitrate (soluble materials) gave entirely different potassium nitrate extracts from the extracted soils than dicalcium phosphate and dried blood (insoluble materials).

TABLE IV—CHANGES IN WEIGHT OF MATERIAL PRECIPITATED BY AMMONIUM HYDROXIDE FROM POTASSIUM NITRATE EXTRACTS OF VARIOUSLY TREATED SOILS

	CO ₂ Treat-ment per Day Hours	Normal Potassium Nitrate Extracts		
		Wt. of Ppt. before Extraction of Soil Grams	Wt. of Ppt. after Extraction of Soil Grams	Change in Grams
Experiment 1				
	0	0.0367 ¹	0.0348	-0.0019
	8	0.0399	0.0406	-0.0093
	24	0.0404	0.0382	-0.0022
Experiment 2				
	0	0.0375	0.0362	-0.0013
	8	0.0413	0.0316	-0.0097
	24	0.0437	0.0326	-0.0111
Experiment 3				
	0	0.0291	0.0328	+0.0037
	8	0.0338	0.0464	+0.0074
	24	0.0335	0.0524	+0.0189
Experiment 4				
	0	0.0284	0.0464	+0.0180
Banner bone.....	8	0.0269	0.0388	+0.0118
	24	0.0244	0.0424	+0.0180
Experiment 5				
	0	0.0231	0.0282	+0.0051
Acid phosphate.....	8	0.0248	0.0286	+0.0038
	24	0.0338	0.0256	+0.0018
Experiment 5				
	0	0.0233	0.0490	+0.0257
Dried blood.....	8	0.0288	0.0458	+0.0170
	24	0.0276	0.0350	+0.0074
Experiment 6				
	0	0.0279	0.0260	-0.0019
Sodium nitrate.....	8	0.0226	0.0264	+0.0038
	24	0.0289	0.0298	+0.0009
Experiment 5A				
	0	0.0255	0.0264	+0.0009
	8	0.0251	0.0282	+0.0031
	24	0.0233	0.0264	+0.0031

¹ Figures are ignited precipitate from aliquot representing 50 g. of soil. The material was principally aluminum oxide (Al_2O_3) but contained a little iron and some silica.

TABLE V—CONDUCTIVITY OF WATER EXTRACTS OF THE VARIOUSLY TREATED ACID SOIL

	CO ₂ Treatment per Day Hours	Specific Conductivity	
		Experiment 1	Experiment 2
	0	0.0914 $\times 10^{-3}$	0.0911 $\times 10^{-3}$
	8	0.0911 $\times 10^{-3}$	0.1001 $\times 10^{-3}$
	24	0.0948 $\times 10^{-3}$	0.0953 $\times 10^{-3}$
	0	0.0953 $\times 10^{-3}$	0.1039 $\times 10^{-3}$
	8	0.0856 $\times 10^{-3}$	0.0965 $\times 10^{-3}$
	24	0.1001 $\times 10^{-3}$	0.1001 $\times 10^{-3}$
Experiment 4			
	0	0.1334 $\times 10^{-3}$	0.1362 $\times 10^{-3}$
Banner bone.....	8	0.1414 $\times 10^{-3}$	0.1414 $\times 10^{-3}$
	24	0.2799 $\times 10^{-3}$	0.2976 $\times 10^{-3}$
Acid phosphate.....	0	0.2976 $\times 10^{-3}$	0.3000 $\times 10^{-3}$
	8	0.1757 $\times 10^{-3}$	0.2704 $\times 10^{-3}$
Dried blood.....	24	0.2107 $\times 10^{-3}$	0.3144 $\times 10^{-3}$
	0	0.3007 $\times 10^{-3}$	0.3007 $\times 10^{-3}$
Sodium nitrate.....	8	0.1946 $\times 10^{-3}$	0.1946 $\times 10^{-3}$
	24	0.2107 $\times 10^{-3}$	0.1999 $\times 10^{-3}$
	0	0.1999 $\times 10^{-3}$	0.2034 $\times 10^{-3}$
	8	0.2034 $\times 10^{-3}$	
	24		

The specific conductivities of the extracts obtained with distilled water give indications of the nature

of the material removed by the extraction. The results are given in Table V.

The following may be deduced from the specific conductivities:

(1) Carbon dioxide gas additions to the soil have changed the constitution of the soil. This is shown by the differences in the conductivities of the water extracts.

(2) Calcium carbonate additions to the soil had comparatively little effect on the conductivities of the soil extracts. Two things undoubtedly account for this: the low solubility of the calcium carbonate, and the low solubilities and conductivities of the substances in the soil that the calcium replaced.

(3) Phosphorus and nitrogen applied in different forms were the cause of water extracts of very different specific conductivities. The extracts from the soils receiving dicalcium phosphate and calcium carbonate had low specific conductivities in comparison to the extracts from soil receiving sodium nitrate of acid phosphate (which contains sodium sulfate in addition to phosphate).

(4) The specific conductivities of extracts from the full application of sodium nitrate and acid phosphate are believed to show:

(a) The soluble sulfate ion from the calcium sulfate stayed in solution and kept up the specific conductivity.

(b) Where sodium nitrate was added the soluble sodium gave increased conductivity.

(c) The action of carbon dioxide gas on the soil constituents increased the ease with which sodium replaced substances in the insoluble compounds, and the conductivity would decrease due to the slight solubility and ionization constants of the replaced substances. The losses of nitrates from bacterial activities and plant absorption undoubtedly were also concerned.

(d) Evidently the one-half application of sodium nitrate did not furnish a large excess of sodium over that entering into the replacement reactions.

(e) The organic nature of the nitrogen in the dried blood and its constant conversion by bacterial agencies under the different conditions of aeration helps in explaining the conductivities of the extracts obtained.

DISCUSSION

Carbon dioxide gas added to this soil which does not have enough bases present to allow for the formation of carbonates gives increased acidity results by the potassium nitrate method.

Sharp and Hoagland¹ have found the hydrogen ion concentration of soils to be increased by the addition of potassium chloride, sodium chloride, and barium chloride. The increases were greater with barium chloride than they were with either potassium or sodium chloride, and it is to be noted that the salts of barium are more insoluble than those of sodium or potassium and thus the replacement of metals (such as aluminum) by barium would be more complete. Barium removed from solution would leave each chlorine ion offset by the ions of some metal or metals

further down in the electromotive series, and increased hydrolysis would result.

Bouyoucos has followed the changes in the freezing points of soil-water emulsions when treated with successive portions of calcium hydroxide and other dilute solutions. His results and those obtained in our investigations confirm the conclusion previously developed in the theoretical part of this paper, namely, that soil acidity is the resultant of the workings of physicochemical laws. The following paragraphs take up the work of Bouyoucos in connection with the present investigation.

Bouyoucos¹ has advanced as a method for the determination of the lime requirement of soils to replace or supplement the well-known Veitch lime-water method, the results obtained by adding successive portions of $N/25$ calcium hydroxide to soil-water emulsions. On graphing his results, he gets three types of curves which he designates as (1) the acid curve, (2) the absorption curve, and (3) the alkaline or no lime curve. His acid curve is well illustrated by the changing freezing point depressions of acids and hydrolyzable salts, such as aluminum nitrate when treated with successive additions of calcium hydroxide solution. Example: When hydrochloric acid, which is highly ionized in dilute solution, is treated with $N/25$ calcium hydroxide solution, the freezing point of the solution is raised, due to the neutralization of the hydrogen ions of the acid by the hydroxyl ions of the calcium hydroxide. When neutralization is complete, the freezing point depression increases again, due to the high ionization constants of both calcium chloride and calcium hydroxide. His absorption curve (2) is illustrated by soils which on the successive additions of calcium hydroxide undergo no change in the freezing point depression for a time and then depress it for each addition of the alkali. It is to be noted in this connection that organic matter combines with compounds such as calcium hydroxide and it is apparent that no change in freezing point depression would accompany a reaction of this kind. Further, it is well known that calcium is leached out of soils and that plant ash contains much more potassium and sodium than calcium and magnesium and but very little iron and aluminum. The increase in acidity of the limed soil in Expt. 3 after extraction in comparison to the decrease in acidity of the unlimed soil in Expt. 1 after extraction, in these investigations, shows that the addition of calcium is concerned with the replacement of iron and aluminum, which give titratable acidity because of the hydrolysis of aluminum and iron nitrates. This result and Bouyoucos' finding soils that give freezing point depression curves of the Type 2 show that both calcium and hydroxyl can be removed from solution by soil components. This is evidence *per se* that the freezing point depression is not going to be changed appreciably as long as both the calcium and the hydroxyl radicals are entering into chemical reactions with the soil. Bouyoucos' type 3 freezing point depression curve is a depression of the freezing point for each portion of calcium

¹ *Lec. cit.*

¹ Michigan Agricultural Experiment Station, Technical Bulletin 27.

hydroxide added. Soils of this type have no lime requirement.

The analysis of the soil used in the experiments reported in this paper has been given but this analysis gives little information concerning the constitution of the soil or the soil solution. The results obtained by Bouyoucos¹ on determining the freezing point depressions of soils under various conditions with different salts and acids throw some light on the reactions taking place between the soil and the soil solution. Quartz sand showed no lime requirement by the freezing point method except when treated with dipotassium phosphate (K_2HPO_4) and monocalcium phosphate [$CaH_2(PO_4)_2$]. These salts have lime requirements of their own, due to the way they ionize and the insolubility of the calcium phosphates which result. The addition of soluble salts to soils increased their lime requirements as shown by the freezing point method.

Bouyoucos' curves resulting from the lime requirement determination by the freezing point depression method when the soil is treated with a soluble salt are all of the acid type. This shows that in such cases the calcium hydroxide neutralizes hydrogen ions resulting from the hydrolysis of the soluble salt which in turn result from reactions between the soluble salt and the soil. This acid type curve is evidently the resultant of both the acid curve and the lime absorption curves. The broken curve from the soil treated with sodium nitrate, the more broken curve where calcium nitrate was used, and an almost horizontal section in the curve where monocalcium phosphate was used with the soil illustrate this.

In another article, Bouyoucos reports obtaining practically the same freezing point depressions on successive freezings of quartz sand, sands, and some sandy loams in comparison to changing depressions for successive freezings of loams, silty clays, and peats. This is rather conclusive that water enters into chemical combination with the soil constituents. The per cent of the original concentration of $N/10$ acids and salts which goes to concentrate the soil solution, as measured by the changes in freezing point depression observed by Bouyoucos, depends quite regularly both on the solubilities of the salts of calcium, magnesium, iron, and aluminum, which can be formed from these compounds and the soils, and on the tendency of the salts formed to hydrolyze and form insoluble or hydrated compounds.

Some writers have said that no method will ever be devised by which the acidity of a soil can be determined. The changes in the soil used in these (Bouyoucos and Noyes) experiments make it quite certain that when the hydrogen ion concentration of the soil can be determined without the addition of water to the soil the result will give the hydrogen ion concentration of the soil at that instant. The addition of salts and changes in the water content of soil with attendant influences make it quite certain that the acidity of a soil is constantly changing and that recommendations for the application of agricultural lime have got to be

made, not specifically by the results of a chemical method, but by the results of chemical determinations in connection with extended knowledge of soil types and the crop results obtainable on these soil types.

SUMMARY

1—Soil acidity is discussed in relation to the place of the metals, ordinarily occurring in soils, in the electromotive series; the differences in the hydrolysis of the salts used in different soil acidity methods; and the conditions under which water may act as an acid or a base.

2—The presence of free hydrogen ions in the soil solution is accounted for on the basis of hydrolysis. Physicochemical explanations of the hydrolysis of silicates and of organic matter and the ability of organic matter to form complex ions with bases are held to be more satisfactory explanations of the rôle of organic matter than "adsorption" theories.

3—The active masses of substances normally present in soils and their tendencies to hydrolyze can account for the presence of substances in the colloidal state, and thus any soil acidity which might exist due to the peculiar properties of substances present in the colloidal condition is primarily due to the conditions which govern the formation of the colloidal solutions.

4—A special apparatus for extracting the water-soluble material in soils is described and the soils of all the experiments were extracted by this apparatus.

5—Carbon dioxide gas, added to the soil, has in every case increased soil acidity by the Hopkins potassium nitrate method. The average results for all experiments, expressed in terms of calcium carbonate, are as follows: Before extraction, no carbon dioxide treatment, 342 lbs. per million; 8 hrs. carbon dioxide treatment per day, 456 lbs. per million; and continuous carbon dioxide treatment, 521 lbs. per million. After extraction, no carbon dioxide treatment, 300 lbs. per million; 8 hrs. carbon dioxide treatment per day, 388 lbs. per million; and continuous carbon dioxide treatment, 431 lbs. per million.

6—Calcium carbonate decreased the acidity of the soil but not in proportion to the amounts added, showing that this compound has made other chemical combinations beside those which decrease the acidity measured by the Hopkins potassium nitrate method.

7—Calcium carbonate has also produced chemical changes in the soil that are shown by the differences in acidity before and after extraction with conductivity water. There was a 58 lb. decrease due to extraction where no lime was applied, an increase of 16 lbs. on extraction where the single application of lime was made, and an increase of 25 lbs. on extraction where the double application of calcium carbonate was made.

8—The form in which the phosphorus was applied and both the form and the amounts in which the nitrogen was applied effected changes in the soil, which are apparent when the soil is treated with normal potassium nitrate solution.

9—Carbon dioxide gas additions to the soil changed the amounts of substances precipitable by ammonium hydroxide, which are extracted by a normal potassium nitrate solution.

10—Calcium carbonate additions to the soil did not decrease the weights of ammonium hydroxide precipitable material in proportion as they decreased the acidity results. Calcium will replace aluminum, and the results of such a reaction are apparent in the increased weight of precipitates from the potassium nitrate extract of the soil receiving double application of calcium carbonate.

11—The form in which the phosphorus and nitrogen were applied was the cause of reactions which influenced the amount of material extracted by the normal potassium nitrate solution. The increased amounts of substances obtained after extraction are evidence that the fertilizing materials were the causes of soil solutions of different composition, which in turn affected the solubility of aluminum-containing compounds in the soil. Acid phosphate and sodium nitrate (soluble materials) gave entirely different potassium nitrate extracts from the extracted soils than dicalcium phosphate and dried blood (insoluble materials).

12—Calcium carbonate additions to the soil had comparatively little effect on the conductivities of the soil extracts. Two things undoubtedly account for this, the low solubility of the calcium carbonate and the low solubilities, as well as conductivities, of the substances in the soil that the calcium replaced.

13—Phosphorus and nitrogen applied in different forms were the cause of water extracts of very different specific conductivities. The extracts from the soils which had received dicalcium phosphate and calcium carbonate had low specific conductivities in comparison to the extracts from soil which received sodium nitrate or acid phosphate.

14—The specific conductivities of extracts from the full application of sodium nitrate and acid phosphate are held to show: The soluble sulfate ion from the calcium sulfate in the acid phosphate stayed in solution and kept up the specific conductivity; carbon dioxide gas augmented the increased conductivities; where sodium nitrate was applied, the sodium ions gave increased conductivity; the action of carbon dioxide gas on the soil constituents increased the ease with which sodium replaced substances in the soil; the conductivity decreased due to the slight solubilities and ionization constants of the new substances formed; the loss of nitrates through bacterial activities and plant "absorption" were also concerned.

15—Chemical reactions are held to be the causes of, and known laws of chemistry offer satisfactory explanations for soil acidity.

16—In conclusion, the reaction of a soil at any time is dependent both on the nature of and the proportions in which its constituents are present with water. Changing the water content, removing substances from solution, and the addition of other substances change the reaction in accord with the working of the law of mass action. The solubilities of sub-

stances in, the possibilities of combination, and the rate at which reactions take place in soil vary so that the condition of a soil at any time can be considered but a stage in its progress towards a constantly shifting equilibrium in accordance with the principle of LeChatelier.

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A FURTHER STUDY OF THE DEROODE METHOD FOR DETERMINING POTASH

By T. E. KEITY AND H. E. SHIVER

Received March 31, 1919

We have proved¹ that the Lindo-Gladding method for determining potash gives low results in the presence of certain constituents normally present in mixed fertilizers and present in some sources of domestic potash. As a substitute² for the Lindo-Gladding method we have offered a modification of a method suggested by DeRoode,³ and we have presented much concordant analytical data to prove its accuracy.

With potash selling at the present high prices it is but just that the producers of domestic potash shall have a fair valuation of their product, which will no doubt soon come in competition with foreign sources of potash. Treater dust is a case in point: this material shows about 0.6 per cent more water-soluble potash by the DeRoode method than it does by the Lindo-Gladding method. That this potash is actually present in water-soluble form will be shown in this article. With water-soluble potash selling for \$4.50 per unit, this means a loss of \$2.70 on each ton of this material due to an inaccurate method of analysis. When \$2.70 is multiplied by the total tonnage produced annually, we readily see that the aggregate loss is large.

The high degree of accuracy obtained through the use of the DeRoode method, the lessened number of operations, and the elimination of platinum apparatus make the method highly desirable.

Since the publication of our former article certain chemists have expressed doubt as to the accuracy of the method in the presence of nitrate of soda, ammonium salts, high content of phosphates, and large amounts of organic matter. We had already tested the samples used in the former work for ammonia and had established its presence in most of them. We have since estimated quantitatively the percentage of ammonia present as ammonium salts, by distilling over magnesium oxide. Table I shows that the ammonia content ran as high as 1.87 per cent in these samples.

An inspection of the following table shows that eleven of the twenty samples contained less than $\frac{1}{2}$ per cent of ammonia, with an average plus difference for the DeRoode method of 0.081 per cent. Three samples contained between $\frac{1}{2}$ and 1 per cent of ammonia with an average plus difference of 0.11 per cent. Six samples contained between 1 and 2

¹ THIS JOURNAL, 10 (1918), 994.

² *Ibid.*, 10 (1918), 219.

³ J. Am. Chem. Soc., 17 (1895), 85.

per cent of ammonia with an average plus difference for the DeRoode method of 0.089 per cent. These results indicate that there is no error in the DeRoode method due to the presence of as much as 1.8 per cent of ammonia.

TABLE I—PERCENTAGE OF AMMONIA PRESENT IN SAMPLES USED FOR COMPARING THE LINDO-GLADDING WITH THE DEROODE METHOD

SAMPLE No	Potash by L.-G. Method Per cent	Potash by DeRoode Method Per cent	Difference between Columns 2 and 3 Per cent	NH ₃ in Sample by MgO Method Per cent
18	0.90	0.88	-0.02	0.08
54	2.18	2.19	0.01	1.27
59	4.34	4.46	0.12	0.17
74	4.45	4.57	0.12	0.43
90	2.71	2.79	0.08	0.34
93	4.60	4.66	0.06	0.45
160	0.90	0.93	0.03	0.34
247	1.84	1.84	0.00	1.87
302	4.75	4.89	0.14	1.36
311	4.61	4.85	0.24	0.51
313	3.52	3.59	0.07	0.19
335	2.88	2.89	0.01	0.17
356	1.64	1.74	0.10	0.42
357	2.54	2.71	0.17	0.25
386	0.25	0.26	0.01	1.44
421	0.95	1.10	0.15	0.09
641	1.74	1.94	0.20	1.27
694	1.73	1.87	0.14	1.19
770	1.38	1.40	0.02	0.51
961	0.86	0.93	0.07	0.68

It seemed advisable, due to the criticisms already mentioned, to greatly exaggerate the percentage of ammonium salts and to further test the accuracy of the procedure. With this end in view the samples used in Table I of a former article¹ were selected, and enough ammonium sulfate added to furnish 5 per cent of ammonia (NH₃). With these large amounts of ammonium salts it was found that the results obtained by our former procedure ran high, due to the incomplete removal of the ammonia. A single treatment with aqua regia followed by an evaporation with hydrochloric acid was tried with unsatisfactory results. We next reversed the proportions of nitric and hydrochloric acids, and after evaporating to dryness, added hydrochloric acid and evaporated to dryness again, prior to taking up with water and precipitating with platonic chloride. This procedure gave unsatisfactory results, again running too high. Next we tried two evaporations with aqua regia, using 30 cc. each time, followed by taking up with hot water and several cubic centimeters of hydrochloric acid, and evaporating to dryness preparatory to taking up with hot water and precipitating with platonic chloride. This procedure gave satisfactory results even in the presence of more than 5 per cent of ammonia as shown in Table II.

The results given in Column 4 are the first and only determinations made by this method of procedure on these samples. The results obtained are in such close agreement with the results obtained in Column 3 that duplication appears unnecessary, the average difference being 0.04 per cent. It is also worthy of note that the results are not all too high, some being above and one below the results obtained by the Lindo-Gladding method.

The DeRoode method as finally applied is carried out as follows: Ten grams of material are transferred to a 500 cc. flask, 300 cc. of water added, brought to boiling and boiled for 30 min., cooled, made to

volume, thoroughly shaken, and filtered through a dry, folded filter paper, the first runnings being discarded. A 50 cc. aliquot is placed in a 200–250 cc. thin porcelain dish and 30 cc. of aqua regia added after putting the dish on the hot plate. The hot plate should preferably be located under a good hood. After evaporating to dryness another 30 cc. of aqua regia are added and the solution again evaporated to dryness, the residue

TABLE II—EFFECTIVENESS OF TWO EVAPORATIONS WITH AQUA REGIA FOLLOWED BY ONE WITH HYDROCHLORIC ACID, PREPARATORY TO TAKING UP WITH HOT WATER AND ADDING THE PLATINIC CHLORIDE SOLUTION

SAMPLE No.	Potash by Lindo-Gladding Method, Per cent	Potash by DeRoode Method without Ammonia, Per cent	Potash by DeRoode Method with Addition of 5 Per cent Ammonia, Per cent	Difference between Columns 2 and 3, Per cent	Difference between 2 and 4, Per cent	Ammonia in Samples after Adding 5 Per cent Ammonia, Per cent	Difference between 3 and 4, Per cent
58	3.15	3.34	3.34	0.19	0.19	5.17	0.00
160	2.71	2.97	3.08	0.28	0.39	5.08	0.11
547	5.98	6.23	6.33	0.25	0.35	5.17	0.10
850	2.68	2.95	3.00	0.27	0.32	2.28	0.05
1229	3.10	3.29	3.23	0.19	0.15	5.34	-0.06

taken up with a small volume of hot water, 10 cc. concentrated hydrochloric acid added, and the solution again evaporated to dryness. The residue is taken up with hot water and platonic chloride solution added. When the solution is almost evaporated to dryness, we prefer to remove from the water bath, on which the final evaporation is accomplished, and whirling the dish, cover the dried portion with the liquid portion, avoiding a baked condition. The precipitate is covered with acidulated alcohol prepared as previously described¹ and allowed to stand for about an hour, thoroughly breaking up the precipitate with a policeman. We used tared filter papers, either Whatman No. 42, 9.5 cm., or S & S No. 589, 7 cm. Blank determinations on the filter paper showed —0.007 per cent loss. The precipitate is washed with acidulated alcohol until the runnings are colorless, then at least seven times with 10 cc. portions of Lindo's ammonium chloride wash. The washing is continued five times with 80 per cent alcohol, washing to the top of the funnels.

The following results obtained with treater dust serve to confirm the evidence already secured.

TABLE III—INFLUENCE OF OCCLUSION ON THE DIFFERENCE FOUND BY THE TWO METHODS

SAMPLE No.	Potash by the Lindo-Gladding Method, Per cent	Potash by the DeRoode Method, Per cent	Potash by the Lindo-Gladding Method Occluded Potash, Per cent	Gain for the DeRoode Method on the Lindo-Gladding Method, Per cent	Difference between Columns 3 and 4, Per cent	Occluded Potash determined by the DeRoode Method, Per cent
5691	9.72	10.30	10.18	0.58	0.12	0.46
5691	...	10.32	...	0.60	...	...
5801	11.14	11.73	11.60	0.59	0.13	0.46
5801	...	11.74	...	0.60	...	...

In a former article¹ we have accounted for the increased percentage of water-soluble potash as shown by the DeRoode method and have shown that the errors incident to the Lindo-Gladding method are partially compensating, being due to the occlusion

¹ Loc. cit.

¹ Loc. cit.

of potash by the precipitates formed on the addition of ammonia and ammonium oxalate, and due to the diminution in volume occasioned by the volume of the precipitates so formed, the former causing a minus error and the latter a plus error.

The above table shows that there is a constant difference in the potash content of the two samples of treater dust estimated by the two methods under discussion. Further, the potash occluded by the ammonia and the ammonium oxalate precipitate, which is formed when the solution is made for the determination by the Lindo-Gladding method, is constant, the determinations in the last column being made on an acid solution of the precipitated material by the DeRoode method. These results, as well as those in Table III of a former article,¹ indicate that the phenomenon is a chemical one, and that it is dependent upon the nature and amount of impurities present.

To further test the efficiency of the DeRoode method in the removal of ammonia, determinations were made using 10 g. of ammonium sulfate. The result obtained with the DeRoode method was 0.09 per cent potash (K_2O), while the result obtained by the Lindo-Gladding method was 0.04 per cent, showing a difference of only 0.05 per cent potash on an ammonium salt for the DeRoode method. This work clearly establishes the non-interference of ammonium salts with the accuracy of the DeRoode method. Having successfully devised a procedure that will take care of ammonia greatly in excess of what we find combined as ammonium salts in manipulated goods, we then proceeded to ascertain if this procedure is accurate in the presence of varying amounts of nitrate of soda and organic matter in the mixtures. These mixtures were made up in 250 g. lots from materials previously analyzed. These determinations were made by the DeRoode method as outlined in this article, and represent the water-soluble content of potash. The weighings were made on torsion balances and for that reason would only approximate the following formulas.

TABLE IV—THEORETICAL WATER-SOLUBLE POTASH CONTENT OF THE VARIOUS MIXTURES

Approximate Analysis	Acid Phosphate, Grams	Acid Phosphate Potash Content, Grams	Meal, Cottonseed Grams	Cottonseed Meal Potash Content, Grams	Nitrate of Soda, Grams	Nitrate of Soda Potash Content, Grams	Sulfate of Potash, Grams	Potash Content, Grams	Total Potash Content, Grams	Water-Soluble Potash in Mixture, Per cent
8-0-4	125	0.375	0.00	0.00	0.00	0.000	20.00	0.356	3.89	0.356
8-1-4	125	0.375	0.00	0.00	14.00	0.322	20.00	0.356	4.02	0.356
8-2-4	125	0.375	0.00	0.00	28.00	0.644	20.00	0.356	4.15	0.356
8-4-4	125	0.375	0.00	0.00	56.00	1.288	20.00	0.356	4.41	0.356
8-7-4	125	0.375	0.00	0.00	98.00	2.254	20.00	0.356	4.79	0.356
CSM	0.00	0.000	250	4.45	0.00	0.000	0.000	0.000	1.78	0.000
CSM. Mix.	115	0.345	115	2.05	0.00	0.000	20.00	0.356	4.70	0.356

The various materials used show the following water-soluble potash contents: acid phosphate 0.30 per cent, cottonseed meal 1.78 per cent, sulfate of potash 46.78 per cent, and nitrate of soda 2.30 per cent potash (K_2O).

These small batches of material were thoroughly mixed on manila paper and bottled, being subse-

quently analyzed by both methods. The results of these analyses of mixtures containing nitrate of soda are shown in Table V.

TABLE V—ANALYTICAL DATA PROVING THE NON-INTERFERENCE OF NITRATE OF SODA WITH THE ACCURACY OF THE DEROODE METHOD

Approximate Analysis	Nitrogen Equivalent Per cent NH_3 from Nitrate of Soda	Water-Soluble Potash in Mixture, Per cent	Potash by Lindo-Gladding Method, Per cent	Potash by DeRoode Method, Per cent	Difference between Columns 4 and 5, Per cent	Difference between Columns 5 and 6, Per cent	Difference between Methods, Per cent
8-0-4	0.00	3.89	3.76	4.14	-0.13	0.23	-0.38
8-1-4	1.00	4.02	3.92	4.03	-0.10	0.01	-0.11
8-2-4	2.00	4.15	4.06	4.11	-0.09	-0.06	-0.06
8-4-4	4.00	4.41	4.27	4.41	-0.14	0.00	0.14
8-7-4	7.00	4.79	4.46	4.74	-0.33	-0.05	-0.28

The foregoing table shows that the Lindo-Gladding method averaged 0.16 per cent lower than the calculated results, while the DeRoode method was 0.026 per cent higher than the calculated results. These results indicate that the Lindo-Gladding method gives low results; that this is due to occlusion of potash will be shown later. It further shows that the DeRoode method is accurate within experimental error.

We will now prove that the lower results obtained by the Lindo-Gladding method are due to occlusion of potash in the combined ammonia and ammonium oxalate precipitates. Solutions were made as outlined for the Lindo-Gladding method¹ and filtered. The volume of the filtrate was measured, and 50 cc. aliquots for the determination of potash were taken and analyzed. These are the results used in Table V. The combined residues and precipitates on each filter were saturated with concentrated sulfuric acid in a porcelain dish, ignited, digested with hydrochloric acid until dissolved, transferred to the flask in which the solution had been made up, and further digested. A separate series was run by filtering from the insoluble residue of the sample, washing filter, returning to original flask, and bringing to a boil before adding ammonia and ammonium oxalate. These precipitates were treated in the same manner as the above-mentioned series. Potash was determined in each case by the DeRoode method and the results were so concordant that there appears to be practically no hydrochloric acid-soluble potash in the residue. These results are averaged in Table VI.

TABLE VI—EFFECTS OF OCCLUSION AND DIMINUTION OF VOLUME ON THE ACCURACY OF THE LINDO-GLADDING METHOD

Approximate Analysis	Volume of Filtrate, Cc.	Potash (K ₂ O) by Lindo-Gladding Method, Per cent	Potash (K ₂ O) Calculated on 500 cc. Vol., Per cent	Potash (K ₂ O) Occluded in Ppt., Per cent	Potash (K ₂ O) Recovered, Per cent	Potash (K ₂ O) by DeRoode Method, Per cent	Potash (K ₂ O) Calc. from Weighing on Torsion Balance, Per cent	Diff. between DeRoode and Lindo-Gladding Methods in Potash (K ₂ O), Per cent	Diff. between DeRoode and Lindo-Gladding Methods Calc. to Vol. Plus Occluded K ₂ O, Per cent
8-0-4	475	3.76	3.57	0.51	4.08	4.14	3.89	0.38	0.06
8-1-4	470	3.92	3.65	0.36	4.01	4.03	4.02	0.11	0.02
8-2-4	468	4.06	3.80	0.36	4.16	4.11	4.15	0.05	-0.05
8-4-4	470	4.27	3.62	0.45	4.47	4.41	4.41	0.06	0.06
8-7-4	472	4.46	4.21	0.46	4.67	4.74	4.79	0.28	0.07

The foregoing table shows that the DeRoode method at one operation averaged within 0.008 per cent of the results obtained by the Lindo-Gladding method

¹ Loc. cit.

¹ Bureau of Chemistry, Bulletin 107 (Revised) p. 11

calculated to the volume on which 50 cc. were taken for analysis, and to which was added the amount due to occlusion as determined in an acid solution by the DeRoode method. All of the Lindo-Gladding results are below the DeRoode results, the average being 0.19 per cent. On the other hand three DeRoode results are higher and two lower than the recalculated Lindo-Gladding results to which occluded potash was added, and all analyses check within the limits of good analytical work.

The value of this procedure was then tested in the presence of large amounts of organic matter. In this work we used a cottonseed meal and a cottonseed meal mixture, the last two samples of Table IV. Table VII shows the results obtained. It is well to mention in this connection that the moist combustion as prescribed in the DeRoode method gave perfectly clear solutions both with cottonseed meal and with the cottonseed meal mixture. It is quite difficult to burn off cottonseed meal to a white residue as prescribed in the Lindo-Gladding method.

TABLE VII—ACCURACY OF THE DEROODE METHOD IN THE PRESENCE OF LARGE AMOUNTS OF ORGANIC MATTER

MATERIAL	Water-Soluble Potash (K ₂ O) Calculated for Mixture from Table IV, Per cent	Water-Soluble Potash (K ₂ O) Lindo-Gladding Method, Per cent	Water-Soluble Potash (K ₂ O) DeRoode Method, Per cent	Difference between Lindo-Gladding Method and Calculated Results	Difference between Lindo-Gladding Method and Calculated Results
CSM	1.78	1.70	1.78	—0.08	0.00
CSM. Mix.	4.70	4.69	4.70	—0.01	0.00

In the foregoing table the results are well within the limits of experimental error, therefore we went through the work as already reported in Table VI to ascertain if the close agreement is due to the balancing of the two sources of error already shown for the Lindo-Gladding method. Table VIII summarizes the results so obtained.

Table VIII shows that cottonseed meals and fertilizers containing a large proportion of cottonseed meal

show practically no occlusion, beyond the potash content of the volume occupied by the precipitate.

MATERIAL	Volume of Filtrate, Cc.	Potash (K ₂ O) by Lindo-Gladding Method, Per cent	Potash (K ₂ O) Calculated on 500 cc. Vol., Per cent	Potash (K ₂ O) Occluded in Ppt., Per cent	Potash (K ₂ O) Recovered, Per cent	Potash (K ₂ O) DeRoode Method, Per cent	Potash (K ₂ O) Calculated on Torsion Balance, Per cent	Difference between DeRoode and Lindo-Gladding Methods	Difference between DeRoode and Calculated to Vol. Occluded
CSM	435	1.70	1.48	0.30	1.78	1.78	1.78	0.08	0.00
CSM. Mix.	455	4.69	4.27	0.51	4.78	4.70	4.70	0.01	—0.08

We have already shown that precipitated phosphates, as well as the hydroxides of iron and aluminum, occupy large volumes in the flask when the Lindo-Gladding method is used.¹ Each of the mixtures used in these studies contained a large percentage of phosphatic material, and in no case is there any indication that this affected the accuracy of the DeRoode method.

SUMMARY

In summarizing we claim that the DeRoode method as herein outlined is accurate in the presence of any amount of ammonium salts, organic matter, nitrate of soda, or phosphatic matter that will be used in a manipulated fertilizer, or that may be present in natural fertilizing materials. The method is easy of manipulation and dispenses with platinum apparatus; but above all else, it is more accurate than the Lindo-Gladding method, the latter method varying in accuracy with the kind and amounts of impurities present in the material.

ACKNOWLEDGMENT

The work herein reported was begun by us at the South Carolina Experiment Station, and by agreement with the director of that station was continued and completed here.

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¹ *Loc. cit.*

LABORATORY AND PLANT

A NITROGEN GENERATOR FOR LABORATORY USE

By W. L. BADGER

Received June 26, 1919

The usual process for obtaining nitrogen in the laboratory depends on a furnace containing copper, whether the copper is used as the means of fixing the oxygen, or whether it is merely an indicator, as in Hulett's method.¹ Both are inconvenient; the first where considerable quantities of nitrogen are required, the second where a steady stream is wanted over a long period of time. Van Brunt² describes an apparatus for the preparation of nitrogen for laboratory purposes by the use of copper and ammoniacal solution of an ammonium salt. His apparatus works satisfactorily, but is more complicated than is necessary; and the glass blowing required is a little difficult for many laboratory workers. The apparatus here

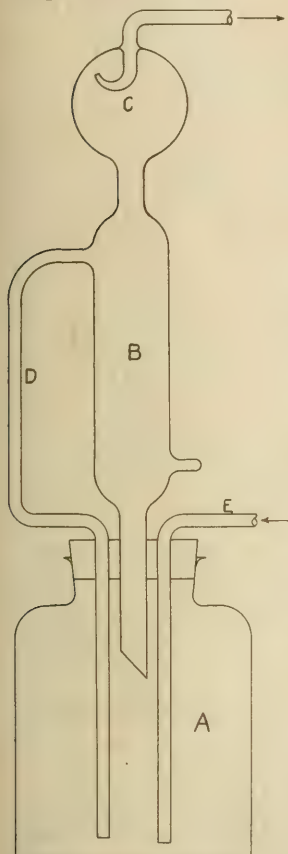
described was suggested by a desire to simplify the above apparatus.

A wide-mouthed bottle, A, is filled with the reagent and with as much metallic copper as can be got into it—preferably in the form of straight wires standing vertically, as this gives more thorough contact with the gas. B is a Liebig condenser shell with the lower water connection sealed off. It is filled with copper turnings or punchings. A tube, D, is connected to the upper water connection, and goes nearly to the bottom of the bottle A. At the upper end of the condenser should be a bulb, C, though the trap as shown is not necessary. The gas inlet should also go nearly to the bottom of the bottle. The lower end of the condenser may be cut off at an angle or left square. A fourth tube may be added for blowing out spent reagent, if desired. On passing in air or commercial nitrogen by the tube E, most of the oxygen is removed by the copper in the bottle, and the tower is usually

¹ J. Am. Chem. Soc., 27 (1905), 1415.

² *Ibid.*, 36 (1914), 1448.

needed only to remove the last traces. Unless very large volumes of air are to be run through, a copper column 4 or 5 in. high (if punchings are used) is quite sufficient. Where turnings are used, a much higher column is necessary to present the same surface. The bottle should hold a couple of liters to make frequent filling unnecessary.



The reagent recommended is made by diluting one part of commercial ammonia with one part of water and saturating the mixture with ammonium chloride. This mixture is a quantitative absorbent of oxygen until so heavy a precipitate forms that the apparatus is clogged.

If the tube D is not a part of the apparatus there is a stagnation of reagent in the tower and that becomes clogged long before the apparatus is exhausted. The tube D furnishes a slow circulation which effectually prevents stagnation in the tower. The circulation so obtained is not nearly as rapid as in Van Brunt's apparatus, but is amply sufficient to keep the tower in operation.

That this reagent gives very pure nitrogen is shown by the fact that

Ferguson¹ used this apparatus in his electrotitrimetric determination of iron; and after reaching the end-point, if the nitrogen so prepared was allowed to flow for some minutes, no change in the end-point could be detected. Mr. R. K. Mac-Alpine² of the chemistry laboratory of the University of Michigan used this apparatus to prepare nitrogen for use in atomic weight work. He found that the nitrogen so prepared, very slowly reduced a dilute chromate solution. The action was exceedingly slow and took some time for reduction enough to cause a visible color change in a solution of chromate so dilute that the yellow color was just apparent.

Using 8 mm. glass tubing for connections and a tower containing about 5 in. of copper punchings, the author has been able to put a stream of 95 per cent commercial nitrogen through this apparatus faster than ordinary Drechsel gas wash bottles could remove the ammonia, and yet the resulting gas gave no test for oxygen with colorless cuprous chloride solution. The introduction, following the generator, of a wash bottle containing a little cuprous chloride solution with some metallic copper is very useful in indicating a leak or other failure of the apparatus.

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FAT EXTRACTION APPARATUS

By J. M. PICKEL

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The fat extractor pictured here (Figs. 1 and 2) was designed by the writer and has now entered on the third year of its use in his laboratory. It is compact and economical—more so than any other that has come under his notice. Twenty fat extractions are made simultaneously on one electric heater $4\frac{1}{2} \times 24$ in., ten on each side of the heater, as against a total of seven by the leading extractor of this general style now on the market. About 15 cc. of ether, one-third

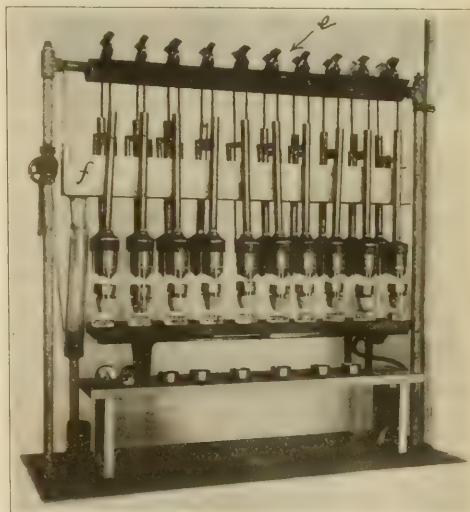


Fig. 1

to one-half of which is recovered for future use, are required for each extraction. The ether is distilled off from the extract (recovered) by merely giving the condenser a slight turn on its axis; there is no interruption of the distillation and no time or ether lost in taking the apparatus apart, removing the substance extracted, putting in its place a tube or receiver for the ether, putting the apparatus together again, and starting up the distillation again.

¹ THIS JOURNAL, 9 (1917), 941.

² Personal communication.

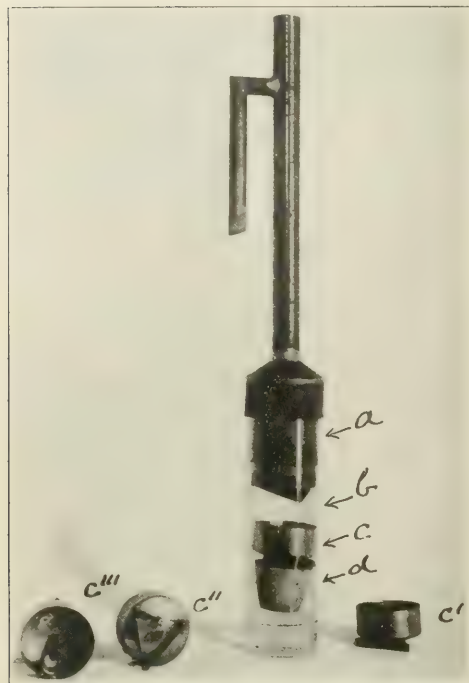


FIG. 2

APPARATUS

CONDENSER, metal (Fig. 2, *a*; Fig. 3, A). Note the eccentric position of the ether drip-point, and the smaller diameter of the lower half-inch of the condenser.

CYLINDER, glass (Fig. 2, *b*; Fig. 3, B). A cylinder is used rather than a flask for the reason that it takes up less room on the heater.

ETHER RECOVERY CUP,¹ metal (Fig. 2, *c*; *c'* side view; *c''* bottom view; *c'''* top view; and Fig. 3, C). Note the small funnel (top view, *c'''*) which, by means of its bent stem passing through and soldered to the center of the cup (bottom view, *c''*), conveys the ether to the substance being extracted. A small triangle is soldered to the bottom of the cup. This supports the cup on the crucible below. During the extraction the drip-point of the condenser is over the funnel. A slight turn of the condenser brings the point to one side; the ether then drops into the cup and is thus distilled off from the extract.

CRUCIBLE, alundum RA 360, No. 5204 cut down to a depth of $\frac{1}{8}$ in. (Fig. 2, *d*; Fig. 3, D). This will accommodate 2 (and often as much as 4 or 5) g. of ordinary feeding stuffs. A small disc of filter paper or, better, of perforated metal is laid on the stuff to prevent the constant dropping of the ether from drilling a canal through the stuff.

¹ This Journal, 7 (1915), 236, the writer described an ether recovery tube adapted for use with the Knorr fat extractor.

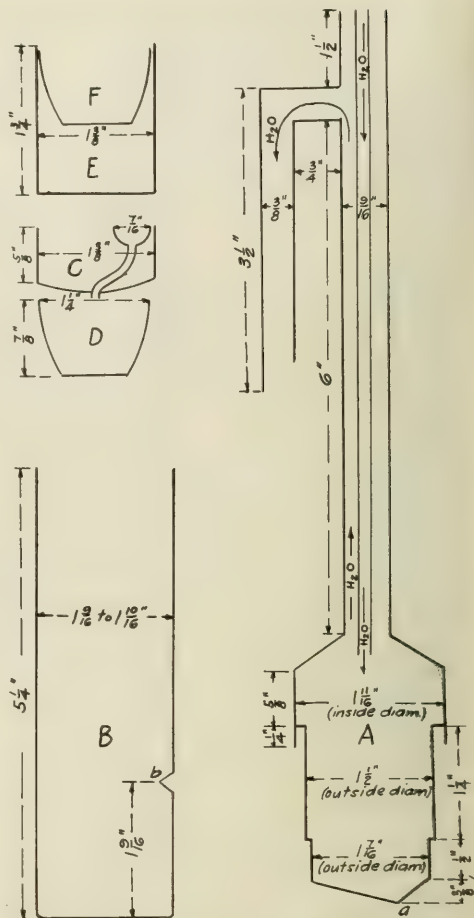


FIG. 3—VERTICAL SECTIONS OF THE PICKEL FAT EXTRACTOR

- A—Condenser, metal (copper or brass); *a*—eccentric drip point.
 B—Jar, glass, weight 30 to 40 g.; *b*—three support points for crucible.
 C—Ether recovery cup with funnel (both metal, but glass possible).
 D—Crucible (alundum) RA 360, No. 5204 cut down to a depth of $\frac{1}{8}$ in. (Norton Co., Worcester, Mass.).
 E—Receiver for fat, glass or metal (preferably aluminum). Use optional, but if used, it sits in B, in which case B is without the support points *b*; and in which case, also, it is E, not B, that receives the fat and is weighed.
 F—Shows position of crucible whose top should be about $\frac{1}{8}$ in. below top of E. F is supported by suitable indentations in E or else on a little aluminum wire tripod to be weighed along with E. A little sand or copper filings in the bottom of B improves the heat-conducting contact between B and E; or mercury may be used, but it is otherwise a nuisance best avoided. It would improve E if its bottom diameter were $\frac{1}{16}$ in., its top diameter remaining $\frac{1}{8}$ in., but in this, reference must be had to the inside diameter of B.

WATER SYSTEM (Fig. 1, *e*). The small pipes which convey the cooling water from the cocks down into the condensers end at the point where the larger tubes join the condenser, thus making it possible to raise and lower the condensers for the admission and removal of the cylinders. Momentum carries the water down to the bottom of the condensers; the cooling effect is thoroughly adequate. Practically all the ether condenses on the lower quarter-inch of the condenser,

through which the cooling water overflows and passes to the drain (Fig. 1, *f*). Immediately underneath the cocks (ordinary brass gas cocks) is a trough which catches the water leakage (if any) from the cocks.

"Low heat" of the electric heater is, in the Raleigh climate, adequate and best.

The glass cylinders are $5\frac{1}{4}$ in. high, $1\frac{9}{16}$ in. in diameter (inside) and weigh 40 to 50 g. But instead of receiving the ether extract in these larger cylinders it may be received in smaller cylinders, set inside the larger ones. These smaller cylinders will have a height of $1\frac{7}{8}$ in., and diameter (outside) of $1\frac{7}{16}$ in., and, if of glass, weigh 14 to 18 g., if of metal (aluminum) 5 to 8 g. In this arrangement the large cylinders have no projections for the support of the crucibles. The supporting is done by projections in the smaller cylinders or by a small triangle (aluminum wire) set inside. If the bottom of the larger cylinder is covered with sand or, better, copper filings (No. 80), the heat conducting contact between outer and inner cylinder is improved. Mercury would make a perfect contact, but the avoidance of mercury, corks, and ground glass joints is a virtue—and no small one—of this type of extractor. In this arrangement (of an inner receiver), the "medium heat" of the heater has been found best.

Cylinders or jars of appreciably smaller size ($1\frac{7}{16}$ in. instead of $1\frac{9}{16}$ in. inside diameter) have proven efficient. There is space for twenty-two of these smaller jars on the $4\frac{1}{2} \times 24$ in. heaters, eleven on each side.

Vertical sections of the parts (except the water-distributing system), with dimensions and brief description, made originally over a year ago for Mr. Glenn H. Pickard, Chicago, are given in Fig. 3.

FERD LABORATORY

NORTH CAROLINA DEPARTMENT OF AGRICULTURE
RALEIGH, N. C.

A COLORIMETRIC DETERMINATION OF LEAD DIOXIDE IN LITHARGE

By WALLER V. MORGAN

Received June 14, 1919

The object of this note is to present a simple method for the determination, in a semi-quantitative way, of lead dioxide in the presence of litharge. The method has been used to advantage in connection with rubber work where it is important to know the amount of oxidizing agent present. The method with slight alterations is applicable to the determination of oxidizing agents in general where they occur as an impurity with non-oxidizing agents.

METHOD

A definite amount of litharge, *e. g.*, 5 g., is boiled for a minute with a solution containing 2 g. of aniline hydrochloride dissolved in 10 cc. of water and 5 cc. of concentrated hydrochloric acid. The solution is then cooled to separate any lead chloride which has formed, then filtered to remove the lead chloride and any litharge which has not been dissolved. It is not necessary to convert all or part of the litharge into lead chloride as the action depends upon the oxidizing power of the dioxide only. The filtrate is compared

with standards made by adding definite amounts of lead dioxide to the above-mentioned solution. A colorimeter may be employed to estimate the amount of aniline purple formed, or the solutions may be compared in suitable receptacles.

The lead dioxide oxidizes the aniline to aniline purple. The intensity of the color is proportional to the lead dioxide content.

33 TROWBRIDGE STREET
CAMBRIDGE, MASSACHUSETTS

A METHOD FOR BRINGING ELEMENTARY SULFUR INTO SOLUTION FOR ANALYSIS

By A. P. BJERREGAARD

Received June 8, 1918

This method was devised to analyze some samples of flowers of sulfur intended to be used for making sheep dips. The work was done in June 1909 at the laboratory of the New Mexico Agricultural Experiment Station.

On ignition these sulfurs all left a small amount of coke, which slowly oxidized away on continuing the ignition. Practically no incombustible ash was left. The presence of this carbonaceous matter made the combustion method of analysis unavailable for determining the percentage of actual sulfur present.

An attempt was made to extract the sulfur with carbon bisulfide, but it was found that most of the samples left a very large residue of insoluble sulfur, making this method also unavailable. Some of the samples containing large proportions of insoluble sulfur were then boiled for a few minutes with alcohol, the alcohol poured off, and carbon bisulfide added. There appeared to be no change in the proportion of insoluble sulfur. Heating the samples to fusion and then to 125° C. in the air bath did not render the insoluble sulfur soluble; moreover, small amounts of sulfur were volatilized in this procedure, thus tending to vitiate the results even if the sulfur had become soluble. A higher temperature would of course aggravate this error.

Boiling with a mixture of nitric acid and bromine dissolved part of the sulfur, but about half of it fused to small globules which dissolved with extreme slowness. Boiling with a mixture of bromine and water resulted in the evolution of gas of a strong sulfurous odor, nor did this procedure dissolve all the sulfur.

Finally advantage was taken of the solubility of sulfur in dry liquid bromine, and it was dissolved in that substance and concentrated nitric acid added. On slightly warming this solution a vigorous action ensued, copious bromine and nitrous fumes were given off, and the sulfur dissolved completely in a few minutes.

In practice about 0.1 g. of sulfur was dissolved in 1 cc. bromine, and 10 cc. nitric acid added. After removing the excess of bromine and the nitrous fumes by heat, 100 cc. water and a few cubic centimeters of hydrochloric acid were added, and the solution boiled again to expel the rest of the nitric acid, after which the sulfuric acid was precipitated in the hot solution by barium chloride in the usual manner. The results were entirely satisfactory.

CLEVELAND, OHIO

ADDRESSES AND CONTRIBUTED ARTICLES

PROBLEMS AND METHODS IN AGRICULTURAL RESEARCH¹

By H. J. WHEELER

Presumably the subject of agricultural chemistry appears wholly dull and uninviting to those engaged in other lines of inquiry; yet I recall that upon reading the life of Sir Humphry Davy I was led to abandon the study of law and substitute agricultural chemistry because of its great interest and because of what seemed to be the greater importance for useful service.

In view of the recognized importance of agricultural chemistry in recent years it may be of interest to call attention to the conditions existing in this country from 1870 to 1885. The student who then wished to devote himself to the study of chemistry in its relation to agriculture would have found Atwater at Wesleyan University; Johnson at the Sheffield Scientific School, Yale University; Storer at the Bussey Institute, Harvard University; Caldwell, who had studied under Goessmann in Germany, at Cornell University; Hilgard at the University of California; Kedzie at the Michigan Agricultural College; Goessmann at the Massachusetts Agricultural College; and Schweitzer at the University of Missouri. All of these men performed magnificent service and all have passed to their reward in the Great Beyond. I trust none of that generation have been overlooked.

Three of these men were Germans, educated in Germany, and the remaining four went to Germany, in their earlier years, in search of knowledge and inspiration. It was no wonder, therefore, that many of their students should have felt the same impelling forces drawing them to Germany for further study. Furthermore, at that time various difficulties were placed in the way of the American student who might have desired to study in France under Schloessing, Muntz, Girard, Grandeaun, Deherain, and others. Neither had Great Britain any special facilities to offer to the student of agricultural chemistry, notwithstanding the world-wide recognition of the work of Lawes and Gilbert at Rothamsted and of Voelecker at Woburn.

Prior to the passage by Congress of the Hatch Act of 1887, only a few agricultural experiment stations had been established in the United States, and the United States Department of Agriculture had but just entered upon its early stage of expansion and development.

With the passage of the Hatch Act and the establishment of an agricultural experiment station in each state in the Union, the demand for agricultural chemists became suddenly far greater than the supply, and in consequence many men were appointed as chemists who had no training in practical agriculture and whose knowledge of general and agricultural chemistry was inadequate. By way of illustration, a chief chemist who was supposed to investigate the carbohydrate contained in certain plants could read neither French nor German; he knew none of the methods of determining the different sugars and had never heard of Tollen's "Handbuch der Kohlenhydrate." This condition has now been largely overcome, but it illustrates the handicap which the work of agricultural chemical investigation has had to face.

The early chemical work of the experiment stations in animal nutrition embraced a study of the following problems:

- 1—The substitution in feeding rations of one concentrated feedingstuff or of a given kind of roughage for another.
- 2—The effect of different nutritive ratios upon the milk production or growth of different farm animals.
- 3—The relative economy of different rations for feeding farm animals of different kinds under a variety of conditions.

A foundation for the study of proteins had already been laid by the early work of Rithausen in Germany, and of Schulze in Switzerland. The subsequent long-continued and painstaking investigation of proteins by Osborne at the Connecticut Agricultural Experiment Station, supplemented by the further nutritional studies made by Chittenden, Mendel, and Osborne at Yale University, and by the work on vitamins by McCullon and others, has now changed the whole trend of investigation in animal nutrition. This work has shown that the chemistry of human foods and feedingstuffs is not only concerned with problems of mere nutrition but also with malnutrition, or with scurvy, pellagra, and beri-beri, some of the worst, most obscure, and heretofore uncontrollable diseases with which we have had to deal.

In connection with the chemical study of plants the early work of the agricultural experiment stations and of the United States Department of Agriculture embraced chiefly the making of chemical analyses for the purpose of determining the amounts of different food and mineral ingredients which they contain on different soils and under varying conditions of manuring, fertilization, and rainfall. The scope of these and other chemical investigations has, however, been greatly broadened in the years which have elapsed.

At present the United States Department of Agriculture, in addition to many other lines of work, is engaged in a study of plants and plant substances useful for medicinal, fiber, and other purposes. A typical illustration of the possibilities of plant investigations has been the study of the giant kelps of the Pacific Coast in the search for potash, acetone, and other substances which were war-time essentials. These are merely a few of the thousands of possibilities of plant studies of probable economic value. In line with such work and with the production of paper from the waste of sugar cane, of ethyl alcohol from sawdust, and of innumerable other materials from waste plant products, and from plants heretofore unutilized, it would seem advisable for the Federal government to enlarge the work of its drug, forest, and fiber laboratories to include investigations of all kinds of plant wastes and of wild and cultivated plants, for the purpose of learning their possible economic value.

Perhaps with the aid of modern methods and machinery we may find a means of utilizing milkweed economically as a source of oil, fiber, and rubber, just as the Germans during the war were able to utilize the nettle for the production of fiber. Who knows, for example, but what the water hyacinth which is rapidly blocking many of the streams and waterways of the South may, like the giant kelps of the Pacific Coast, find some useful application and perhaps be turned into a source of great usefulness or profit. This is a broad field which will require and should attract the services of men having the best fundamental training in general and agricultural chemistry, coupled with the best sort of technical experience.

It had already been claimed by Ville in France in the beginning of the last half of the preceding century that certain of the legumes were able to assimilate atmospheric nitrogen. Subsequently, however, the investigations by Boussingault in France and by Lawes and Gilbert in England, who worked with artificial or sterilized soil in which the *Bacillus radicicola* that fixes the nitrogen was either absent or had been destroyed, seemed to show that Ville was wrong, and practically the whole world was led for several years to believe that the large amount of nitrogen contained in legumes was gathered from depths of the subsoil to which the roots of other plants were unable to penetrate.

In 1881 Atwater published in the *Journal of the American Chemical Society* the results of experiments with peas which

¹ Presented at the 58th Meeting of the American Chemical Society, Philadelphia, Pa., September 1, 1919.

showed that they contained more nitrogen than was present at the outset in the seed, water, and soil. At this time Hellriegel and Wilfarth were quietly pursuing their studies at Bernburg, Germany, by which it was shown that the assimilation of atmospheric nitrogen not only occurred in the case of legumes but that it was coincident with nodular growths on their roots. Furthermore, they found that by inoculation of the roots, legumes growing in sterilized soil could be made to develop nodules and assimilate atmospheric nitrogen. Their classic researches, covering several years, were published in 1889. Immediately a large number of other investigators began the study of associated problems, such as the making of artificial cultures for inoculation purposes, the practical inoculation of soils and seeds, the effect of inoculation upon the nitrogen content of legumes, and the possibility of other plants absorbing and utilizing some of the nitrogen fixed by the legumes while growing in association with them.

Studies on the effect of different fertilizers and manures, and investigations on the effect of green manuring upon the growth of crops when grown in a definite order of rotation were also conducted by a considerable number of experiment stations.

Various experiments were made in the earlier years, particularly in England, which had shown that heavy applications of lime lessened the seriousness of attacks of the finger-and-toe (club-foot) disease of certain cruciferous plants, such as the cabbage, cauliflower, and turnip.

For a long time it had been believed that different substances in the soil had a corroding or a directly injurious effect upon potato tubers, and the development of potato scab was attributed to these substances. Subsequent investigations by Thaxter, however, showed that the disease was the direct result of the growth of parasitic plants of a low order upon the surface of the potato. It was then shown at the Rhode Island Experiment Station that if the tuber was surrounded by an alkaline medium, scab was generally increased, and if surrounded by a very acid medium the amount of scab was distinctly lessened.

It has been found in Europe and in this country that oats grown on land that has been heavily limed are more subject in unfavorable seasons to certain diseases. Also in the tobacco growing regions of the United States it has been found that an alkaline reaction of the soil favors the development of tobacco root rot. Thus we have one disease of plants which is lessened by an alkaline treatment of the soil, whereas the destructiveness of several others is increased.

We know that the presence in the soil of large amounts of certain mineral substances, such as manganese and borax, may result in malnutrition or in positive toxic effects. The presence of such compounds may possibly lead to the development of diseases which would otherwise have been unable to secure a foothold in the plant. Here is an almost untouched field of investigation open to the joint attack of the chemist, plant pathologist, and plant physiologist. We should know the specific effects upon all kinds of plants, of deficiencies and excesses of all kinds of plant foods and even of the various occasional soil ingredients, under all sorts of soil and climatic conditions. Studies of this kind would probably disclose in many cases prompt means of recognizing soil deficiencies and excesses. This would place the agronomist and chemist in a position to prescribe immediately the most effective treatment. For example, it was learned more than twenty years ago at the Rhode Island Agricultural Experiment Station, and it was also shown in Germany, that the deficiencies in potash have a very striking and characteristic effect upon the foliage of the potato plant. In consequence of such observations it has been possible, during the war, to recognize by a mere inspection potato fields where potash was becoming seriously deficient and where an abundance was still present. The leaves of buckwheat also show most

striking and characteristic spotting effects, when certain plant food deficiencies exist. These are mere illustrations of the innumerable possibilities coupled with researches of this character.

It may be possible that certain diseases of plants can be combated successfully by introducing into the plant, by spraying the tops or through the medium of the roots, certain substances which are not found in the host plant normally and which even in small quantities may cause no injury to the plants and yet prove destructive to the parasitic organisms.

As an illustration of the possibilities of soil studies in connection with plant nutrition, mention should be made of the studies of Hawaiian soils upon which pineapples could not be grown successfully. When it was found that the difficulty was due to an excess of manganese and a deficiency of available iron, it was possible to reestablish the industry by spraying the plants with iron salts. Similarly Gile found it possible by the same treatment to correct conditions of malnutrition in the case of pineapples which had been unable to assimilate sufficient iron on highly calcareous soils in Porto Rico.

Except for some occasional or incidental reference in this country to injurious acidity in upland well-drained soils, the subject had never attracted public attention nor was it apparently taken seriously by any one until it was made a subject of special study at the Rhode Island Agricultural Station beginning with the year 1891-2. In fact, it was not until several years later that the agricultural chemists and agronomists of the country began to recognize the subject as important, or would believe that it was a condition affecting plant production over vast areas of the United States.

The bad effects of soil acidity were at first attributed directly to the acidity of the soils or to compounds which were likely to be formed, or which were toxic, only where such acidity existed. In fact, Mulder, in Holland, in the early part of the preceding century, and later Voelecker, in England, recognized ferrous sulfate as a toxic constituent of certain soils. These soils were probably either presumed or found to be acid, for lime was recommended as an antidote.

Quite recently Conner and Abbot, at the Indiana Agricultural Experiment Station, have shown that aluminum nitrate may accumulate to a toxic extent in certain acid soils, and the recent investigations by Ruprecht in Massachusetts and by Hartwell and Pember in Rhode Island, have shown that other salts of aluminum or of iron which are formed in acid soils may have similar effects. In fact, Hartwell and Pember have shown that certain cereals fail to react toward increases in acidity created in solutions by artificial means, in the same way that they do toward the acid soils of the station farm. They found, also, that the same plants are affected to the same extent by aluminum sulfate as by the soils. These facts, coupled with the recognition of aluminum sulfate in the acid soils at the station, make it appear desirable that a careful study should be made of acid soils of different types and under varying conditions, in order to determine whether toxic iron and aluminum compounds are present and whether other toxic organic and inorganic substances are found generally in soils of an acid character. It would be of great interest to learn how far each of these substances is directly harmful and whether each predisposes plants to disease.

It is important to ascertain by what methods of culture, fertilization, and amendment, the toxic action of any or all of these compounds can be most quickly and effectively overcome.

The range of the resistance of different kinds of plants should be determined in cases where the soils have become acid naturally, where acidity has been brought about by turning under green crops, or by applying to the soil ammonium sulfate, ammonium chloride, and other substances. This range of re-

sistance noted should be compared with the range under like conditions, when each of the various toxic organic and inorganic substances thus far recognized as soil constituents is added to the soils.

It was found in Rhode Island that on a given acid soil one of the flowering perennials (*Silene orientalis*) thrive to perfection, or far better than when the soil was limed; whereas, on the other hand, beets, spinach, lettuce, upland cress, onions, asparagus, and other kinds of plants were generally unable to survive for more than a brief period unless lime was applied. Other plants were found to range between these extremes. If it should be found that *Silene orientalis* is highly resistant to soluble aluminum compounds and that the same compounds are utterly destructive to the plants which fail to thrive upon the acid soil until after it is limed, evidence would be afforded that a test of the soil for soluble aluminum compounds might afford a far better means of determining its lime requirement than a mere measure of its acidity. If it should be found that ferrous salts failed to affect the plants in the same way as aluminum salts, further evidence would be afforded of the importance of aluminum determinations in soils. If, on the other hand, the ferrous salts act similarly, and to an essentially like degree, the sum of the ferrous and aluminum salts should be determined. It should be mentioned in this connection that certain soils in Minnesota react distinctly acid to blue litmus paper but fail to respond to liming even for alfalfa, which fails to thrive on most soils which are quite acid. Apparently somewhat similar soils exist in parts of Iowa and Missouri.

Notwithstanding that hundreds of tests of plants have been made in Rhode Island on limed and unlimed soil there are still large numbers of agricultural plants, ornamental plants, shrubs, and trees for which the lime requirement on acid soils should be ascertained.

Some plants, like the common sorrel, will grow fairly well on mortar, or in a strongly alkaline medium, and yet they thrive to perfection on soils which are so acid and so well supplied with soluble aluminum compounds that young beet plants die in a few days. Other plants which thrive under very acid conditions become seriously affected when any considerable degree of alkalinity is created; and still other plants which can endure a high degree of alkalinity are unable to live even when the soil is only moderately acid. In view of these facts it is evident that a more complete study of these various relationships between the plant and the soil should be made.

It is held that the chestnut thrives best on acid soils and that at least most of the pines are injured by liming, whereas the beech is supposed to thrive best on soils well provided with lime. In view of the rapid deforestation of the country, it is desirable that a comprehensive study should be made on different soil types in order to ascertain how seedling forest trees of various kinds react towards pure lime, towards magnesian lime, and towards all sorts of artificial fertilizer materials, in order that nursery stock for planting our forests may be produced under the most favorable conditions. In fact, the same is true as concerns the seed bed and nursery treatment even of our fruit trees.

As yet we have only a hint as to whether those plants that endure high acidity and thrive despite the presence of assimilable iron and aluminum salts are merely resistant to these salts or are actually benefited by them. One may naturally wonder why common sorrel (*Rumex acetosella*) grows most profusely where onions and beet plants cannot live for even a few days or weeks. Is it possible that those plants which thrive even on very alkaline soils and fail to thrive on acid soils are exceedingly sensitive to the presence of soluble aluminum and ferrous compounds? Are they able to develop chlorophyll with far smaller quantities of iron than are required for the successful growth of plants which are typical of acid soils? Why do

pineapple plants remain in a chlorotic condition on highly calcareous soils until they are sprayed with iron salts, while other plants still thrive to perfection? Does the pineapple require more iron than certain other plants, is it less able to take up iron from the soil, or does it find in the soil too much assimilable manganese in proportion to the assimilable iron? These and innumerable other questions must be answered before we shall approach a thorough understanding of the various plant and soil relationships.

Common sorrel thrives to perfection on soils containing no carbonate of lime and in which there are apparently none but acid silicates. Yet sorrel takes up from the soil large amounts of lime and changes it into calcium oxalate. When these plants are introduced into the soil the calcium oxalate is changed very promptly, by bacterial action, into carbonate of lime. Is the condition of an acid soil gradually corrected by the growth of these and other plants which are typical of acid soils, and is this nature's feeble way of refitting soils for plants which are more sensitive to the toxic compounds which are formed in acid soils?

Why is it that on the Everglades of Florida certain plants will not thrive when the soils are first brought under cultivation, or not until other kinds of plants have first been grown? Is it due to toxic substances in the soil which are oxidized in the meantime, or had the former native plants removed too completely some soil ingredient which is essential to the growth of the crops that fail, or do the immediately preceding crops absorb and remove certain toxic substances to such an extent that the growth of the crop which failed at the outset is no longer inhibited? Here are the most interesting and important problems awaiting solution.

We may still have much to learn in regard to the relationship of plants to silicon, manganese, aluminum, iron, or even fluorine when present in soils in assimilable form. The ash of certain grasses often contains 17 to 20 per cent or more of silica, and the ash of sugar cane and rice as much as 50 to 60 per cent. Is the presence of a large amount of assimilable silica in soils beneficial to some plants and injurious to others; and do some kinds of plants grow better following the growing of several crops of grass or sugar cane because of the organic matter added to the soil by the grass, roots, and stubble, or by the sugarcane roots; or is it because of the removal of large amounts of silica present in forms which interfered with the plants' physiological functions?

When attempts are made to grow plants in pure silica, with the aid of the usual nutrient solutions employed in water culture, they often apparently become so highly charged with silica that normal growth becomes impossible.

The effect of crops upon those which follow is a subject of special importance. At the Rhode Island Agricultural Experiment Station a large number of experimental plots were first tested without fertilizer or manure and found to be uniform as concerned the production of onions, buckwheat, and the other crops involved. All of the plots were then fertilized alike. The first two years a given plot of land was devoted to the same crop throughout, whereas the third-year onions were sown on all of the plots. The yields of onions ranged from 12 bushels to 412 bushels to the acre, according to the crop which had preceded. The poorest crops followed buckwheat, mangels, Swedish turnips, and cabbage, and the best followed redtop. The results following other crops ranged between these extremes.

At the time when this experiment was begun the soils were sampled, samples of the succeeding crops were preserved for analysis, pot experiments were begun, and plans were laid for careful chemical investigations, bacteriological studies, and observations in other directions for the purpose of determining the reasons for these phenomenal results. This work is now being continued by Hartwell, Pember, and Damon in the hope

of solving some or all of these problems. In fact, the plans as outlined involved similar studies of the effect of the growth of all kinds of plants upon all of the others, just as it has been determined for onions. This involves observations calculated to extend over the next half century. The sixth year of the experiment buckwheat followed all of these various crops and it was found generally to thrive best following the crops which had affected onions the most seriously.

Here are problems that should be studied on many different types of soil and under widely varying climatic conditions. Who is prepared to say that the differences mentioned are explainable solely on account of the different amounts and proportions of plant foods removed from the soil by the different crops? Is it possible that any of these plants excrete substances or leave root or stubble residues toxic to other plants that follow? Do their roots and stubble liberate such widely varying amounts of plant food in the soil while they are undergoing decomposition and are the differences in growth due to the differences in their fertilizing action? Have the differences in the chemical character of the plant residues exerted a widely different effect upon direct nitrogen assimilation, upon ammonification, or upon other bacterial, fungous or protozoan activities of the soil? These, and many other problems arising from such initial field observations may well tax the skill of the chemist, bacteriologist, and plant physiologist for many years. When they are all answered we shall have what we now lack—a fundamental basis for the arrangement of crops in rotation. In fact these questions can never be solved satisfactorily by merely testing convenient and arbitrary systems of crop rotation.

We still have much to learn as to the relative merits of legumes and non-legumes as contributors to soil humus from the standpoint of the chemical, physical, and biological effects of their residues upon the soil.

The recent work by Russell and Hutchinson at the Rothamsted Experimental Station has shown that certain protozoa, including amoeba and ciliates, which are destroyed by sterilization and by treatment with carbon disulfide, toluene, tricresol, and other substances, actually consume the bacteria which promote ammonification in soils. Thus, to bacteria, fungi, and earthworms, all of which are responsible for chemical and physical changes in soils, we must now add these lowest forms of animal life.

The study of soils now offers an attractive field of effort even for the physical chemist, for colloidal substances apparently exert a powerful influence upon soils through the formation of hardpan, the fixation of plant food, and possibly also in several other important and as yet unsuspected ways.

Are we to find the counterpart of vitamins in the as yet very hypothetical auxinones, which shall perform wonders in plant nutrition, comparable with those performed by the vitamins in human and animal nutrition? Already Bottomley, in England, makes such claims. These, however, will require much further substantiation before they should be given credence.

The effect of soaking seeds in various solutions before planting should receive further study if, as recently asserted by a European investigator, the effect is equal to that produced by the application of large quantities of nitrogen in the soil. Sometimes investigations are as valuable by way of dispelling false notions or conclusions as they are for establishing facts in support of a promising theory.

In connection with the work in agricultural chemistry in this country there is much to regret, much to praise, and there are some things to condemn. The chief cause for regret is the lack of practical agricultural experience and the state of unpreparedness with which many chemists entered upon their work, especially in the early nineties. There is much to praise in the splendid contributions which have been made in the field of both plant

and animal nutrition, and in the chemical studies of plant proteins, and of soils and their amendment.

The drawing of unwarranted conclusions and the attempts to treat mere hypotheses as if they were already workable theories, even in the face of opposing facts, may lead to discussion and controversy and thus stimulate research, but the end, nevertheless, does not justify the means, any more than the misfortunes of war are justified by some scraps of good that may result from it. There is no safe and justifiable procedure for the scientist but to apply the most crucial test to all hypotheses and theories; and he who is not as ready to look for facts which are as likely to militate against as to support his hypotheses and theories is unfitted to direct research.

There is one tendency connected with the nature of the institutions engaged chiefly in agricultural research which cannot be too strongly condemned. I refer to attempts to exploit the results of scientific agricultural investigations by endeavoring to interpret them prematurely in terms of agricultural practice. This is sometimes referred to as "doing stunts" for the purpose of impressing Congress and the state legislatures as an aid in securing appropriations. This sort of work should have no place in any institution whether federal or state. Great detriment to the cause of agricultural investigation has resulted, and is always likely to result, from the promulgation of mere hypotheses or theories as if they were already established facts. The farmer is by nature abundantly skeptical and slow to adopt desirable procedures, without foisting upon him undigested and premature ideas which are contrary to common observation and well-established facts.

The investigator who finds that plants can feed from very dilute solutions and that the minerals of the soil are continually passing into solution is not warranted in concluding that fertilizers and manures are no longer needed as plant foods. While both of the observations are correct, the "pinch of the shoe" comes in the fact that the relative proportions of soil and solution in a test made in a laboratory beaker are utterly unlike those met with in the soil where the solvent action of the soil moisture, aided by the root action of the plants, often utterly fails to keep pace with the localized demands of the plant rootlets for immediately available plant food. It is very much like the hoax of the "invisible man," who starts out with a citation of the fact that there is no such thing as color, and that objects have the peculiar property of absorbing all of the colored rays but one, which, being reflected, gives to the object what we call color. Next follows the illustration of the separation of the sun's rays into the various colors of the spectrum, and it is pointed out that there are other rays outside of the spectrum known as actinic rays which are colorless or invisible. It is now but a step to the assertion that a chemist has found a substance which absorbs all but these colorless or invisible rays and one has merely to coat himself over with this substance if he wishes to go about unseen. Both ideas are based upon two sound and convincing facts, but in the end they amount to the dorky's definition of an alibi, "It's provin' you're where you ain't."

It is of scientific interest to show that artificially prepared tricalcium phosphate is reacted upon practically in a quantitative way by the nitrous acid formed in the nitrification of ammonia by bacterial means. It is going too far, however, if one attempts to use such an observation for the purpose of making the farmer believe that the reaction with finely ground rock phosphate would follow the same course, and take place to the same extent, in the soil. It must be remembered that where the soil moisture is often greatly limited in amount, and where carbonates, or at least basic silicates, are present at every point to compete with the phosphate in seizing upon the acid, the action upon the phosphate cannot be comparable with that secured in the laboratory, where nothing but the phosphate is present for the acid to attack.

Satisfactory comparisons of the efficiencies of different phosphates in the field cannot be made if there is only a slight deficiency of phosphoric acid, particularly if unusually large amounts of phosphates are applied. In all such comparative work the supply of the most efficient phosphate should fall a little short of, or certainly not exceed, the actual requirements of the particular crop.

In testing the efficiency of nitrogenous fertilizers the same principle holds true, and in both cases one should so plan the experiments that positive information is furnished as to the adequacy of the other plant foods employed, in order that it may be certain that the only "limiting element" is the one under consideration.

In testing the rate of nitrification of different ammoniates one must use only what would be considered rational proportions of soil and material and not several times the amount that would be used in agricultural practice, for if larger amounts are used in conjunction with an alkaline soil the better and more available the ammoniate, from an agricultural standpoint, the greater the amount of ammonia that would be formed from it in a given time. This ammonia added to the existing alkalinity is likely to give rise to a total degree of alkalinity which would seriously interfere with or inhibit nitrification, and thus observations based upon the rate of nitrification might lead to conclusions as to relative availability which are diametrically opposed to the truth.

In making studies of the chemical reactions of calcium carbonate and of magnesium carbonate on soils it is important that the experiments be conducted with natural limestone and magnesium limestone because of the relatively high solubility in carbonated water of artificial magnesium carbonate and the low solubility of magnesium carbonate in magnesian or dolomitic limestone.

These are merely illustrative of types of work from which false and misleading conclusions have been or may be drawn at any time if the essentials of a true experiment are not observed.

At the present time the outlook for agricultural chemistry in the United States is not particularly encouraging, for the reason that we are placing great emphasis upon other lines of endeavor which are drawing some of the best and most promising young men away from postgraduate study. I refer to the passage of the Smith-Leaver Act and the large sums of money made available for employing county agricultural agents. Many of these men who have become county agents within two or three years after graduating from college, and who may not have pursued any postgraduate studies, are often paid more at the outset than some of our agricultural chemists who have taken their doctor's degree and who have already devoted many years to agricultural chemical research. In other words, instead of increasing progressively the salary of these research men commensurate with their experience and ability, and as an incentive to thorough preparation on the part of young men who are to follow them, they are unfortunately paid so poorly that the young men find no inducement to spend several more years at the university, especially in view of the present high cost of living. The situation is also aggravated by the fact that the purchasing power of the dollar has shrunk to such an extent that the Federal and State appropriations for the agricultural experiment stations have dwindled to such an extent that even the investigational work already in progress on the low salary basis is being seriously jeopardized, while many of the new problems developing from the research in progress must remain untouched.

Too much emphasis cannot be placed upon the importance of thorough fundamental preparation on the part of those who intend to take up agricultural chemistry, for there is no safe short cut. Thorough general training in inorganic, organic,

and physical chemistry is absolutely essential as a basis for the prosecution of the study of chemistry in its relation to agriculture. The agricultural chemist will also be brought in frequent contact with problems related to physics, biological chemistry, physiological botany, bacteriology, and even protozoology. Furthermore, in order to be best equipped for his work he should have an actual knowledge of practical agricultural matters. He should also be familiar with the subjects embraced under agronomy and animal feeding and should be able to read at least French and German freely. I say this notwithstanding the present unfortunate hysteria concerning the teaching of German in American schools.

There is now, and always will be, a demand for broadly trained agricultural chemists, with organizing capacity in the various industries, as well as in the agricultural experiment stations.

In connection with the work of the agricultural experiment stations it is particularly important to have men in charge who are qualified to lead into proper channels the enthusiasm and energy of some of the young men who, if left to themselves, might startle the world with some imaginary discovery which, if real, would be calculated to revolutionize agriculture. Well trained men are and always will be needed in these stations to organize and concentrate research around given projects. They must see that the scientific work is interpreted wisely and that conclusions are not passed out to the farmer while everything is still in a hypothetical or theoretical stage. In a word, men are needed who, to borrow from President Wilson, have the patience and skill to first "make real the things that have been conjectured," before they are passed along as a guide to the practical hard-working American farmer who has neither time nor money to waste in chasing visions.

BOSTON, MASS.

CHEMICAL WARFARE¹

By MAJOR GENERAL WILLIAM L. SIBERT, CHEMICAL WARFARE SERVICE, U. S. A.

My mind within the last year has been drawn to the necessity of chemical development in every direction in this country. When one looks back he must appreciate the absolutely helpless condition the United States would have been in prior to 1917 had it been called upon to prosecute a war with a great Nation, and had it been unable to control the seas. Its effort to resist a foe would have been on a par with that of China. It would not have had powder enough to last two weeks, and would have had no nitrates out of which to make more. The absence of a dyestuff industry with its by-product coke ovens, would have limited the supply of raw materials for the manufacture of explosives and gases. Future wars will be more and more chemical wars, more and more scientific, and the nation that has developed its chemical possibilities will enjoy a great advantage.

One of the big questions presented for solution to-day in this country is chemical preparedness for war, through the development of chemical industry that has peace application.

There is nothing to indicate that Germany, prior to the war, had made any systematic arrangement to utilize her dye factories for war purposes, because many of her chemists were in the beginning called into the military service. This and many subsequent developments of chemical plants for war needs cause one to think that Germany confidently expected the war to end in a very few months, that she had sufficient materials in storage, and that her mind was not turned to the full utilization of the chemical resources of the nation for the support of the army until after the results at the Marne.

There is one notable exception to this, and that is the development of the processes for the production of ammonia from

¹ Address delivered at the Annual Convention of the International Acetylene Association, New York, July 15, 16, and 17, 1919.

atmospheric nitrogen. It was not until the end of 1912 that there was any large-scale production of ammonia by this method. In other words, the Great War was not brought on until the way was clear. That is, it was not brought on until Germany could produce within her own boundaries a supply of ammonia and nitric acid needed in the manufacture not only of her high propellants, but also for the fertilization of the land, so as to make the feeding of the army certain.

When it became apparent, after the Battle of the Marne, that the available supply of material for the manufacture of suitable propellants and explosives would soon be exhausted, it was then that the great chemical establishments of Germany were called upon to convert their plants, that had been utilized in making dyestuffs, into high explosive plants and gas plants; it was then that the chemists who had been drafted into the army were returned and utilized with existing plants and with necessary extensions—all in order that the needs of the army might be met. The existence of this great potential reserve made Germany a powerful adversary.

It is a peculiar fact that if you probe nearly any line of chemical industry you will find that it has a war application as well as a peace application. I will mention some of the ways that our people think the manufacturing plants for acetylene may be a preparation for war. The ordinary uses of acetylene, the processes of welding and cutting steel, and its use for signal flares and illuminating processes need not be dwelt upon. The use of burning acetylene to light the fields of England in order that all the land possible might be planted, was merely an extension of a well established use.

The great development of airplanes in this war called for a large supply of acetone for the preparation of airplane dope. The synthesis of this chemical commodity as well as of acetic acid, beginning with acetylene as a starting point, is now a commercial reality. The Government expended over \$100,000,000 in its nitrate plants, which nitrates were to be used in making propellants and fertilizers, both in times of peace and in times of war. The largest of these nitrate plants utilized the cyanamide process of fixing nitrogen, and this audience need not be told that cyanamide in turn is prepared from calcium carbide.

Mustard gas is prepared from ethylene, which is usually prepared from alcohol. Have we not in acetylene a raw material from which ethylene can be prepared on a successful commercial basis? Further research and development may establish such a fact. In fact, our research people tell me that the entire subject of the chlorination of acetylene, and the preparation of its chlorine derivatives, is one that should be carefully investigated, not only from the standpoint of chemical industry in times of peace, but also from the standpoint of the preparation of raw materials for war needs.

The interaction of acetylene with phosgene, with arsenic trichloride, with stannic chloride, and with antimony trichloride are all fertile fields for investigation. It is apparent, therefore, that we have in the acetylene industry an association with war problems which may be as important as the association of the coal-tar chemical industries with such problems.

What the Government needs is chemical industry in every line that nature has made it commercially practicable to develop. We want to be in the same position that Germany was in during this last war, so that whenever research indicates that some new substance or some substance hitherto not manufactured has a military value, the heads of the chemical interests of the country could be called together and given the problem with the full expectation that they could solve it and would solve it, that some existing chemical plant could be changed into one suited for making this substance, that the various well-tried research establishments could soon overcome any difficulty in its manufacture, and that there would always be a personnel available for such manufacture; because

this war has shown more strongly than it has shown anything else, that a country without an extensive organic chemical industry will be seriously handicapped in war against the nation that has such an industry.

Of course, there is no need for me to tell this audience these things. If they stop to think, they will know them. But it is always well to impress upon people that there is a public use that might be made of their appliances when their country is in need, because the average man takes pride in assisting his Government when it is in need.

This country needs now to develop a certain and sure nitrate supply; it needs to develop large dyestuff industries; it needs to have its acetylene industries developed and protected, if need be, against hurtful foreign competition.

Chemical warfare, as such, made its first appearance in this war. It probably caused more casualties than any other single implement in the war. It has in it more possibilities than any adopted implement of war. If the Chemical Warfare Service of the Army keeps closely in touch with all of the chemical industries of the land, if such industries are sympathetic with the needs and aspirations of the Government, and each of them exchanges research information of value to the other, and if the Congress of the United States insures the development of such chemical industries, we can trust to the ingenuity of our chemists and chemical engineers to see that this country enters no future war, except upon equal terms, with any adversary, in so far as chemical warfare is concerned.

Had the Germans known at Ypres the effect of the first chlorine cloud that they passed over the allied lines, and had they had confidence in their own protective devices and followed closely that chlorine cloud, they could have penetrated to the channel ports—all of which shows what the surprise use of a chemical substance means.

Although the gases used in the great spring drive by the Germans in March and April of 1918 were known gases, the new tactical use of gases made possible through Germany's ability to make them in great quantities almost resulted in a German victory. By saturating the strong points of the line with mustard gas for 48 hours before an attack, back to a depth of 5 or 6 miles, and by saturating the road crossings through which reserves and ammunition must pass, one of the English armies in the first onset in March was largely paralyzed, its strong points were made ineffective, and the weak points easily taken.

A recent inspection of the German gas manufacturing plants and chemical plants in general in the Rhine district, made by representatives from the Chemical Warfare Service, has led to the conclusion that we have nothing to fear from Germany. In fact, the first mustard gas plant which was inspected by one of our men, one of the biggest of these plants in Germany, led to the opinion that the Germans had abandoned their own methods of making mustard gas and had adopted the American method.

At the time the war stopped Germany was making mustard gas at the rate of 10 or 12 tons a day. We had actually made it at the rate of 40 tons a day, and had a capacity of 80 tons, and we actually shipped to Europe 4000 tons of gas of various kinds, a good deal of which was chlorine, used as a raw material in the manufacture of mustard gas and phosgene, which we exchanged with the French for shells loaded with gas. That was our shortage—we did not have the shells for this gas.

At the beginning of the war there were a great many prejudices against the use of gas, a large part of it due to the propaganda against the Germans, picturing the frightfulness of the use of gas.

While about 30 per cent of all the casualties among the American troops was due to gas, only about 3 to 4 per cent of these casualties died, and of those who did not die nearly all of them will recover. I read a report not long ago from a

surgeon who, in giving the results of his observations on 2000 cases of men who had been gassed 4 or 5 months previously, stated that there was no indication of the development of tuberculosis, no indication of the opening up of any old tubercular lesions in any of these gas cases, and that the majority of them seemed to indicate that they would become entirely normal.

The question of research is one that bothers us a great deal, if the Chemical Warfare Service is to live. The surprise effect of a new chemical is often the most important thing connected with it. For instance, if we could discover a new gas that would penetrate the enemy's gas mask, manufacture it secretly in large quantities, and spring it on him as the German sprang the first gas cloud on the English at Ypres, we might win the campaign. Secrecy is, therefore, one of the most important things connected with our research, and it is unfortunate that the average chemist likes to put the results of his investigations in the journals.

I have thought of attempting research through the various institutions, through the National Defense Council and its relations with the universities and societies; but I feel almost certain that if any of the institutions, the universities or societies, made a discovery, they would advertise it to the world. Gas warfare research that becomes public is more than bad. It does the enemy more good than it does you, especially in a country like this which is never in a hurry to prepare for war, while others may be. I have thought that, if Congress retains a permanent Chemical Warfare Service in the Army, the best plan would be to have one big diplomatic, thoroughly scientific chemist, who would keep in touch with the various institutions and universities which have been doing work along lines similar to those that are indicated as best for us to pursue, and who could go to these institutions and say: "The Government wants to employ this man for one year, or that man for two years." Of course, we would expect to pay the requisite salary. Such a man coming into our laboratories would become thoroughly impressed with the fact that secrecy is, above all, the most important element. In that way the Government could keep in touch with the work being done by the various chemical and educational institutions in this country, and still maintain secrecy. I believe that is the best plan we could adopt.

If we should attempt to have a chemical research organization of our own, and commission men in the Army to conduct such work, they would be certain to get into a rut and get behind the times.

The Chemical Warfare Service has a great deal of research information, it has issued many monographs of research at the American University, it is willing and glad to give any information possible to the industries as long as it does not reveal some important military secret, and it wants to keep in touch with, and work with, the commercial industries in this country.

WASHINGTON, D. C.

THE WORK OF THE HARRIMAN RESEARCH LABORATORY, ROOSEVELT HOSPITAL, NEW YORK CITY, IN AFFILIATION WITH THE DIVISION OF FOOD AND NUTRITION, MEDICAL DEPARTMENT, U. S. ARMY

By K. GEORGE FALK

Received June 7, 1919

In November 1917, Major (later Lieutenant Colonel) John R. Murlin, in charge of the Division of Food and Nutrition, assigned the subject, "The Protein Decomposition of Meat," to the Harriman Research Laboratory for study. Three lines of investigation were begun: (1) The chemical study of meat

spoilage; (2) a study of the factors upon which the toxic actions of spoiled meat depend; (3) a study of the methods for preventing spoilage. The study of the prevention of spoilage resulted in the new vacuum dehydration process, applicable as well to other food products, including fish, fruits, and vegetables. This led to a comparative study of the enzymes, proteins, and carbohydrates of fresh vegetables and of vegetation dehydrated by different processes.

In the study of the chemistry of spoiling meat,¹ the quantitative changes in the ammonia, non-protein nitrogen, total creatinine, and purines, were followed in meat broth inoculated with nine different strains of bacteria, most of which were obtained from meat considered responsible for food poisonings. Definite chemical differences were found in the changes brought about by the different bacteria. It is probable that a continuation of this work would aid in making it possible to identify bacteria by their metabolic actions and in the preparation of suitable synthetic media, different for different bacteria. The increase in the ammonia content observed in all these actions was studied further in connection with its use as a test for meat spoilage.²

The toxic properties of meat infected with various strains of bacteria obtained from food suspected of having caused poisoning were studied as well as meat from animals suffering from septicaemia. The conclusions from this work together with the published literature show that meat from animals healthy at the time of slaughter, but becoming infected after killing, if thoroughly cooked, may, in general terms, be considered safe to eat. Meat from animals infected at the time of slaughter may contain heat-stable toxins and is therefore unsafe as food even if thoroughly cooked.³ The possible formation of methylguanidine from creatine was studied because of the toxic properties of the former. None was found in spoiled meat in quantities sufficient to be the cause of toxic symptoms.⁴

The problems of the existing emergency as related to the use of meat involved transportation and the safety factor of food handling. To solve these problems, a new process of dehydration was developed with Dr. E. M. Frankel. After the principles and method had been worked out on a laboratory scale, the process was applied on a commercial scale with the aid of Prof. Ralph H. McKee, of Columbia University. The method consists essentially in removing the water from food substances in a vacuum at a temperature below that at which appreciable changes in the foods occur, supplying the requisite quantity of heat rapidly enough to forestall spoilage. The process was devised mainly for meat and fish but has been applied to vegetables, fruits and other food substances as well.⁵ The advantages of the vacuum process as compared with the older air-blast dehydration processes are (1) shorter time required for dehydration; (2) applicability to such products as meat and fish; (3) general character and appearance of products; (4) more economical operation; (5) smaller chemical changes. The disadvantage at present is a greater initial cost of apparatus, but this would be written off in a few months of operation.

The study of the dehydration process for various foods led to the question of changes taking place in vegetables on simple treatments, such as dehydration. The destruction of the antiscorbic property toward guinea pigs of certain vegetables dehydrated by the air-blast process indicated the timely importance of such studies. In general, the question of food hormones (including in this term vitamins, antiscorbic property, growth-producing property, etc.) has become prominent

¹ K. G. Falk, E. J. Baumann and G. McGuire, *J. Biol. Chem.*, **37** (1919), 525.

² K. G. Falk and G. McGuire, *Ibid.*, **37** (1919), 547.

³ I. Greenwald, *J. Pub. Health*, **8** (1919), 595.

⁴ I. Greenwald, *J. Am. Chem. Soc.*, **41** (1919), 1109.

⁵ *This Journal*, **11** (1919), 1036.

in recent years in connection with the development of certain pathological conditions due to the lack of these chemically unknown constituents in diets apparently adequate in protein, fat, carbohydrate, mineral components, and calories.

A series of studies was undertaken with the object of obtaining further evidence of the changes occurring in biological material and with the hope of obtaining some insight into the chemical nature of the changes. This part of the work was limited to vegetables and included enzymes, proteins, and carbohydrates.

The properties of the oxidase, peroxidase, catalase, and amylase of cabbage, carrot, yellow and white turnip, tomato, and potato juices were studied at different hydrogen ion concentrations. Certain changes in the enzyme actions and properties were found on dehydrating these vegetables, air-blast dehydration producing considerably greater changes than vacuum dehydration.¹

An extended study of potato amylase was begun. The action of this enzyme on potato starch as it exists in the juice pressed from the potato and on Lintner starch prepared from potatoes was found to be different. Optimum conditions with both were found at a hydrogen ion concentration very nearly 10^{-6} *N*, approximately the acidity of the natural juice. On naturally occurring starch good action was obtained in more acid solution, but practically none on Lintner prepared starch. The conditions were reversed in the more alkaline solutions, marked action on prepared starch and very little on natural starch.

The titration curves of the juices were obtained by plotting the hydrogen ion concentrations (in terms of *pH*) against the amounts of standard acid and alkali required to obtain these hydrogen ion concentrations. Differences were observed between the titration curves of the juices from the fresh and the dehydrated vegetables. These indicated that a change took place on dehydration in the sense that the acidic constituents were increased, more so in air-blast dehydration than in vacuum dehydration.

A study of the physicochemical properties of the proteins of potato, tomato, and carrot, was made.² The hydrogen ion concentrations, iso-electric points, and titration curves of the juices of these vegetables and the proteins prepared from them were determined. The proteins were separated and purified by several different methods, including precipitation at the iso-electric points, salting out, and dialysis. It was found that every physical or chemical treatment modified the properties of these proteins to some extent, as evidenced by the titration curves, and that apparently the least change in their preparation was brought about by precipitation at the iso-electric points.

The effect of different methods of dehydration on the carbohydrate constituents of carrots, turnips, cabbage, and potatoes, was determined. A full description will appear in a future issue of *THIS JOURNAL*. Reducing sugars, soluble starch and dextrans, and insoluble starch were determined in fresh, vacuum-dehydrated, and air-blast-dehydrated products. No changes were observed in these constituents as a result of the dehydration processes.

The physiological actions of the dehydrated vegetables are being studied by Dr. Maurice H. Givens of Rochester University, by Dr. K. Sugiura of General Memorial Hospital, New York, and by others and will presumably be communicated later.

The work described in this part of the investigations shows that dehydration does not produce changes which can be observed by ordinary chemical methods; that physicochemical methods show changes in fresh vegetables on very simple treatments and also some changes in these same vegetables on dehydration, greater in air-blast dehydration than in vacuum; and that changes in enzyme actions may be caused by dehydration, greater in air-blast de-

hydration than in vacuum. In general, it appears that enzyme action is the most sensitive index of change taking place in animal or vegetable matter susceptible to simple tests, but that modifications in the enzyme actions need not necessarily be accompanied by changes in food hormone properties or in the nutritive values of foodstuffs.

HARRIMAN RESEARCH LABORATORY
ROOSEVELT HOSPITAL
NEW YORK CITY

CHARCOAL IN SWEDEN

By J. W. BECKMAN

Received April 16, 1919

It is a well-recognized fact all over the world that Swedish charcoal iron stands at the very top of iron products; its reputation is of long standing and its name has become a by-word when high-grade iron products are spoken of.

Sweden does hold large deposits of high-grade iron ores. Enormous tonnages of these ores are shipped to most industrial countries of the world including the United States of America, but these alone do not make the Swedish iron world-famous. It is the superior quality of the charcoal used as a reducing agent that gives the Swedish iron its excellent characteristics.

The charcoal demands for an iron industry, even of the size of Sweden's, are enormous, and recently some illuminating statistics have been published showing in detail the production of charcoal there, all of which is consumed by the iron furnaces.

Charcoal is derived in Sweden from three sources. The principal source is that of pit-charcoal operations out in the woods and forests of Sweden; next in importance is the pit charcoal obtained from the waste from lumber operations and paper mills where slabs and sides are made into charcoal; the third source is the by-product charcoal oven which contributes only a comparatively small amount of charcoal, yet at the same time represents considerable financial returns on account of the commercial value of the by-products obtained.

The statistics deal principally with the production of the years 1914 and 1915, but, due to the intensive war activities, it is safe to assume that the charcoal production during the later war years has increased tremendously.

Charcoal produced during 1914 in the forests of Sweden amounted to 55.9 million bushels, 20.8 million bushels were obtained from the wood wastes of lumber mills and paper pulp plants, while 7.1 million bushels were derived from the by-product charcoal ovens operating on stumps, mill waste, and other wood—a total production of 83.8 million bushels of charcoal for the year 1914.

During the year 1915 the charcoal made in pits from mill waste, as well as in the forests, amounted to 94.4 million bushels, while in by-product ovens 6.2 million bushels were obtained, or a total production of 100.6 million bushels.

All the charcoal made in Sweden is that obtained from soft wood and a bushel weighs about 14 lbs., giving a total tonnage as follows:

YEAR	TOTAL WEIGHT, TONS	PRICE PER TON	TOTAL VALUE
1914.....	536,320	\$22.50	\$12,067,000
1915.....	636,000	\$22.50	15,900,000

All this charcoal is consumed by the iron industry in Sweden, a part of which is now using electric shaft furnaces for the purpose of saving the charcoal for reduction purposes only, producing in this way close to three times as much metal with the same amount of charcoal, the electric energy supplying the heat necessary for the reduction.

But in addition to the value of the charcoal alone the by-products obtained from the oven installations represent considerable value.

From the 7.1 million bushels of charcoal produced in by-

¹ K. G. Falk, G. McGuire and E. Blount, *J. Biol. Chem.*, **38** (1919), 229.

² E. J. Cohn, J. Gross and O. C. Johnson, *J. Gen. Physiol.*, **1919**.

product ovens in the year 1914 the following quantities of by-products were obtained:

	Tons
Tar.....	6122
Heavy tar.....	180
Wood oil.....	201
Wood alcohol, 100 per cent.....	524
Turpentine.....	297.5
Formaldehyde.....	227
Acetate of lime, 80 per cent.....	917
Acetone.....	5.5
Cresote oils and various other products.....	53

The value of these chemical products vary naturally with the market conditions. While in 1914 their aggregate value was the

same as that of the charcoal with which they were simultaneously produced, during the later years of the war the by-products plants have been enormously prosperous due to the high prices of chemicals.

These details from the Swedish industry serve as an indication to all countries with large and extensive lumber operations of what may be done and what should be done for the purpose of preventing a national waste and creating from the same a national wealth.

BALBOA BUILDING
SAN FRANCISCO, CALIFORNIA

FOREIGN INDUSTRIAL NEWS

By A. McMillan, 24 Westend Park St., Glasgow, Scotland

CARBON ELECTRODES FROM NATURAL GAS

It is interesting, says *Engineering* 108 (1919), 326, to point out that natural gas especially when not sufficiently plentiful for lighting purposes may be cracked to produce electrode carbons. The gas is passed through pipes which are suitably heated so as to produce a mixture of soot and tar. The mixture is briquetted and then baked. The electrodes so obtained are free from ashes and the proportion of tar in them can be varied by adjusting the temperature to which they are heated. According to the *Journal für Gasbeleuchtung* of March 17, Dr. E. Szavasy of Budapest was making carbons in this way from the natural gas found in some parts of Hungary.

A COLLOIDAL SILICATE

In the course of the work of the Department of Scientific and Industrial Research, attention has been called to a certain colloidal silicate apparently not hitherto in use, which may possibly prove to be of commercial value, especially in the textile industry. A limited number of small samples may be obtained on application to the Department of Scientific and Industrial Research, 15 Great George St., Westminster, London.

FERMENTATION GLYCERIN

In connection with the production of glycerin by the alcoholic fermentation of sugar, a paper recently appeared in the *Schweiz. Chem. Z.*, 18-19 (1919), dealing with the effect of adding a reducing agent to the fermenting liquor. According to Oppenheimer, the glycerin is formed by reduction of glyceraldehyde or dihydroxyacetone into which the hexoses are primarily broken up. The author found that acid reducing agents were unsuitable, but sodium sulfite produced a greatly augmented yield, whereas Pasteur (1857) obtained from 100 g. of sugar with yeast 3.6 g. of glycerin, Oppenheimer (1914) with yeast juice obtained 3-12 g., while Schweitzer with yeast and sodium sulfite obtained 21.3 g. The yield obtained by Eoff, Linder and Beyer (1919) using a yeast and sodium carbonate was 20-25 per cent.

HYDRAULIC ROCK BLASTING

A hydraulic service for the blasting of rock and especially for the demolition of concrete piers and foundations is briefly described in the *Zeit. für Schiesswesen* for May 2, by Dr. Tübben of Westfalia. A pressure pipe leads to a cylinder, 85 mm. in diameter, in which eight pistons move one after the other in telescope fashion. The cylinder is inserted in a hole drilled into the rock by an electric motor. The pistons are forced out and crack the rock. The drilling of the holes about one inch in depth is said to take 15 to 20 min. and the blasting 5 min. When the rock is cracked, a tap is opened and the water allowed to spurt back. The device is said to have proved very successful in mines and quarries where the concussions of explosives would be dangerous.

GLYCERIN SUBSTITUTE

Oil and Color Trade J., 56 (1919), 58, quoting from a German patent, says that the soluble magnesia salts of butyric acid form good substitutes for glycerin on account of their high viscosity, neutral reaction, and low freezing point, their suitability being further improved by a slight addition of alcohol or glycerin; for example, a 30 per cent aqueous solution of magnesium butyrate with 5 per cent alcohol remains homogeneous at -20° C. and exhibits no tendency to crystallize. For many purposes a 23 per cent solution of the butyrate is sufficient. The preparation is not corrosive, dissolves to a clear solution in water, has a high solvent action on many substances, and is miscible with glycerin and other substitutes.

TRADE OPENINGS IN ITALY

The following inquiries for sources of supply from firms in Italy have been received by the Chamber of Commerce for Italy, 7 Via Carlo Felice, Genoa. Communications regarding the inquiries should be sent to the Secretary of the Chamber. A Turin chemist would buy for his own account or represent on commission manufacturers of chemicals, pharmaceutical specialties, etc. A Genoa merchant would buy on his own account or handle on commission, soap, perfumery, and other such articles. A Genoa firm of produce merchants is desirous of forming connections with colonial produce exporters, edible oil refiners, etc. Another Genoa firm would represent mineral oils and such articles.

USES OF GLAUCONITE

Bulletin 77, 1919, by E. S. Simpson (Geological Survey, Western Australia) on the sources of industrial potash is opportune in its treatment of glauconite. It is pointed out that a mixture of a greensand with superphosphate renders much, if not all, of the potash in the glauconite water-soluble. The alunite which occurs in veins of kaolinized rock is stated to be widely distributed over the belt of weathering and contains 9 per cent potash. In view, however, of its possible origin in other cases through sulfur bearing waters, there seems no reason why it should be confined only to weathered masses of rock.

RE-USE OF PERISHED RUBBER STOPPERS

A simple method of rendering hard perished rubber stoppers again serviceable for use is given in a recent issue of the *Zeit. öffentliche Chemie*. If the rubber stopper is not entirely perished it can be restored to a usable condition by turning off the hardened portion in a lathe, the turned surface being finally smoothed with sandpaper. The softer the stopper the greater must be the rotation of the lathe in point of speed. The hardened surface of a boring in a rubber stopper is simultaneously removed by means of a round file, the stopper being rotated in a lathe.

LEAD SODIUM ALLOYS

It has long been known that an addition of sodium to lead hardens the lead. As nearly the same effect can be obtained by the addition of other elements, which do not render the lead subject to corrosion as the sodium is apt to do, the lead-sodium alloys have been little studied. In the *Z. Ver. deut. Ing.*, May 10, Dr. J. Goebel describes some tests to which he submitted ternary alloys of lead-sodium-mercury and lead-sodium-tin. He started from the binary alloys lead-sodium, lead-mercury, lead-tin, fusing the constituents in a hydrogen atmosphere and cast test cylinders 2 cm. in diameter and 1.75 cm. high which he submitted to hardness tests (Brinell), bending tests, and impact tests. The specimens were tested immediately after quenching or after an interval of about 8 days. Lead dissolves 0.8 per cent sodium and the mixed crystals formed in the 4 per cent alloy contain the compound Na_2Pb , the eutectic containing 2.5 per cent sodium. The addition of up to 7 per cent mercury to lead raises the hardness figure from 4 to 9. When sodium, up to 4 per cent, is added to lead, the hardness is raised very much, reaching the value 8 when the sodium percentage exceeds 0.8 and keeping nearly at that value up to 2.5 per cent, but falling off with higher sodium values. The hardness figure of zinc would by the same test be 27, that of electrolytic iron 47. The further addition of mercury to these binary alloys does not make much difference, the curves are in general more regular and the maximum is shifted nearer 2.5 sodium. Ternary alloys containing less than 1 per cent sodium are softer than the corresponding lead-sodium alloys. Bending tests gave better values with mercury added and poorer values when sodium is added. The experiments with binary and ternary tin alloys, lead-sodium-tin, were not satisfactory. The sodium made alloys up to 7 per cent tin harder but not stronger, and the conclusion drawn is that only the lead-sodium-mercury alloys would answer for certain technical purposes.

THE "BUOY" HANDLAMP

The General Electric Company, Ltd., says *Electrician*, 83 (1919), have introduced a handlamp for industrial purposes for which special advantages are claimed. The new lamp is known as the G. E. C. Buoy Handlamp. The base is of black insulating material of a robust and indestructible nature and weighs about $1\frac{3}{4}$ lbs. The guard is of strong tinned steel wire and is of small weight compared with the base. The latter owing to its curvature and weight will keep the lamp upright. The lamp will stand also on a gently sloping surface and can be used without greater care than is commonly accorded material by unskilled labor in heavy industrial work. It is very compact, measuring only $8\frac{1}{2}$ in. long by $4\frac{1}{2}$ in. diameter, is provided with a side hook and top hook, and has no weak appendages. It is easily grasped and, as it can be hung or stood anywhere, both hands are left free. It is shock proof and designed to comply with the Home Office regulations with regard to handlamps in factories.

MINE RESCUE APPLIANCES

The Home Office has issued a warning that neither the army box respirator nor the Eeds helmet is any protection to a man who is attempting to penetrate a noxious atmosphere underground. In attacking a mine fire or entering workings after an explosion the main risk is due to carbon monoxide, and a second risk, which is seldom of importance at the surface but cannot be disregarded in mines, is that the atmosphere may not contain sufficient oxygen to support life. Neither of the appliances mentioned above gives protection against either of these dangers, and therefore cannot be regarded as a substitute for self-contained breathing apparatus. Both, however, will stop smoke and thus may give a person ignorant of the real danger a feeling of security when entering smoky air, and thus add to the probability of his being overcome.

A NEW USE FOR OIL OF MEADOWSWEET

According to an article in *Oil and Color Trade J.*, 55 (1919), 2431, salicylic aldehyde, which, in its artificial form, is used as a substitute for the natural oil of meadowsweet, has been found to act as a reagent towards caustic alkalies and may be used as an indicator in, for example, the determination of salicylic acid. It has been found that the usual calorimetric method of estimating salicylic acid by means of ferric chloride fails in the presence of salicylic aldehyde which also gives a coloration with ferric chloride. It is found, however, that the aldehyde yields a yellow color with caustic soda, so that salicylic acid may be titrated, in the presence of the aldehyde, with standard alkali, the aldehyde acting as an indicator. The procedure is as follows: The salicylic acid containing the aldehyde is extracted in the usual way with ether and the ethereal solution is shaken three times with 10 cc. dilute sodium bicarbonate solution. The united extracts and washings are then titrated with *N/20* sulfuric acid until the yellow color, due to the action of the alkali on the aldehyde, is discharged, after drawing off the carbonic oxide, as it is formed, by boiling.

STARTING PANELS FOR ELECTRIC MOTORS

A descriptive list received from the British Thomson-Houston Company, of Rugby, deals with automatic contactor panels for starting non-reversing direct-current motors. They consist of a number of magnetically operated switches or contactors fitted with a calibrated current or time limit relay. The contactors are of the single-pole type, opening with a quick positive action which prevents fusion of the contacts, while each is fitted with a powerful magnetic blow-out, arranged with an arc chute of insulating refractory material, which carries away the arc from the contactor and adjacent parts. As automatic starting rheostats the panels are primarily designed for use with motor driving pumps which have to be started and stopped automatically according to a predetermined change in the level of the liquid in a tank, and in such cases a float switch is used to open and close the operating coil circuit of the contactors. A pressure governor can be used for the same purpose when the operation of the motor depends on the variation of water or air pressure, or when a predetermined pressure has to be maintained. For controlling air compressors, instead of time relays, a magnetic air valve may be used to unload the compressor automatically during the starting period so as to reduce the starting current to a minimum, and also to unload the compressor at the moment of switching off current from the motor, the object being to prevent shock and strains on the shaft and revolving parts of the motor due to the sudden bucking of the compressor when power is taken off.

ACETYLENE AS MOTOR FUEL

In Switzerland where hydroelectric power for making calcium carbide is abundant, acetylene is the most promising substitute for petrol as a motor fuel. Its drawbacks include violent explosiveness when mixed with compressed air in the carburetor and corrosion or clogging of the motor by soot and acids of combustion. Remedies are the dilution of the acetylene and an extra supply of air to insure burning of all the carbon. H. Grossman reports that the explosion of even the diluted freshly generated acetylene is too sudden, but that acetylene from a solution in acetone carried under pressure in steel cylinders is safer and is ready for the starting of the motor until the cylinder is practically empty. The cylinders are not only heavy and expensive, but are not generally obtainable. A large one for a motor car gave a run of 75 miles for one charging. Diluents included alcohol, petrol, light tar oils, naphthalene, water, etc., and the use of at least 20-25 per cent was necessary. Good results were given by 20 per cent of an equal mixture of light tar oil and alcohol.

DEDICATION OF PITTSBURGH STATION UNITED STATES BUREAU OF MINES

Formal dedication exercises in connection with the new experiment station of the U. S. Bureau of Mines at Pittsburgh were held on September 29-30 and October 1, 1919. The building has been in use for about two years, but the dedication ceremonies were postponed on account of war conditions. T. J. Gillespie, of the Pittsburgh Chamber of Commerce, was the presiding officer at the opening session, and addresses were delivered by the Mayor of Pittsburgh, A. T. Vogelsang, First Assistant Secretary of the Interior, Governor Sproul, and J. Parke Channing, representing the American Institute of Mining and Metallurgical Engineers. Director Van H. Manning of the Bureau of Mines formally received the keys to the building, which he said he regarded as a symbol of the function of the Bureau to unlock the secrets of nature for the benefit of all mankind.

During the second day's exercises announcement was made by Director Manning of the names of those to whom there had been awarded the first gold medals of the Joseph A. Holmes Safety Association, in recognition of remarkable heroism displayed by miners in attempting to save the lives of others.

A feature of the three days' program was the Fourth National First Aid and Mine Rescue Meet. Contestants from various industrial corporations, representing fifteen different states, carried out various problems in mine rescue work and first aid to the injured in mine and mill accidents, and medals were awarded to the winning teams in each event.

The exercises included an inspection of the experimental mine at Bruceton, Pa., where methods of prevention of explosions were not only demonstrated, but actual experimental explosions involving hundreds of pounds of coal dust were carried out.

On the second evening there was presented a pageant entitled "The Hidden Treasures of Earth," which showed in spectacular form the story of the conquest of the secrets of the earth by the aid of knowledge.

The new laboratories and museum were open for inspection by the official delegates and guests.

This new building of the Pittsburgh Experiment Station of the Bureau of Mines is a realization of the vision of a great man, the first director and organizer of the Bureau of Mines, Joseph Austin Holmes, Professor of Geology in the University of North Carolina, from 1891 to 1901, and from 1901 to 1903 State Geologist of North Carolina. He was chosen in 1903 to organize the Department of Mines and Metallurgy of the Louisiana Purchase Exposition at St. Louis. His creative imagination saw there an opportunity to secure results of permanent value through the analyzing and testing of the coal resources of the United States and of structural materials in connection with the exhibition, and this was done under the direction of a commission of which he was a member.

In 1907 the Technologic Branch of the U. S. Geological Survey was organized with Dr. Holmes in charge. At that time the United States had the unenviable distinction of being not only the most prodigal nation in the expenditure of national resources, but of the lives of its citizens as well. There was an unusual number of mine explosions during that year, and the result was a general movement to take steps to prevent the needless loss of life. These culminated in the creation of the Bureau of Mines, in 1910, for the purpose of increasing health, safety, and efficiency in the mining industry. Though the work of the Bureau was at first housed in temporary and unsuitable quarters, Dr. Holmes had a vision of a great experimental station for mining, where all kinds of accidents could be studied, and methods developed for their prevention, which miners and

operators alike could feel was their station and could come to for information and education. It was also his conception that for this station should help to stop the waste in mining resulting from the inefficient methods employed and the excessive competition in the coal industry. To this end he foresaw the need for research laboratories for chemical and physical investigation of gases, explosives and mineral substances, and equipment for the testing of mine lamps and other machinery, and finally, of the establishment by the Bureau of such agencies as would result in the training of thousands of miners in the use of rescue apparatus and in giving first aid to the injured.

DESCRIPTION OF THE BUILDING

By A. C. FIELDNER

The close proximity of the Bureau of Mines Station, located in the educational center of Pittsburgh, to the Carnegie Institute of Technology, the University of Pittsburgh, the Mellon Institute and the Carnegie Library, affords many advantages in carrying on the research and educational work of the Bureau.

The general style of architecture harmonizes with the adjoining Carnegie Institute of Technology group of buildings. The construction is practically fireproof. The side walls to the first floor are imitation granite, above which is reinforced concrete faced with buff bricks. The floors are tile and concrete overlaid by wood floors in the offices and some of the laboratories. The partitions are of gypsum block and the roof is slate.

The central part of the building measures 59×240 ft., and each of the east and west wings is 46 ft. wide and 211 ft. long. The central portion contains the offices of the administrative, mining, mine safety and explosives sections; the east wing is devoted to the chemical, physical and metallurgical laboratories; and the west wing to offices and laboratories of the mechanical, electrical and fuels investigations sections. The west wing has no basement and the ground floor is one large open room of a height equal to the basement and first floor rooms in the center and east wing. This room is arranged for large scale experimental work. A traveling crane track runs from end to end of this wing, whereby machinery and large apparatus may be installed and removed. Under the cement floor along the side of the laboratory is a service tunnel; connecting with the tunnel and at right angles to it are six cross tunnels; these are 2 ft. deep and 3 ft. wide. The tunnel and trenches carry the service pipes and wires for convenient distribution to any required point.

At the present time the north end of this laboratory is devoted to a museum illustrating the investigative work of the Bureau. The south end of the wing contains a well equipped machine and carpenter shop for building apparatus and equipment used in connection with the investigative work of the station. The electrical laboratory occupies the south end of the second floor of the west wing.

The central portion is one story higher than the two wings of the building. On the top floor is a cafeteria for employees, a photographic laboratory, drafting and computing rooms. The headquarters of the mining and mine safety sections, and a well stocked technical library occupy the second floor. On the first floor are the general administrative offices and the office of the explosives section which has its testing laboratories at the Bureau's Experimental Mine at Bruceton, Pa.

In a circular bay projecting into the court at the rear is a well-furnished auditorium capable of seating 228 persons; the



GENERAL VIEW PITTSBURGH STATION, BUREAU OF MINES, LOOKING NORTH

stage is equipped for lantern slide, motion picture, and demonstration work of various kinds.

All chemical and other supplies are handled through the store-room in the basement. Here is also an instrument shop with precision machines and benches for five instrument makers. Special and delicate apparatus of all kinds are made in this shop. Laboratories for testing oxygen breathing apparatus, safety lamps and for training men in the use of such apparatus occupy the remainder of the basement floor.

CHEMICAL AND PHYSICAL LABORATORIES

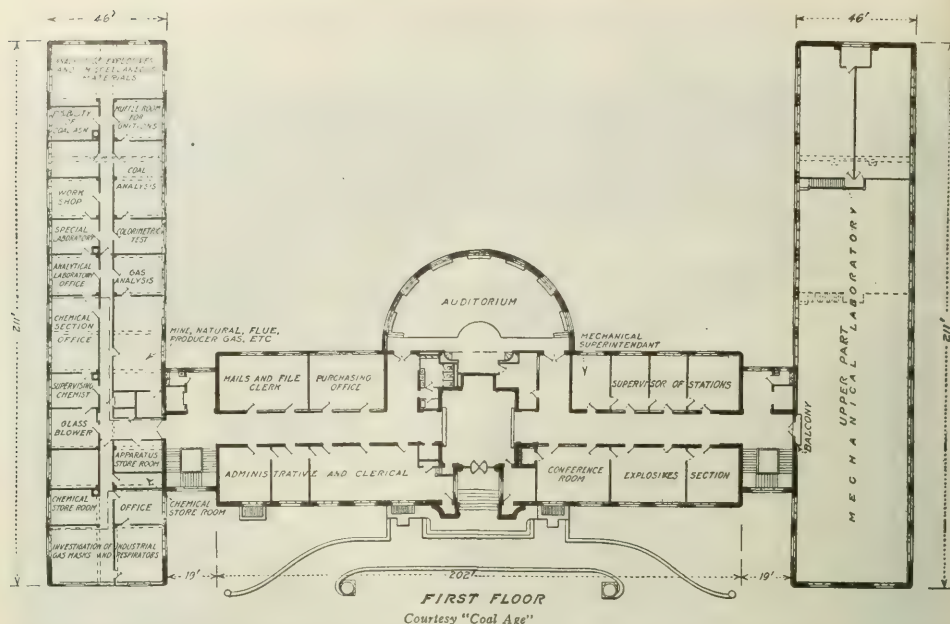
The entire east wing of the building is especially designed for chemical and physical laboratories. The general arrangement of the various rooms are shown in the floor plan. The partitions are of pyrobar, 6 in. thick over all, including the plaster. All doors into the rooms are 3½ ft. wide, thus facilitating the removal of desks and tables from one room to another. Service pipes, wires and flues to the hoods are distributed to the various rooms from tunnels that occupy the upper portions of the corridors. This makes the ceiling in the corridor six feet lower than in the laboratory rooms. Ample space is thus obtained for the general service pipes and wires. These consist of hot and cold water, gas, vacuum, compressed air, 110- and 440-volt alternating, 220-volt direct current, leads to the large storage battery in the basement and flues from the hoods. A horizontal section of terra cotta in each side of these tunnels is provided for running the service branches into the upper portion of each room. Also, connections can be made to the floor of the rooms on the story above the tunnel between the wood joists that support the wood floor above the concrete.

The main service pipes and electrical wires come from the power plant into the basement in a tunnel which continues under the basement corridor; from here they pass through a vertical shaft up to the first and second floors, where connection is made to the service tunnels of each floor.

Most of the hoods are of alberene stone and glass. They are usually placed with the back against the corridor wall so that the flue can pass directly upwards and into the tunnel connecting to galvanized iron ducts of liberal dimensions. The ducts are painted with black acid resisting paint. The ventilating system of the entire wing includes four vertical flues 2 ft. in diameter equally distributed along the length of the building. These flues are of vitrified tile embedded in concrete. At the top of each flue in the attic of the wing are exhaust fans directly connected to 12 h. p. motors. The ventilation has proven adequate. Each hood has a slide damper whereby the amount of draft can be regulated. Hot air and gases from large furnaces are removed through sheet iron canopies connected to the same system.

Most of the laboratory work tables are of oak with heavy wood tops built up of strips of maple or birch. An acid resisting black finish is applied to the tops of tables and shelves. Tables and benches on which burners and furnaces are used have tops of alberene stone. Owing to the fact that the rooms are heated from low pressure steam radiators placed at the windows, it was necessary to omit cupboard space beneath all tables placed at the windows. In such cases the table tops are supported on iron pipe legs. This construction is also used for special tables for specific apparatus.

Service pipes are entirely exposed in all laboratories to facilitate changes and repairs. The electric wires are enclosed in galvanized iron conduits which are run in parallel lines with the service pipes from the tunnels along the walls of the rooms to the tables and hoods. Wall tables have backboards above the table on which the pipes are fixed. Above this wall board are oak shelves for reagent bottles. Each table and hood is provided with an 1½ in. galvanized iron drain pipe beneath the back of the tables. Risers from this pipe are flush with the table top and serve to receive drains from condensers and water baths.



Drains from the benches and sinks are carried to vertical risers of acid resisting fiber pipe leading down to a terra cotta drain in the basement tunnel. The fiber pipes have proven unsatisfactory in service and are being replaced with cast iron pipe. The sinks are of alberene stone.

NATURE OF WORK OF CHEMICAL AND PHYSICAL LABORATORIES

The chemical and physical laboratories consist of research units and special laboratories devoted to those branches of the Bureau's work in the mining and metallurgical industries which are represented at the Pittsburgh Experiment Station. These laboratories with the other stations of the Bureau have many problems which require the aid of a large, well-equipped organization with all the essential accessories of research such as instrument shop, glass-blower, drafting and photographic departments, storeroom and technical library. Someone has said that the output of a group of investigators working in close cooperation with each other is proportional to the product rather than the sum of the individuals. The research organization is operated on this principle.

Weekly conferences are held at which each investigator brings up his problems for discussion and receives the benefit of advice from other members of the group.

The nature and purpose of the investigations carried on by the various subdivisions of the chemical and physical laboratories are briefly given in the following description.

COAL AND MISCELLANEOUS ANALYTICAL LABORATORY

The analytical laboratory is engaged principally in making the necessary analyses and tests that are constantly required in connection with a study of the more efficient utilization of the fuel resources of the country, and with the investigations of mine accidents that are being conducted at the station and in the field. The laboratory is equipped with the most improved apparatus for the complete and accurate analysis of coal, coke, lignite and peat. Special features of this equipment are automatic, constant-temperature calorimeters constructed in the Bureau's instrument shop, which are capable of giving the highest precision in determining the heating value of fuels in

approximately half the time required by the ordinary commercial instrument. There is also a special room equipped with complete outfits of furnaces, pyrometers, and all accessories needed for the determination of the fusibility of coal ash.

For several years the Bureau has been conducting a survey of the composition of American coals and the fusibility of the ash from various coal beds. The results of this work are published from time to time, so that much of this data is now available to the operating engineers and purchasing agents of railroads, steamship lines, and industrial concerns. From these publications they can determine in advance the probable quality of coal available in any given locality.

An excellent example of one of the branches of miscellaneous work carried on by this laboratory is the examination and determination of the amount and nature of rock dust in the atmospheres of metal mines. The drilling of holes in quartz rock throws into suspension in the air minute particles of quartz and other rock dust. The quartz particles, because of their splintery fracture and knife-like edges, penetrate the tissues of the lungs of miners working in these atmospheres, and if this air is breathed for a considerable period of time, the health of the miner is seriously affected, producing silicosis, commonly called miners' consumption.

In cooperation with the U. S. Public Health Service, the Bureau is making an examination of the amount of siliceous dust that is in suspension in the atmosphere of some of the copper mines in Arizona and the effect of this dust on the lives of the miners. Samples of dust are collected by pumping 15 or 20 cu. ft. of the dust-laden air through glass tubes containing a two-inch layer of granulated sugar. These sugar tubes are then mailed to the Pittsburgh Laboratory, where the sugar is dissolved in water, which leaves the dust particles that were filtered out by the sugar in suspension in the sugar solution. A drop of this suspension is examined under a microscope, and the number of silica particles are counted and their size noted. The total quantity of rock dust is determined by weighing the insoluble residue.

GAS LABORATORY

The analysis and examination of gases is a very important part of many investigations on which the Bureau of Mines is engaged.

The gas laboratory coöperates with the mining division in analyzing samples of mine atmospheres from all parts of the United States. These samples are taken in connection with improving mine ventilation and thus reducing the dangers from explosions in coal mines and promoting more healthful working conditions for miners in metal mines. The nature of the gaseous products of explosives used in mining and also the atmospheres created by fires and explosions in coal mines are determined.

This laboratory also makes analyses and tests of flue gases and products of combustion required in the fuels investigations of the Bureau, as well as examinations of natural gas and various industrial gases that may be required at the Pittsburgh station or in field investigations.

The equipment used in gas investigations is highly specialized. Much of it has been developed in the laboratory and built in the Bureau's shops; the Burrell-Haldane mine air analysis apparatus is capable of determining the constituents of mine air to an accuracy of 0.01 per cent; the Burrell methane-indicator is probably the first simple and accurate gas detector that has been found practical for use in mine air. Complete apparatus for the liquefaction and fractional distillation of gas mixtures at low temperatures by using air and mercury pumps are available for natural gas and other complex gas mixtures that cannot be handled by ordinary methods.

At the beginning of the war the gas laboratory was turned over completely to war gas investigations and thus formed the nucleus from which the large war gas research organization was built up. The first gas masks made in this country were tested by methods and apparatus specially designed for the purpose, and these methods in their essential features were used throughout the war in connection with the manufacture and improvement of the American gas mask.

GAS MASK LABORATORY

With the close of the war the Bureau of Mines took up the investigation of the use of the army type gas mask in the mining, metallurgical and allied industries. The army mask was found unsuitable for use in mines or any places where carbon monoxide was likely to be present, such as blast furnaces, illuminating gas plants or gas producer installations. It was found useful for protecting workmen around smelters and acid plants from sulfur fumes and in many chemical industries. The standard army mask was also found to be a good smoke filter for fire fighters, although in this case the protection is not always complete, as carbon monoxide and insufficient oxygen may sometimes be encountered, in which event the gas mask will not save the wearer. The purpose of the gas mask laboratory is to furnish information regarding the usefulness of various types of gas masks under various conditions and to develop suitable masks and breathing apparatus for special gases.

A large gas chamber of 1000 cu. ft. capacity built air-tight of glass and metal has been installed for testing out masks in any concentration of gas, by actually wearing the mask under working conditions. Other apparatus is provided for testing absorbents and canisters for their capacity for removing poisonous gases from air. Chlorine, carbon monoxide, sulfur dioxide and ammonia are some of the poisonous and asphyxiating gases that are frequently met with in the industries.

The Bureau will make tests of commercial gas masks submitted by manufacturers, to determine whether they are permissible for use in the gases for which they are intended. If they pass the tests they are placed on the list of approved masks.

A novel and important peace-time application of some of the evil-smelling but non-poisonous gases that were developed in connection with the Bureau's war gas investigations is their use

as danger signals in metal mines. The introduction of a few ounces of ethyl or butyl mercaptan above ground into the compressed air lines will in a few minutes spread a very penetrating and disagreeable odor throughout the mine and thus warn the miners that something is wrong and that they must leave the mine at once. Engineers of the Bureau have tested this method of giving signals in metal mines in Montana and California with complete success.

The problems of the natural gas research unit pertain to the more efficient utilization of our natural gas resources. Several publications have been issued on the recovery of gasoline from natural gas both by compression and absorption processes. Recent investigations have shown that the activated charcoal that was developed for gas masks is an excellent catalyst for making carbon tetrachloride, chloroform, and methyl chloride from natural gas.

Another important problem is the production of carbon black. Various methods of producing this material by the incomplete combustion of natural gas are being investigated. In present methods of manufacture only 3 per cent of the carbon in natural gas is being recovered. However, if the process is modified to increase the yield the quality of the black deteriorates. Hence in the interest of conservation it is important that some method of increasing yields without sacrificing quality be worked out. An exhibit showing the various grades of carbon black and lamp-black and their function in the production of products such as rubber tires, printing inks, etc., is shown in the museum.

BY-PRODUCT COKING RESEARCH UNIT

True conservation of coal and the abatement of the smoke nuisance in our cities demand that all bituminous coal for domestic use must eventually be carbonized in suitable or coking plants with the full recovery of valuable by-products such as ammonia, benzol, toluol, and the host of materials that can be made from coal tar. The by-product coking unit is engaged on problems in this field. A comprehensive investigation of the forms in which sulfur occurs in American coals and lignites is being conducted with special reference to the changes which this element undergoes in the coking process. Fundamental information of this character may prove to be a great aid in developing new and more efficient processes for removing sulfur from by-product and producer gas, thus enabling the use of high sulfur coals that are not now suitable in the metallurgical industry.

Other important problems are the study of smokeless binders for carbonized lignite and utilization of the tars resulting from the low temperature carbonization of lignite. This work is in connection with the big government lignite carbonization plant that is to be erected in Texas.

MICROSCOPIC RESEARCH UNIT

One of the best methods of studying the constitution of materials and the changes which they undergo in various processes is to examine them under the microscope. The microscopic laboratory has completed a comprehensive study of the constitution and origin of coal. Sections of coal and lignite have been made of such a thinness that rays of light can penetrate them and render the structure of coal visible under the microscope even at very high magnifications. A collection of enlarged photomicrographs of coal and lignite as well as actual sections under the microscope may be seen in this laboratory.

An important war problem was the substitution of American graphite in place of foreign graphite for making crucibles. In coöperation with the Bureau's ceramic station at Columbus, Ohio, valuable information was obtained on the form and structure of these graphites and their relation to the manufacture of durable crucibles for use in melting brass and steel.

Aside from these major problems the microscopic laboratory is constantly being called upon to aid other investigators of the Bureau in their problems, as, for example, the examination

of rock dust from metal mines to see if these particles are of such a nature as to endanger the health of the miners; the examination of dusts from coal mines after explosions to discover if the flame of the explosion passes the point from which the dust sample was taken; and the examination of explosives for use in mines to determine the nature and size of those constituents which have an important relation to the permissibility of the powder.

PETROLEUM LABORATORY

The work of the Pittsburgh petroleum laboratory includes that part of the activities of the chemical section of the petroleum division requiring facilities for scientific research, as distinguished from investigations along the technical and industrial lines, which work is conducted in other stations, particularly that at Bartlesville, Okla. The Pittsburgh laboratory is equipped to handle the routine analysis of certain types of petroleum products and is believed to possess the best equipment available in the country for both fuel oil and gasoline testing. The major work of the laboratory is, however, investigative and includes several lines of activity. Considerable attention is devoted to the development of methods and apparatus for the analysis of petroleum products. At present attention is being given to the problem of making accurate and rapid vacuum distillation of high boiling oils, to the problem of accurately estimating the water content of oil emulsions and to the problem of dehydrating such emulsions without changing the physical and chemical properties of the oil. A comprehensive survey of the grades of gasoline sold throughout the country has just been completed, the results to be published for the purpose of general information and for use in drafting specifications both for government purchases and for legislative enactments. An investigation of the vapor phase cracking method for the production of gasoline has recently been completed. A survey is also in progress of the various types of crude petroleum produced throughout the country.

In addition some work has been begun for the purpose of obtaining accurate and comprehensive information regarding the physical and chemical properties of the constituents of different types of crude oil produced in this country.

The laboratory has developed electrical heating devices and distillation apparatus for the varied needs that have arisen and this equipment will be found of particular interest.

EXPLOSIVES CHEMICAL LABORATORY

The explosives chemical laboratory is completely equipped for research and analytical work upon powders, dynamites, permissible explosives, detonators, fuses, and their component materials. All of the explosives submitted for permissibility tests are analyzed here, and field samples collected from time to time are examined to determine whether or not the original composition has subsequently been altered beyond the tolerance limits fixed by the Bureau. This laboratory also examines the explosives and explosive materials used in the extensive mining investigations of the Bureau. The files contain records of thousands of analyses comprising not only all types of mining explosives, their ingredients, and accessories, but also many military explosives and materials, for the resources of the laboratory were used during the past war in the development of synthetic methods for nitro-organic compounds such as hexanitrodiphenylamine and nitroxyline. Indeed, some of the researches such as that on the nitration of toluene, and on propylene glycol dinitrate anticipated military needs. Other studies, such as hygroscopicity of modified black powders, and the preparation of different crystal forms of potassium chlorate, were essentially military.

Many of the tests, methods of analysis, and much of the equipment of the laboratory were developed here. One such test is the sand test for determining the strength of detonators. The detonator is placed in a suitable bomb, which is then par-

tially filled with a given weighed quantity of pure quartz sand of uniform granulation, care being taken that the detonator is approximately in the center of the mass of sand. The detonator is then fired and the degree of the resulting disintegration or pulverization is determined by removing the sand and sifting it through a series of standard sieves.

Other interesting features of the equipment are a densimeter for determining the absolute density of black powder under mercury, a large nitroglycerin shell first used in the investigation of the behavior of nitroglycerin when heated and now used for protection with tests of a like hazard, and a detonator cutter for opening detonators without risk to the operator. All of these were developed in this laboratory.

This laboratory also possesses that desirable appurtenance for organic synthesis—a large stock of organic chemicals. One of the interesting recent researches in this line was the isolation for the first time of crystalline sucrose octanitrate. The subsequent study of its optical properties has opened the way for the estimation of nitrosugar in the presence of nitroglycerin—a mixture encountered at present in many mining explosives.

METALLURGICAL AND METALLOGRAPHIC LABORATORIES

The metallurgical and metallographic laboratories occupy rooms in the basement of the east wing, and a laboratory for metallurgical chemistry is on the second floor of the east wing. These laboratories are devoted to the Bureau's work on the metallurgy and metallography of nonferrous metals and alloys. The metallographic laboratory is equipped with a photographic camera, a photographic microscope, and a large metallographic microscope for the study and photography of metals and alloys. Grinding wheels and polishing tables are employed for preparing microsections for examinations. A dark room is available for developing and printing.

Electric furnaces are used for melting and heat-treating metals, pyrometers measure the temperatures. The laboratory for metallurgical chemistry is investigating routine and analytical work and chemical research on nonferrous metals and alloys and drosses.

In coöperation with the nonferrous foundry industry, particularly the light aluminum-alloy casting branch, studies are being made of the details of nonferrous casting practice, the causes for and prevention of defective castings in the foundry, and the disposal of foundry wastes and drosses. The actual foundry studies are carried out at a number of foundries throughout the country, and the required laboratory work is performed in the Bureau's metallurgical and metallographic laboratories. Aluminum-alloy foundry practice is now being studied.

PHYSICAL LABORATORY

The physical laboratory is charged with the repair and calibration of apparatus used in physical measurements, both at Pittsburgh and in the field. For example, dozens of thermocouples are used in making a boiler or furnace test. Some of these are likely to become contaminated in the tests so that the temperature readings are incorrect. In order to guard against unknown errors, all thermocouples are checked in the physical laboratory against a standard couple after each extended test. For similar reasons, frequent checks are made on anemometers, aneroid barometers, thermometers and other physical apparatus. A large 60 cell storage battery, with $3\frac{1}{2}$ k. v. a. motor generator set, is installed in the basement. Special leads from this battery through a suitable switchboard furnish current to the various laboratories.

POWER PLANT

All power, light and heat are obtained from the station power plant which is shown in the lower foreground of the figure. This building also contains the laboratories of the fuels investigation section of the station.

BUREAU OF MINES
PITTSBURGH, PA.

CONTRIBUTIONS FROM THE DYE SECTION AMERICAN CHEMICAL SOCIETY

Papers presented at the 58th Meeting of the AMERICAN CHEMICAL SOCIETY, Philadelphia, Pa., September 4, 1919.

INTRODUCTORY REMARKS

By CHAS. L. RESER

Gentlemen, this is the "baby" section of the AMERICAN CHEMICAL SOCIETY. Those who arranged for the room in which to hold this meeting evidently considered it as such, and consequently they gave us that little one upstairs, though I told them that I did not believe it would hold half the people who would come, and I see that I have been justified in saying that.

I want to explain to the members that any new division that is formed has to be started as a section. I told Dr. Parsons yesterday that I thought the subject of dyes in this country was going to be of such importance that this section should be turned into a division. He told me, however, that he hoped we would not ask for that until we had met at least twice as a section, because there have been sections that wanted to be divisions, which expired before the second meeting; so we will be content to remain as a section until we have demonstrated the fact that we are going to live.

It certainly is very interesting to me to see this large body of chemists who are interested in the subject of dyes. About two years ago I addressed the American Cotton Manufacturers' Association on this subject, telling them what I believed the American chemist could and would do for them. I think we can begin to talk now about what the American chemist has done for them. Someone in the General Meeting yesterday made a remark that the American chemists were not able to handle propositions of this kind before the war. My answer to that statement is that the problems were not put up to the American chemist before the war. I assure you gentlemen, that, although I was one of those American chemists who went to Europe—to Germany—to complete, or try to complete, my education in chemistry, for the last ten or fifteen years it has not been necessary for Americans to go to Germany to study chemistry. I would not advise any student of chemistry, or of any other branch, to go abroad until he has taken his doctor's degree in this country, because I believe from my own experience and from my own knowledge of the efficiency of instruction in this country in the greater universities, and some of the smaller ones, that the instruction is more thorough in every respect in our own universities than in those of Germany, and possibly in those of the other countries. After a man has received his doctor's degree, and has a thorough fundamental training in the science, I would advise him to go abroad, as he then gets a point of view away from his own country that he cannot get from within.

Now at the time I referred to, two or three years ago, we were a little uncertain what the American chemist could accomplish. I based my personal belief in the ability of the American chemist to solve the problems of the dye industry in this country on the fact that when the war started and we were without many complex organic materials, we put American chemists and American brains to work on the problems of manufacturing those materials which were absolutely necessary and essential in the manufacture of munitions, such as diphenylamine, tetranitrodimethyl aniline, etc. These materials were manufactured, not only in the laboratory, but plants were designed and the materials actually manufactured on an enormous scale without a day being lost in the production and exportation of munitions to the Allies for the want of any of those materials. Previously we had been importing these materials from Germany, Belgium, Holland, Switzerland and other European countries because

we got them cheaper and there was no inducement for the American chemist to make them. Three or four different methods for the manufacture of synthetic toluol were put in operation in a very short time. These did not require an intricate knowledge of organic chemistry, but they did require the ability to "get there." When I found that we could do that, I felt the greatest confidence in solving any problem in organic chemistry which anybody else could solve. There were many difficulties connected with entering the dye industry and attempting to reach that state of the art which had been reached in countries where factories had already been established. The extreme complexity of the proposition was brought out in the press and in some of the scientific journals at the time the war started. Many of our own chemists believed it would be impossible owing to the intricacies, the large number of by-products, and the interrelation and utilization of these by-products. It was felt by many of our own people that it would be impossible to manufacture dyes. Of course you all know that I am talking about the intermediates, as the manufacture of the dyes is very simple if you have the intermediates.

Nothing could have been of greater benefit to the chemist of the United States, or to the chemical industry here, than the experiences acquired during the war. The manufacturers now know what they can do, and they have the courage of their convictions to spend the money to do it. It may be interesting to you to know that there is not less than one hundred million dollars invested in the United States to-day in the dye industry. If I were to include in that the investment in the manufacture of raw materials which go into the dye industry, such as nitric, sulfuric and hydrochloric acids, by-product coke ovens, etc., the figure would run up into hundreds of millions of dollars.

The life of our section is dependent upon the life of the industry, and everyone recognizes that the life of the industry is not only dependent upon the ability of the American chemist to solve the chemical problems, but is also dependent upon his ability to manufacture these complex materials at a figure which will meet the competition of the world. No new industry has ever started that did not incur high cost of production in the beginning. It would be folly to strive for tonnage in the beginning because of the enormous losses which would be involved. Consequently, the early production must be limited to smaller units in order to avoid enormous losses. In spite of that the courage of capitalists of this country who have put their money in this business has enabled them to face the prospects of great losses until the time comes when the scales can be turned the other way.

It may be of interest to many of you if I review some of the things, which probably many of you know, that have been done for the purpose of establishing this important industry in this country and taking care of that necessary high cost of production in the early stages of the game.

In the beginning the Federal Trade Commission was delegated power under the Trading with the Enemy Act to extend to manufacturers licenses for the operation of enemy-owned patents. In order that manufacturers might enter the dye industry in this country, it was absolutely essential that they have access to and use of certain United States patents owned by enemies, and the Government made an arrangement by which anybody in this country who showed that he was able to handle the matter could secure licenses from the Federal Trade Commission for operating under these patents, for which they paid the Govern-

ment a license fee or royalty, that royalty to be turned over to the owner after the war. But this left a great uncertainty as to what was going to happen after the war, as the enemy owner of the patent could sue the licensee for the use of the patent in spite of the Government license which was given. Mr. Palmer, after he had finished his task of buying and selling the property owned or controlled by enemies, began to look into the patent situation and saw this difficulty of the manufacturer who had invested large amounts of money for the use of these patents. He secured power from Congress to seize the patents as enemy-owned property and devised a scheme by which they could be seized and sold. I do not know of a fairer scheme than that which Mr. Palmer and Mr. Garvan, the present Alien Property Custodian, devised for handling these patents. They organized a company which was to buy and hold these patents, under the name of the Chemical Foundation, Inc., and immediately the Alien Property Custodian sold them to the Chemical Foundation for \$250,000. The articles of incorporation of the Chemical Foundation made it absolutely necessary and incumbent upon that Foundation to license any reputable American concern to utilize these patents under uniform conditions of royalty. The stock was subscribed to by as large a number of concerns in this country as it was possible to obtain. No concern was allowed to own more than one share of common stock, so that no one concern could control it. They were allowed to purchase a certain amount of preferred stock, but that was limited in dividends, and does not control the Foundation. I shall not go into details as to the articles of incorporation, or names of the people, because that is all published in a booklet entitled, "The Chemical Foundation, Inc.," which is available to everybody, and covers what has been done in that direction. Another interesting feature is that any profits to the Chemical Foundation, after dividends on the preferred stock are paid, must be utilized for protecting these patents, or for fostering research, if these profits should amount to enough, but this research must be along chemical lines, particularly along the lines of the dye industry. The fact that these patents are now owned in this country forms a large measure of protection to the dye industry, because they cover many of the important dyes and intermediates. Everybody, without exception, as far as I know, agrees that the dye industry should be protected further than that. Everybody knows the importance of the dye industry to this country in times of peace as well as of war. In fact, it has been brought out very forcibly in a number of different ways in the newspapers and literature. There is no question that a well-organized organic chemical industry in this country will develop a large number of well-trained chemists, who will supply the needs of the Army and Navy, in case of war, with the chemical materials which it is necessary for them to have. We will have a much better organized and trained set of men. Further than that, if we were to have no large, well-organized chemical industry in this country, we would be in a condition worse than before the war. I do not mean to say that we would not have well-trained chemists, but we would not be in a position to manufacture immediately materials needed for a war. It is not so much the factories *per se*, as it is the trained men who know how to handle this proposition. A great number of German dye factories were turned into factories for the manufacture of poisonous gases when the war broke out because they had well-trained chemists who could handle the proposition.

I do not want to cause any argument, and do not want to make any argument for or against, but I am trying to give you some idea as to what has been done to protect the dye industry in this country. Mr. Longworth has introduced a bill in the House, about which you have probably read, for the protection of the chemical industry, or at least for that part of the chemical industry which has to do with coal-tar products. It increases very materially the tariff over the previous rates, and also places

those products, such as indigo, indigoids, and dyes derived from anthracene and carbazol, under a tariff rather than leaving them on the free list. Great Britain went further than placing a tariff. The British government has financed its dye industry to a very large extent, and, as we all know, since Great Britain is opposed to a tariff in any form, they devised a scheme of protection by adopting a scheme of licensing. Of course, the thing to do is not to hinder or prevent the consumer of dyes from getting the dyes he needs that cannot be produced in his country. The British government saw that immediately, and devised the scheme by which the importation of those dyes could be licensed. They formed a Board, consisting of consumers, producers, and a government representative, who would decide whether certain dyes could or would be produced in Great Britain, and if they were not, this Board had the privilege of licensing their import into Great Britain from any other country. That gave absolute protection to the dye industry, and also absolute protection to the consumer. The Longworth bill involves a Licensing Board of consumers and producers, and that Board has the power to license the importation of such dyes as are not produced in this country of good quality and economically.

The high tariff and the licensing system, if they go through Congress, will certainly protect the dye industry. The present bill, as it passed out of the Ways and Means Committee to the House, continues the licensing system for two years. In other words, they felt two years would be sufficient time to enable the dye industry in this country to get on its feet, and after that the high tariff which is involved would protect the industry sufficiently. This will be determined as time goes on. If the present bill providing for higher rates of tariff and a license system is passed by Congress, no one can doubt that the dye industry will be made permanent in this country.

It might be interesting for you to know that by the end of this year I predict, and I think I am right in it, that the dye industry of America will be 80 to 90 per cent self-contained as regards production and quality. I will not say it will be self-contained as regards cost unless we get the necessary protection. In the eyes of the consumers the dyes that they are anxious about are the so-called vat dyes. It might be of interest to know that indigo, the most important of vat dyes, is now being produced in this country in quantities equal to, if not in excess of, the amount of synthetic indigo which was brought into this country from abroad before the war. It might also be interesting to know that the great question in which the cotton manufacturers are interested is that of the fast dyes known as indanthrene dyes. They are being produced now in insufficient quantities to supply the demand of the consumers, but in the course of the next six months I am satisfied that they will be supplied with all they require of the principal indanthrene colors. I think this announcement will be met very heartily by the consumers. I believe that arrangements have been made to license through the War Trade Board enough of those colors to come into this country to meet the requirements until this prediction has been fulfilled.

I want to say to you that I had hoped to have here for distribution, copies of the testimony given before the Ways and Means Committee for the benefit of those who have not been able to secure that information. It is very interesting reading and simply sets forth the facts.

In concluding I want to give you a few figures which, while not particularly accurate, are very elucidating.

Dyes imported into this country before the war.....	910
Made in the United States before the war.....	121
New sold in the United States, not including imports.....	219

These figures were compiled about two months ago, but they give you some idea as to the progress being made. Although 910 is a considerably larger number than 219, this figure includes a large number of unimportant dyes, which were used in very small quantities.

I think that covers the situation at present, but the thing I want to emphasize is the great duty which we American chemists have, not only to the dye industry of this country, but the important duty we have to our country in times of war as well as in times of peace.

CHEMICAL DEPARTMENT
E. I. DU PONT DE NEMOURS & COMPANY
WILMINGTON, DELAWARE

FOREIGN DYE PATENTS THEIR RELATION TO THE DEVELOPMENT OF THE AMERICAN DYE INDUSTRY

By R. E. ROSE

The dye manufacturers of this country are faced by one problem, which is of the greatest interest to dye consumers and to those interested in chemical patents. The problem is that of improving the line of colors made here by extending it to include those newer dyes which the trade has found to possess particularly favorable properties.

I wish to make clear that the difficulty giving rise to this problem is one which will be overcome, while at the same time I wish to point out one of the chief reasons for the present condition; one with which those who are disappointed by the delay are probably not familiar, at least I have seen no mention made of it in the newspapers or journals.

For the sake of those who have had no occasion to interest themselves in the intricacies of dyestuff chemistry as found in patents and have, therefore, made no study of the patent literature as it has been my pleasure and misfortune to do, I will outline the existing condition.

Ever since the discovery of synthetic dyes there has been a very keen competition among producers. At first there was piracy and every other form of unfair competition, but soon there came into existence a respect for the protection offered by patent laws; it was a case of self-interest showing this to be the best policy. Once this attitude was adopted the inventor or his assignee enjoyed the exclusive right to a discovery and it became therefore of the utmost importance to each producer to be able to compete with the invention of a competitor by discovering something either better, as good, or only slightly worse. Of course, there was the possibility of taking the essential of an invention by a rival and modifying it sufficiently in non-essential details to persuade the patent office that the modifications were radical enough to constitute a patentable novelty. This has always been permissible, but the United States and German patent offices have been very difficult to persuade and have become increasingly so with passing time. In consequence, it has been necessary for a firm to do something really worth while in order to prevent a new field from becoming, in its entirety, the property of a competitor. Naturally this has resulted in a very active working of a field and the consequent issue of a great number of patents. These patents have been the outcome of healthy competition and they show the excellent effect of patent protection in stimulating chemical research. Those which were not of any value when translated into commercial production were none the less of importance in defining the possibilities and limitations of the discovery. On the other hand, there were a number of patents, taken more particularly in Germany, which were granted to the original inventor though he knew them to have little or no value. They were to ward off attacks on the essential process by parallel lines, that is, to prevent the issue to competitors of what the Germans called "Umgehungs Patente." These patents added nothing essentially new; they were defensive, not creative.

The whole aspect of affairs may be likened to a new gold field where claims are staked everywhere about the original strike, the owners of which have put in dummy claims to the area immediately about their original stakes, simply to keep others at a

proper distance. To carry the simile further, the great bulk of claims are valueless but the region is likely to give good results, probably at some distance from the first location.

The dye chemist soon learns that the dye business is very much more than synthetic organic chemistry. The industry has grown as a result of the interplay of science and art; the growth of the application of dyes has been a spur to the chemist and the successes of the chemist have widened the possible method of utilizing dyes; the interrelation has been so close that it is often impossible to distinguish between cause and effect. However, in both directions there has been steady progress and, in consequence, modern methods and recent dyes are usually superior to older ones, though not quite so superior as the introducers of dyes would have their customers believe. It is true, then, that in almost every class of dyes there are some representatives which, because of their properties, such as ease of application, brilliancy, fastness to light, good levelling, are much to be preferred to older ones; these dyes are usually introductions of the last ten or fifteen years. It is these very colors which the consumers of dyes want, and it is these which the industry in this country has found it hardest to produce. To explain this it will be necessary to go into further detail.

We can divide these new dyes into two large classes: those whose method of production is very nearly exactly known but whose production is so complex that their making is too heavy a task for an infant industry, especially one with an incomplete line of intermediates. The second class is composed of those dyes whose composition is unknown to any but those responsible for their manufacture abroad.

The first class is diminishing in numbers, as is clear from the fact that the most important vat and alizarine dyes are actually being produced, and, the beginning having been made, there should be a very quick development.

Regarding the other group, it will perhaps come as a surprise to many to hear that the composition of many of the very best dyes is either entirely unknown to American chemists or is known only in the rough, that is, with insufficient detail to allow of their production without much research. To illustrate, if we take the census of dyes by Dr. Norton we find that in the Azo Group there are 166 classified and 96 unclassified dyes, the latter being those of unknown composition. In justice to ourselves we should point out that English chemists are not ahead of us in this respect.

It should be noticed that members of the second group may be transferred to the first group when their manufacture is understood because it may well be that their constitution is such that it calls for a particular intermediate or intermediates which cannot be made profitably by a dye industry at the stage of evolution reached by ours.

Now this statement brings us back to the subject of patents because it will doubtless occur to you to ask why it is that the composition of these dyes is unknown when practically all dyes are protected by patents and patents are public documents.

The interested public have sensed this situation to some extent without understanding it and in the kindness of their hearts they have invented a legend to save the face of the chemist. Inasmuch as this involves doing so at the expense of the Patent Office, I feel that in justice I should do my best to place the blame where it belongs.

The legend which has arisen is that the German inventors were culprits because they deceived the Patent Office and secured patents which disclosed no real process while affording protection. In reality they used the patent laws to their advantage but no more so than American firms would have done. Their patents say as little as possible but they are quite within the terms set by the patent laws of the country. They made their claims as comprehensive as possible, which is what patent attorneys advise; at the same time they covered what they wanted

quite securely. The initial failures which met the earlier efforts of dye chemists to substantiate the claims given in German-owned patents were due as much to inexperience as to any faulty disclosure. I feel we should exonerate the Patent Office of the charge that they were deceived by the Germans.

Why then can we not take a patent and from it read the constitution or composition of a dye? Simply because there is nothing to require a manufacturer to state what patent or patents he is using in producing a commercial dyestuff and because a patent may cover a great many possible combinations, only one of which is really utilized.

To make my meaning clearer I need only point out that in a class such as that of the azo dyes, which is subdivided into the great groups of the mordant, direct and acid dyes, the individuals are made from a great many intermediates and the result is determined not alone by the choice of intermediates which are coupled together but also by the order of their assembling or even by the conditions under which they are put together. On the other hand, a great many similar intermediates may be substituted for each other without causing any material change in the resultant molecule.

The pre-war line of dyestuffs produced in Germany and Switzerland required about four hundred intermediates, the majority of which went into azo dyes. While a great many of these are not "compatible" in the sense that they cannot be combined, but rather substitute each other with a resultant modification of hue in the dye, yet it is none the less true that the possibilities are infinite of varying the combinations among those that can be used to produce a dye. Of course, not all of these will be good; in fact, a minute proportion only will meet the rigid requirements for a commercial dye, because it is true that a dyestuff is much more than a dye—a fact which even the dye chemist is apt to overlook unless he becomes familiar with the past and present of the technology of dyeing.

Let us see how all this works out in practice. Let us suppose that the sales department wishes to be in a position to market a certain color which we shall call "Beetle Green 2BN." The desire of the sales department is due to their knowing that the commercial article is a direct dye of very excellent properties which make it a very important color in its class. Prior to the war it was imported in very large quantities and sold by Cartel & Company, of Bingen, on the Rhine.

It is then the duty of the research department to acquire the information necessary to enable the operating department to make the dye. Now, I wish to point out that this does not mean, as the average research chemist is apt to think, that the chemistry of the process and the constitution of the dye must be made known before anything can be done. It is only necessary to know the materials used, their proportion, and the conditions for their interaction. On the other hand, it is true that if the constitution can be determined, the method of production can usually be worked out.

The choice then lies between a recipe or an exact knowledge of the structure of the dye. Having in certain respects a very exalted notion of the powers of the chemist, the public assumes that he can analyze anything. You will appreciate that the analysis of a dye is a very difficult undertaking, one more likely to result in wasted effort than in the identification of the composition of the material. The problem is nearly as difficult as that of determining the constitution of one of the simpler alkaloids and that is admittedly a task which may occupy a research chemist a number of months, or, more usually, years.

In the case of dyes, the real difficulty is that the disintegration of the molecule gives rise to a mixture of components whose members are usually extremely sensitive to oxidizing agents. Furthermore, the systematic analysis of dyes, as contrasted with their identification, has not progressed very far except, perhaps, in the laboratories of the German dye manufacturers.

Also it should be mentioned that an analysis presupposes a sample of fairly generous proportions, while it may well be that five grams is the total available for the research and the necessary dye tests which must be made in order to confirm the research results. Frequently the matter is quite hopeless because no sample is available.

If the analysis is so unproductive, then recipes must be found and the best collection of these which is available to the American chemist is that contained in patents. Occasionally the research literature may be consulted with success, but generally speaking the patents are the only source of information.

However, there are two very grave difficulties which are quite obvious on even a superficial investigation of the problem, and many more which become apparent on closer scrutiny. The most evident is that the patent describes the dye either as the result of a process or as a compound of a certain structure; it says nothing about the name under which it is marketed. The next is that the patent may cover fifty or more examples, a quarter of which may be described as possessing properties somewhat like that of the dye in which we are interested.

Suppose we see how the investigation may turn out.

Let us return to our hypothetical "Beetle Green 2BN." We find that this dye was put on the market in 1903; that makes it probable that the patent covering it appeared about that time. Supposing that we have great luck, that the case is an impossibly easy one, then we shall find a patent assigned to Cartel & Company and describing green to blue dyes of approximately the properties of "Beetle Green 2BN." However, patent claims are very indefinite and there may be merely a statement that the dyes described dye cotton directly in green to blue shades and that they are metallic powders.

Now the patent covers all that it can. It may, for instance, claim a diphenyldiamine or its derivatives, coupled with a phenol, cresol, or the like, coupled with a 1,8-amino naphthol sulfonic acid, coupled with a substituted aniline. There is nothing to do but to set the laboratory to work on an investigation of the claims of the patent, in which the skill of the chemist and his knowledge of dye constitution will determine the success of his work. It will be at least several weeks before certainty can be reached. Evidently the investigation of a number of patents and their relation to commercial colors will take time, money, and a really good research organization employing many chemists.

But we have been assuming a very simple case. Suppose that you find that Cartel & Company took out six or more patents covering green to blue dyes—the complexity becomes just that much more difficult to unravel. Supposing that you find no patent that applies, then you are free to choose from a number of suppositions: the dye may not have been patented because the discoverer could not obtain a patent; the dye was discovered and patented by the chemists of another firm; the dye is covered by a much earlier patent which was not previously used because of some difficulty which was overcome only some years later; the dye is a mixture (this is quite possible and cannot be decided without a sample); the dye is not described as a green in the patent, but as a blue of a greenish shade.

You will appreciate what a problem such a case may present, and how every shred of information must be utilized. This does not argue a faulty knowledge on the part of our chemists—the German chemists have often found it impossible to identify a color put out by a competitor. The truth is that it takes nearly as much effort to decipher the correlation between patent and commercial dye as it does to discover the color originally, and this has been the chief cause of the delay in making the newer dyes.

The matter would not have been entirely different had the patent laws required a greater precision in defining the claims of a patent or in limiting the field covered, although such a re-

quirement might have helped in some instances; it would have been easy to take out ten patents instead of one except for the added expense and it would have been nearly as hard to decide between ten patents as it is to decide between ten examples in one patent.

Moreover, we should remember that to require greater precision weakens the protection offered, because it makes patentable by others, modifications which would have been covered by the basic patent under the existing system. Whether this is desirable or not, I do not pretend to say, only I would have you remember that if we amend the law to force foreign firms to disclose more, the new requirements will apply to ourselves equally.

In conclusion, I wish to state that patents have been extremely valuable to us because the protection afforded by them forced the German firms to publish at least something. Without the patents, the prospect for the newer colors would be much worse than it is. I believe that we can find our way through the maze; there are methods by which the problem can be solved. Just what these are, I prefer to leave unsaid, because by doing so I may persuade others to find still better methods than those I have worked out. One thing I am sure of is that those who have the necessary information can hardly do a greater service to the dye industry of this country than to engage in the very fascinating task of which I have given you this very brief sketch.

CHEMICAL DEPARTMENT

E. I. du PONT DE NEMOURS & COMPANY
WILMINGTON, DELAWARE

EXPLOSIBILITY AND INFLAMMABILITY OF DYES

By BURR HUMISTON, W. S. CALCOTT AND E. C. LATHROP

The following work was taken up with the view of eliminating, or at least reducing, the danger of fire and explosion in the finishing of dyes and intermediates. Although the du Pont Company has not experienced any serious difficulty occasioned by fire or explosion, we have been informed that a number of accidents have occurred throughout the country and because of the risks involved considerable work was carried out along this line. Aside from eliminating the loss of life, there are also the possibilities, of course, of eliminating the loss of material and increasing the capacity of the various units used in finishing operations. Very little data of any sort were available from which it could be predicted under what conditions dyes or intermediates were likely to explode or decompose, other than a certain amount of plant experience. The problem was, therefore, attacked from the laboratory point of view, with the idea of developing methods by which the element of risk in each step of the finishing operation could be accurately determined.

The dyes or intermediates, as delivered to the finishing department, consist of a wet mass, usually a press cake, with a widely varying amount of moisture. To prepare it for the market it is necessary that it be dried, ground to a fineness depending upon the individual material, and standardized, that is, brought to the correct shade and strength. These three operations combined are referred to as the finishing of the material. For the sake of clearness, each of these three operations will be taken up separately.

DRYING

In drying, little danger is encountered from moistures of dust and air, as very few of the dryers used for dyes or intermediates cause the formation of any appreciable amount of dust, except *in vacuo*. Any trouble encountered in this operation is therefore likely to be due to the effect of the temperature upon the mass of the material. This effect may manifest itself as an oxidation, which may cause the material to become heated, or it may consist of a decomposition which may be accompanied by the evolution of gases. This latter may also be sufficiently rapid to become explosive. A good illustration of the oxidizing type of dye is

sulfur black. This in the moist form oxidizes so readily that it is almost sure to fire if dried in the presence of air. In fact, it will frequently oxidize sufficiently to materially injure the shade on simply storing in paste form, if the amount of water present is insufficient to form a slime. If, however, it is dried and cooled in the absence of air, it becomes quite stable and may be kept indefinitely without any change in shade. Victoria green, on the other hand, is a good illustration of the type of material which decomposes without taking fire if overheated at temperatures above 100° C. In the case of Victoria green, an exothermic reaction sets in, the dyestuff being reduced to the leuco base by the oxalic acid present, and carbon dioxide mixed with some carbon monoxide is given off freely. As the reaction is strongly exothermic, it could quite easily become explosive in a confined system.

This investigation did not include slight oxidation of the materials concerned, but only cases in which the oxidation was sufficiently rapid to cause the materials to take fire. The apparatus used for determining both these points and the liability to decomposition without oxidation consisted essentially of a large test tube enclosed in an air bath and capable of being heated to a temperature of 500° C. A small amount of the dye or intermediate is placed in the test tube, a thermocouple immersed in the dye, a slow current of air passed, and the temperature gradually raised. The point at which the dyestuff takes fire is determined, although, as a rule, smoke or fumes can be noted before ignition takes place. The results can be checked with a fair degree of accuracy.

For determining the danger of decomposition of the dye, with or without the evolution of gases, a similar apparatus is used, excepting that no air is passed through and a delivery tube is connected to the test tube so that any gases given off are conducted to a gas burette. The temperature of the test tube is raised until decomposition begins, and it is then noted whether the reaction is endothermic or exothermic, as indicated by the development of higher temperatures in the dye than in the air bath with which it is heated. The point of initial decomposition can be quite readily determined, provided gases are given off under decomposition, or if the decomposition is exothermic. Dyes which decompose exothermically are, of course, much more dangerous to handle than those which decompose endothermically, as the dyes, being in the dry state, are very poor conductors of heat, and being surrounded by the heated vessel, the conditions are very favorable to the development of high temperatures, which result in fires or explosions. Of course, after the point at which decomposition or rapid oxidation sets in has once been determined, it is a simple matter to eliminate this element of risk in the plant by working at a sufficiently low temperature. This should, in general, be not less than 25° to 30° C. below the temperature of exothermic decomposition or ignition, allowing for variations in the quality of the various batches of dyes and for faulty temperature control.

GRINDING

In grinding, in addition to the effect of temperature on the mass of the material, there must also be considered the effect of temperature upon the mixture of dust and air which is invariably present in grinding and drying solids, and also the probability of the occurrence of sparks in the mill. A certain amount of heat must be developed in any grinding operation, and the work done in reducing the size of the particles must reappear in the form of heat, unless provisions are made for removing this heat as fast as liberated, which is not usually the case. There will be a rise of temperature in the grinder, the extent of the rise depending, of course, on the material being ground and on the mill being used for the purpose, so that it is difficult to fix any limits on the temperatures to be expected in grinding operations. It may be stated safely, however, that temperatures up to 75° C. may be experienced in the ball mill

type of grinder, and temperatures well over 100° in the impact crusher type. In the ball mill the possibility of sparks can be largely reduced, as suitable choice of the material of the mill itself and of the balls, copper mills with copper balls being almost free from risk of this sort. In the impact crusher type of mill, however, for example, where the dye is disintegrated by being submitted to blows from a revolving beater arm, the accidental intrusion of foreign particles can easily cause sparking through being struck by the rapidly revolving beater. Sparks due to static electricity must also be considered in grinding.

The method for determining the effect of heat on the mass of dye in grinding is, of course, identical with that used for the corresponding factor in drying. It is obviously necessary, however, in grinding, to determine the effect of the additional factors introduced, the effect of temperature on the mixture of dust and air. In order to determine the stability of the dust and air mixture, there is employed the apparatus developed by the Bureau of Mines for the determination of the explosibility of coal dust and air mixtures. This consists essentially of a 1000 cc. bulb containing a small, hollow cylinder of platinum, heated from the interior by means of a platinum coil, the temperature of the platinum cylinder being accurately determined by means of a thermocouple. The dye under investigation is placed in a funnel at the bottom of the bulb and the dust cloud is carried by blowing air upward through the funnel. This delivers the dust cloud around the heated platinum cylinder. The explosion point is taken as the temperature at which a noticeable development of pressure takes place, which is registered on a gauge connected with the apparatus. At this temperature a visible flame is seen to develop and spread through the bulb. By a slight modification of this apparatus, the dust cloud is subjected to the effect of sparks from an induction coil or from a small emery wheel. Little work has been done on this latter method of testing, however, but from the former, that is, the use of the platinum cylinder, results ranging from 400° to 1100° C. have been obtained as the explosion points of dusts with varying amounts of air, and it is possible to check these results within about 50° . The results obtained are in fair agreement with plant experience, as regards the relative safety of the different dyes so far investigated. This apparatus, however, has the weak point that the dust-air mixture used is not necessarily that most sensitive or most likely to explode. Somewhat more reliable results are therefore given by a modification of the apparatus for determining the decomposition temperature. This apparatus consists essentially of a large test tube immersed in an air bath with a tube for admitting air to the bottom of the test tube. The test tube is gradually heated up, while passing through it is a current of air sufficiently rapid to keep the tube completely filled with dust. In this manner dust clouds of widely varying densities, and therefore of widely varying sensitivities, are secured, ranging from that at the bottom of the test tube, which consists almost entirely of dye, to that at the extreme top of the tube, which contains only a few particles of dye, consisting chiefly of air. The temperature of spontaneous ignition is determined by inspection. Usually the decomposition is very noticeable, being detected by change in color and development of fumes. The increased sensitivity of this apparatus over the Bureau of Mines type is shown by the fact that the temperatures at which explosions occur in the Bureau of Mines apparatus range from 400° to 1100° C., while the temperature range for the same series of dyes in this apparatus is from 250° to 550° C. The data obtained from the two forms of apparatus, however, give a very clear idea of the relative stability or instability of the dye, as the Bureau of Mines apparatus gives the relative ease with which the different dyestuffs will propagate an explosion, once started, whereas the so-called spontaneous ignition temperature gives fairly definitely the order of stability of the different dyes

or intermediates when heated in the presence of air. Little difficulty has been experienced in obtaining concordant results with this apparatus, checking within 10° to 15° .

STANDARDIZING

In the standardization of dyes, explosion risks are very much the same as in grinding, although, of course, to a much lesser extent, as the temperatures encountered are much lower and the risks of striking sparks in the mixture are, of course, much less than the risks of striking sparks in the grinding, whether of the ball mill or impact type. An additional factor is introduced, however, in that standardizing reagents are usually added to bring the mixture to the proper strength. Stability of these reagents, and the possibility of a reaction between the reagent used and the dye or intermediate has to be considered; for instance, the accidental addition of soda ash to Victoria green would probably result in a vigorous reaction between the oxalic acid of the Victoria green and the soda ash, with the possibility of raising the temperature to the decomposition point of Victoria green.

This investigation is still in the preliminary stages and the methods used are tentative. They are being used, however, pending the development of more satisfactory methods for covering these points, or other points which may be brought up. They are believed to be of considerable value, however, as each method has been developed to answer some definite problem known to have occurred, and only after having given a satisfactory answer to an original problem have they been applied to the solution of similar problems for other materials. One difficulty which has been encountered is the lack of satisfactory standards with which to compare the laboratory results. Certain materials, as for example alizarine yellow, are known to be unsafe, while certain others are believed to be safe, and in default of more satisfactory data, these materials have been temporarily taken as standards in carrying out this work. It is realized, of course, that the mere fact that the material has been safe to date does not prove that it will remain safe indefinitely, and that some of the dyes now passed as perfectly safe may eventually be discovered to be dangerous. However, it is believed that by continuing this investigation along these lines, it will be possible to establish fairly definite limits as regards temperature and the proper type of mill for grinding each material, and in cases where the element of risk warrants it, to state which of these materials should be segregated or handled in small lots, or in extreme cases handled in the paste condition. An incidental advantage which has already been gained to some extent has been the selection of the proper temperatures in drying, so as to give the maximum speed of drying with the minimum of danger, thereby increasing the capacity of the drying units. We hope later to communicate more fully on this subject.

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SOME PROBLEMS IN THE IDENTIFICATION OF DYES

By E. F. HITCH AND I. E. KNAPP

At the present stage in the development of the dye industry in the United States, the American manufacturers must necessarily follow the Germans. No matter how much we may dislike to be followers and not pioneers, we must, in the first few years, confine our efforts in this field largely to the manufacture of colors that have already been produced by foreign manufacturers. No matter how optimistic we may be, or how confident we are in the ability of the American chemist to produce results, we cannot overlook the fact that we are several decades behind the German chemists in our knowledge of the preparation of dyes. This handicap can be overcome only by an immense amount of very diligent work on the part of the American chemists and manufacturers.

Before any distinctively new and valuable dyes can be developed, we must first gain experience in the manufacture of some of the more important dyes, the constitution of which is well known. During this first period of development of our dye industry our efforts will be confined largely to a study of processes for the manufacture of the well-known staple dyes. In the meantime, we must obtain as much information as possible on the more important unclassified colors that were imported into this country just prior to the war. These unclassified colors represent the results of comparatively recent investigations in color manufacture, and, in general, command a higher price. The average invoice price per pound of all the more important classified azo colors imported in 1913-14, as shown by Dr. Norton's report on dyestuffs used in the United States, is 15.7 cents, whereas the average price of all the more important unclassified azo colors is 28 cents per pound. There is obviously a distinct advantage to be gained in producing the unclassified colors, and they are, in general, the better grade of colors. Most of these dyes are without doubt covered by patents already issued, and these patents contain a description of their method of preparation. The first problem for the American chemist is to identify these important unclassified dyes and to connect them up with the patents. The second problem is the synthesis of the dyes following the lines indicated by the identification investigation.

It is an extremely difficult matter to locate in the patent literature a description of the process of manufacture of any one of the unclassified dyes. Let us suppose that a manufacturer of dyes in this country desires to produce a direct brown which he believes to be the best direct brown used in the United States prior to the war. The dyeing properties of this color are well known; the commercial name and the name of the German manufacturer are known; but nothing is known concerning the intermediates necessary to produce the dye, or the process used. It is known that this color was placed on the market by the Bayer Company in 1900, and it is probably covered by one or more patents, but it will be an extremely difficult matter to locate the patent or patents corresponding with this dye, because the description of the dye as given in the patent is not always accurate. It may also be found that several patents were applied for by the Bayer Company about that time, each of which may represent this dye, and each may make claims for from twenty to thirty different combinations of intermediates or modifications of procedure. This method of attack without the aid of an identification investigation of a sample of the dye is an almost hopeless task. If a sample of this dye can be obtained, and the intermediates used in its preparation definitely determined by analytical methods, the problem of locating the corresponding patent is very much simplified.

It is the methods of identification of the finished dyes that are of most interest to us at the present time. No specific rules can be laid down which will be applicable to the solution of all identification problems, but we shall endeavor to review the various methods that have been proposed, including those that we have actually used.

In the literature on this subject, unquestionably the best book for general use is A. G. Green's "The Analysis of Dyestuffs" (1916). This is not in any sense a catalogue of the properties of individual dyes, but it does offer an excellent scheme for the classification of unknown dyes according to both their chemical and their dyeing properties. The methods described are of general application and can be used, therefore, in identifying new dyes which are not listed in any of the handbooks. The chapter on the determination of the constitution of azo dyes is especially valuable. Volume 5 of Allen's "Commercial Organic Analysis" contains an excellent description of a large number of the methods that have been employed in the identification of dyes, and is useful in the solution of special problems. Cain and

Thorpe¹ review briefly several of the older schemes that have been proposed, and include Green's tables (in abridged form) for the identification of dyes on the fiber. Mulliken² describes group tests and specific tests for some fourteen hundred of the best-known dyes. The scheme is undoubtedly useful in identifying these particular brands of dyes, but the methods appear to have a somewhat limited application. The treatises of Formanek and Grandmougin³ describe in detail the investigation and identification of dyes by means of the spectroscope. Mathewson⁴ describes general methods for the separation of mixtures of dyes by the use of immiscible solvents. The separation of mixtures by absorption was proposed by Suida,⁵ and elaborated by Dreaper⁶ and Chapman and Seibold.⁷ Rota's⁸ scheme for the classification of dyes depends upon the reduction with stannous chloride, and can often be employed to advantage.

The problems that are likely to be met in the identification of dyes fall naturally into two groups: First, the identification of dyes in substance, and, second, the identification of dyes on the fiber. It is evident that the methods used in solving the problems in the first group will not in general be applicable to the solution of problems in the second group.

The problems in Group 1 may be subdivided into three classes:

- (a)—Comparison of two or more dyes, one of which is of known composition.
- (b)—Determination of the constitution of an unknown dye.
- (c)—Separation and identification of the components of a mixture of dyes.

The methods employed for the solution of problems in Class (a) are usually simple chemical tests, such as are described in the handbooks, *e. g.*, Schultz, Heumann, and Knecht, Rawson and Lowenthal. The most common reagent for these tests is concentrated sulfuric acid. A very large number of dyes show characteristic colorations when dissolved in this reagent, and there is often a sharp color change on dilution with water. Hydrochloric acid, caustic soda, and other reagents are also used. We prefer to carry out some of the reactions as spot-tests on a filter paper; and we also include a reduction with zinc dust and ammonia, followed by an oxidation in air; a reduction with stannous chloride, and, finally, a rough determination of the solubility in several representative organic solvents. We find that with careful manipulation, the amount of material required for all of these tests need not exceed 50 mg.

It may happen in comparing samples of the same dye made by different manufacturers, or in comparing different marks of the same dye, that there will be no noticeable difference in any of the foregoing chemical tests. In such a case, recourse must be had to an actual dyeing, and a comparison of the shades produced on the fiber. This is the final test in proving or disproving the identity of two or more dyes. However, this test alone is not sufficient, for mixtures can easily be made up to produce almost any given shade on the fiber.

The determination of the constitution of an unknown dye is often a rather difficult problem. Ordinarily, the first step is to determine to what chemical class the dye belongs. In order to do this, reactions must be used which are not specific for any particular dye, but which are generally applicable to a given class of dyes. For this purpose we have found the scheme of Green to be unequalled, not only for its reliability, but also

¹ "The Synthetic Dyestuffs" (1918).

² "The Identification of Commercial Dyestuffs" (1910).

³ "Spectraanalytischer Nachweis Künstlicher Organischer Farbstoffe" (1911). See also E. R. Watson, "Color in Relation to Chemical Constitution" (1918), and Dobbie, Baly and Stewart, *Report of the British Association for the Advancement of Science*, 1918, 131-186.

⁴ "The Separation and Identification of Food Coloring Substances," U. S. Dept. of Agr., *Bulletin* 443.

⁵ *Monatsh.*, 25 (1904), 1107.

⁶ *J. Soc. Chem. Ind.*, 28 (1909), 700.

⁷ *Analyst*, 37 (1912), 339.

⁸ *Chem.-Ztg.*, 1898, 437.

for its simplicity. It is unnecessary to set forth the details of this scheme here, for the book may readily be consulted.

The composition of azo dyes can often be determined by reduction, followed by the isolation and identification of the reduction products. Either acid reduction (stannous chloride) or alkaline reduction (zinc dust and ammonia, or sodium hydro-sulfite) may be used, depending on the nature of the dye. The common bases, ordinarily used as first components, can be separated quite easily, either by steam distillation, or by extraction with ether. Their properties and reactions are usually well known, and hence they can be identified easily. On the other hand, the amino derivatives of second components are difficult to isolate, and still more difficult to identify. Very little has been published regarding their properties and reactions. Green describes a few of the amino derivatives of the more common naphthalene sulfonic acids, but the list is by no means complete. In order to obtain the desired information, it may be necessary to reduce certain known dyes, develop methods for separating the reduction products, and finally determine the properties and characteristic reaction of the amino derivatives. This may result in a long and tedious investigation.

The separation and identification of the components of a mixture may be rather difficult. For the detection of mixtures, it is usually sufficient to blow off a few milligrams of the dye on a moistened filter paper, or on concentrated sulfuric acid. In some special cases where two or more dyes are precipitated together, these simple tests may not suffice to detect the mixture. Under these conditions, a variety of other methods are available.

The components of a mixture will rarely have the same affinity for the fiber, and, therefore, fractional dyeing may be useful. Small skeins are introduced into the dye bath, one after another, until the bath is exhausted. Comparison of the shades of these skeins will often give a clue to the components of the mixture.

Examination under the microscope may tend to show the lack of homogeneity of the product. Such a test is especially valuable for detecting admixed inorganic material, such as sodium chloride or sodium sulfate.

One component of a mixture may be soluble in alcohol and the other insoluble. Or one may be readily soluble in cold water, and the other soluble only in boiling water. Thus the varying solubility provides another means for the separation of mixtures.

The extraction of aqueous solutions of dye mixtures with immiscible solvents offers still another convenient means for separating the components. This method has been applied to food colors, but it appears to be of general application. Ether, amyl alcohol, dichlorhydrin, and mixtures of amyl alcohol with petroleum ether are the solvents ordinarily used. Certain dyes can be fractionated by washing the amyl alcohol extract with hydrochloric acid of varying normality, and with acetic acid, sodium chloride solution, and dilute caustic soda. We have found the method especially valuable in detecting and separating mixtures when only a very small percentage of one component is present. A milligram of dye is usually sufficient to impart a strong color to 50 cc. of amyl alcohol.

In some cases mixtures can be separated by adsorption on such material as kaolin, talc, and kieselguhr. Certain dyes are adsorbed and cannot be removed by washing with either water or alcohol. Others can be removed by washing with alcohol, while still other dyes are not adsorbed at all.

After the components of a mixture have been separated by some one of the foregoing methods, they can be identified by specific tests, such as have already been described, or by means of the spectroscope.

The identification of dyes on the fiber is usually a rather difficult problem because of the prevalence of mixtures. For straight

dyeings we have found nothing so satisfactory as Green's table. By following his scheme, the chemical class and dyeing class of an unknown dye can usually be determined. This information, together with the shade on the fiber, is sufficient to reduce the question to a choice between a few closely related dyes. Specific tests with the ordinary chemical reagents may then be employed, and the results compared with those published in the handbooks. As a final confirmation, the same group tests and specific tests should be made on fiber dyed with a known sample of the indicated dye, and these results compared with those obtained on the unknown.

For the separation and identification of mixtures on the fiber, a variety of methods may be employed, depending on the nature of the problem. Among the separation methods are fractional reduction, and extraction with various solvents such as alcohol, acetic acid, aniline and acetic acid, pyridine, or cresylic acid and xylol. Specific tests are then made on both the extracted dye and the dye remaining on the fiber; or the solutions may be subjected to spectroscopic examination.

Spectroscopic methods for the identification of dyes deserve special mention. It is a well-known fact that many chromophoric groupings in the molecule produce absorption bands. Furthermore, the position of these bands, *i. e.*, the wave length of maximum absorption, and their degree of symmetry are characteristic of any given dye.

The results obtained by the use of the ordinary spectroscope are for the most part only qualitative. The edge of an absorption band, as determined with this instrument, is the point at which absorption has attained some appreciable value, perhaps 5 or 15 or 30 per cent, depending on the sensitivity of the observer's eye and on the instrument. Furthermore, only a rough approximation of the degree of symmetry of the band can be obtained. Unfortunately, Formanek and Grandmougin's comprehensive and systematic study of the absorption spectra of dyes was made in this qualitative manner. Their tables are useful, however, in showing the position of the maxima of absorption in dilute solutions in various solvents. The results obtained with the ordinary spectroscope are of value in determining the chemical class to which an unknown dye belongs; also, for determining the purity of standards, for the detection of mixtures, and, in general, as a check on the results obtained by other methods.

By means of the spectrophotometer, exact quantitative data can be obtained. Curves can be plotted to show the relation between the percentage of light absorbed and the wave length for a given concentration of solution. By plotting several of these curves for different concentrations, a thickness-wave-length curve can be constructed. Such a curve shows at a glance the degree of symmetry of the absorption band, together with the wave length of the maximum absorption. As has been stated, this is sufficient to identify the dye.

Before this method can be applied generally, a vast amount of painstaking research must be carried out, using a carefully calibrated spectrophotometer, in order to determine the exact nature of the absorption bands for a large number of especially pure dyes. In some cases it may be necessary or desirable to extend this study to the infra-red and the ultra-violet. Until such a comprehensive quantitative study has been made, it is evident that the application of spectroscopic methods in the identification of dyes will necessarily be limited. The major portion of this work could very well be undertaken by the universities and colleges in cooperation with the industries.

The universities could also assist the industries in a compilation of a catalogue of intermediates. Chemists working on the identification of dyes are seriously handicapped because they do not have ready access to full and complete information on all known intermediates. A catalogue of intermediates should be prepared which would show, for each intermediate, its formula,

a brief outline of the methods of preparation, the ordinary physical properties, such as melting point and solubility, references to the literature and to patents, and a list of the dyes and the other intermediates that are made from it. This list of dyes derived from each intermediate should show, for each dye, the Schultz number or the patent reference, the chemical classification (*e. g.*, azo, xanthone, oxazine, etc.), and the other intermediates that are used in its preparation. The compilation and publication of such a catalogue of intermediates would appear to offer an excellent opportunity for the universities to cooperate with the industries. The completed work would be a real contribution to our chemical literature, and it would be very valuable, not only in the identification of dyes, but also as an aid to the dye manufacturers in directing their research work.

Another compilation which would be very useful in identification work is a classification of all the dyes listed in Schultz's "Farbstofftabellen" (1914), according to their color and their dyeing properties. There would probably be eight main color divisions (red, orange, yellow, green, blue, violet, brown, and black) each of which might be subdivided into acid, basic, direct, mordant, vat, lake, spirit, etc. It might also be advisable to include the chemical classification of each dye. This list could be supplemented from time to time by the addition of new dyes from the patent literature as soon as their classification is determined.

Still another way in which the university laboratories could assist the dye industry would be to determine the properties of the amino derivatives of the second components of azo dyes, that is, the compounds that are formed when azo dyes are reduced. The separation of these amino derivatives, the determination of their properties, and the development of methods for their detection and identification, would appear to offer ideal subjects for one-year investigations, such as are conducted by candidates for the master's degree and by seniors specializing in chemistry. Such an investigation on a single amino derivative would not be so difficult or so highly technical that it would require a long period of study in preparation for the actual work; it would not be so broad as to require more than one college year of work; and the results sought would have sufficient concrete value to maintain the investigator's enthusiasm. There are so few of these amino derivatives described in the literature that the publication of such data would be a real service to the dye industry.

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OBSERVATIONS ON THE ESTIMATION OF THE STRENGTH OF DYESTUFFS

By W. H. WATKINS

In distinction from most buyers of chemicals, the buyer of dyes is not primarily interested in the chemical content of the product he buys. He buys a dye on the assumption that a definite amount of this dye will give him a definite shade when used under definite conditions on the material which he is interested in coloring. No scheme of chemical analysis in the ordinary sense has yet been devised which will effectively reveal the quality of the dyestuff. It is necessary, therefore, to estimate the strength and quality of dyestuffs by color comparison. The colorimeter, properly handled, is very useful and may afford a valuable check on dye trials. The latter method is the method most generally used, and having in mind what the buyer is actually purchasing, it is generally the most useful and reliable.

It is obvious that a chemical analysis might show a satisfactory content of dyestuff and yet the dyestuff might contain sufficient impurity of one kind or another to make it worthless to the buyer. It is conceivable also that a colorimetric

reading might indicate the desired strength and hue, and yet such a dyestuff might not work at all the same way as the standard. It might not be, for instance, sufficiently level dyeing.

The object of this paper is to point out some of the causes that lead to disagreement between seller and buyer, even when both parties are perfectly sincere in their work and findings.

It ought to be unnecessary to call attention to the necessity of definite agreement on standards. I have found, however, that difference in standards is the most prolific cause of disagreement between buyer and seller. This was true before the war and is much more so now after a period of considerable lack of uniformity in deliveries. During the past five years the consumer's great demand has been for dyestuff. He has not cared particularly whether or not it was exactly in accord with previous standards. Under pressure, the manufacturer has frequently delivered goods differing in one way or another from standard, because it was better for the buyer to have his dyestuff even if it were not exactly like the standard, rather than to have no dyestuff at all. Somewhere along the line the buyer finds a delivery that particularly suits him, and adopts this as his standard. The next time he buys, the delivery may be exactly in accord with the manufacturer's standard and yet the buyer may feel that he has a legitimate ground for a claim. In the case of complaints that do not appear to be justified on a test against the manufacturer's standard, the manufacturer should fully investigate the buyer's standard and if necessary explain and adjust the whole situation.

Having considered the standard, some attention is also due the sample. The importance of careful sampling is recognized in the case of most materials subject to analysis. It seems to be assumed, however, that as dyestuffs come on the market as powders or crystals, a small portion taken from a part of a lot will accurately represent the whole. As a rule, this will undoubtedly be the case, and in fact, it should be the case. It is well known, however, that all commercial dyestuffs contain inert material legitimately added for the purpose of bringing the product to standard strength. This applies to dyes in crystal form as well as to powdered products. Now, if, as is sometimes the case, the mixing is not thoroughly done, there is little chance that a small sample drawn from one part of the whole mixture will represent the entire mixture accurately. Before entering upon an ardent controversy this possibility should be investigated. In any event the sample as drawn should be finely ground, as otherwise the small amount weighed off may not be properly representative.

The manner in which the water used for dyeing may affect the apparent strength is often overlooked. As a rule, basic dyes should always be dyed with the addition of a little weak acid, such as acetic. Occasionally, however, a buyer will be found who insists that he does not have to use acid and that there is no reason why each delivery should not be precisely like every other delivery when dyed under the same conditions in the same water. Now, with some basic dyes it is almost impossible to keep the amount of acid constant and in such a case, unless acid is added, a delivery that is practically neutral will not dye up as strong as a sample that is distinctly acid. I recollect a series of controversies on this point with a buyer in New York City over deliveries of a certain basic dye. Having located the source of the difficulty it was simply necessary to be sure that all deliveries to this buyer were distinctly acid. Some direct colors are especially sensitive to hard water and the way in which this may lead to a disagreement between buyer and seller should be considered. For instance, the dye itself may be partly in the form of its lime salt and in order to correct this and the effect of hard water in dyeing, a little soda may be mixed with it. Now, if in testing this the seller boils it up in fairly concentrated solution, he may convert the lime salt into the sodium salt and standardize the dye on this basis.

Now, if the buyer does not boil his dye up at a sufficiently high concentration he may not bring about a complete conversion of the calcium salt into the sodium salt and the calcium salt may not enter into the dyeing process at all. I can remember a lot of dyestuff that was variously estimated at all the way from O. K. to 50-per cent weak according to the locality and method of dyeing.

A practice which prevails in some large laboratories doing much work of this kind sometimes leads to incorrect results. In such laboratories it is customary to keep a girl or boy steadily employed in winding off and weighing to a definite weight, skeins of yarn for use in dyeing, these skeins being stored in such a way that a skein wound and weighed at one time may be dyed against a skein wound and weighed some time previously. Now as wool and cotton are both hygroscopic, it is evident that the moisture content of woolen skeins may vary considerably within a few days. Hence, unless some control is maintained, a considerable error may be introduced here. It has been found in our laboratory that a skein exposed to the air will vary by as much as 8 per cent within a few days. Our practice is to open up the large skeins as received and expose them to the atmosphere of the winding room for 24 hours before winding off the small skeins. Then instead of a metal weight a standard skein of the same quality is used as a counterpoise. Working in this way we find that our skeins maintain a constant weight of dry material. As a further precaution, however, each day's winding is kept separate, and in a trial, only skeins wound and weighed at the same time are taken.

The colorist must also assure himself that his material contains nothing that will interfere in any way with his dyeing. I have found it almost impossible to obtain woolen piece goods from any source, that does not at times contain either sulfuric or sulfurous acids. In some cases either of these acids might vitiate conclusions drawn from a test.

A common practice when very accurate results are wished, particularly in the estimation of yellows of clear shade, is the addition of small amounts of either a red or a blue. This expedient is frequently resorted to without proper consideration being given to the magnitude of the error that may be introduced in this way. These additions of a second color are generally made with the view of catching very slight differences. I have seen such 5 cc. additions made, the measuring being done in a 25 cc. cylinder. I doubt if anything was added to the accuracy of the final estimation of strength by such procedure.

But when all precautions have been taken and all possibilities considered, there remains one cause of disagreement that is well-nigh insuperable. All findings based on comparative dye trials depend for their correctness on the judgment of the observer. I have frequently tested the accuracy with which an experienced dyer can detect a strength difference and have found that the average experienced man will, nine times out of ten, detect a difference of 3 per cent, but will not certainly detect a smaller difference. Now this means that in standardizing it is easily possible that deliveries will sometimes be 3 per cent stronger and sometimes 3 per cent weaker than the standard. Unless the buyer has the exact standard used by the seller he may occasionally, if he has taken for his standard a 3 per cent stronger delivery, find lots that show weakness, and he will, of course, claim a 10 or 15 per cent difference. This is to emphasize the necessity of seeing to it that buyer and seller operate with exactly the same standard and that such standard samples are carefully preserved.

One other point in the estimation of strength from comparative dyeings must always be borne in mind, and that is the fallibility of human judgment. Let anyone divide a skein of colored yarn into two equal portions and mark one portion A and the other B, then hand them to anyone with the remark that B is a trifle weaker. In the majority of cases you will find that

he will agree with you. Unconsciously the man working on dye trials will be influenced by his prepossessions and will frequently honestly see a difference where none exists simply because he expects to find it or has been told that it does exist.

My feeling is that the buyer should make no claim except for differences that are clearly apparent to a trained eye, and on the other hand when such differences are apparent the seller should unhesitatingly allow the claim.

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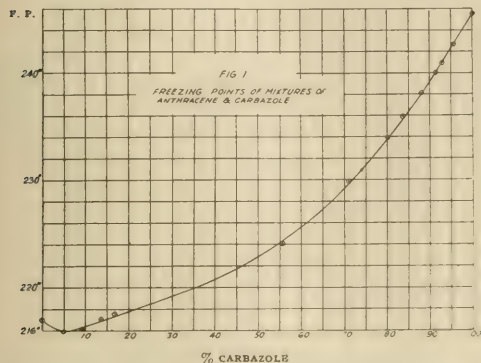
THE PLACE OF PHYSICAL CHEMISTRY IN DYESTUFF RESEARCH

By E. K. STRACHAN

The success of the dyestuff industry, perhaps more than that of any other industry, is dependent on chemical research. It is more dependent upon research than on manufacturing secrets, or patent laws, or tariff protection. Chemical research is the keystone of the entire industry. On account of the important position which it occupies, the research organization of the American dyestuff industry should receive an exceedingly careful scrutiny. No pains should be spared to make our research organizations as comprehensive in their scope and as thoroughly adapted to their purpose as possible. It is as true of research as of any other branch of manufacturing, that a complete and well-developed organization is more effective in the long run, than is individual brilliancy. It is almost a commonplace to state that such an organization should include physical chemistry as one of its departments.

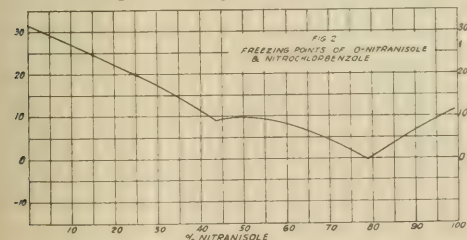
There is hardly a chemical problem that can be mentioned but someone will remark, "Let us see what the physical chemist has to say about this," and I am sure that a good many of our physical chemists would be at a loss to say, off-hand, precisely what they could do to assist in dyestuff research. On the other hand, I know from experience that a very large proportion of the dyestuff chemists would feel that it was futile to attempt to apply physicochemical methods to their work. It is my purpose in this talk to illustrate a few of the uses of physical chemistry in dyestuff research, in order that any man conducting this kind of research will not neglect such a valuable tool. I also desire to turn the attention of physical chemists themselves to a commercial use of their particular methods. Since the larger part of the problems arising at present have to do with the preparation of dyestuff intermediates, these remarks might apply equally well to any other industry manufacturing organic chemicals. For our present purposes, physical chemistry may be regarded principally as an attitude of mind or method of attack, rather than a separate body of knowledge. It is true that this branch of chemistry does possess a small body of knowledge not common to other branches of chemistry, but this is its least important aspect. And indeed, the larger part of the work of the physical chemist connected with dyestuff research or in any other organization dealing with organic chemicals will be the contribution of his attitude of mind and of his methods of study to the discussion of any problem at hand. It is my intention to suggest a few particular uses of physical chemistry and to illustrate them by examples which have occurred in my own laboratory during the past few years. There is nothing strikingly original in any of these methods; most of them have been known for a long time. The function of the physical chemist has been to know when it is profitable to apply various methods, to devise technique and equipment to carry them out successfully, and to systematize all physical chemical methods in use. As illustrations I have chosen to mention the use of physical constants in analytical methods, physicochemical methods applied to a few plant processes, and the contributions of the physical chemist to the chemical engineer.

In any chemical processes in which a small amount of impurities may render the products worthless, the analytical control of materials and procedures is highly important. Indeed, a comparatively small amount of foreign substances in some intermediates may completely ruin the shade of the finished dye. In other cases, only a small percentage of some material that should not be present will decrease the weight yield of product enormously. This is an important consideration in dealing with high-priced materials. One of the very important functions of the physical chemist is that of establishing criterions of purity.



A substance may be considered pure only when no method of fractionation will cause any change in any of its physical properties, that is, a pure substance may be fractionated by any means whatever that can be used and all of its fractions will have the same physical properties. Organic chemists for a long time have used the melting point as a criterion of purity. They have also employed the density, refractive index, solubility, and a number of other properties to a less extent for this same purpose. It is interesting to note, however, that the melting point is not always a sure criterion of purity.

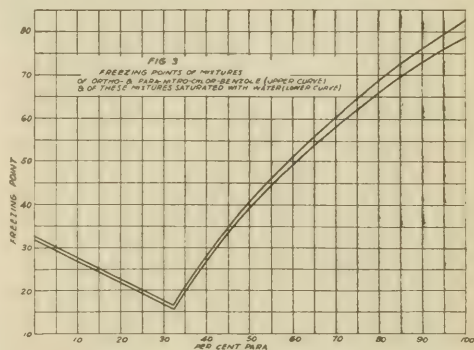
I am exhibiting in Fig. 1 a curve showing the melting point of mixtures of anthracene and carbazole. You will note from this curve that as much as 15 per cent carbazole may be present in anthracene without affecting the melting point by more than 1°, and indeed a mixture containing 15 per cent carbazole has exactly the same melting point as pure anthracene. In such case we must use a different physical property as a criterion of purity. For this particular system the solubility will serve to differentiate pure anthracene from anthracene mixed with carbazole. My purpose in presenting this curve is to show the necessity of knowing the melting point curve over all, or nearly all, of its entire range before using it as a criterion of purity.



Recently one of our chemists attempted to follow the course of a certain distillation by measuring the melting point of the distillate. Much to his surprise the melting point appeared to remain constant while the bulk of the material distilled. Apparently distillation was not separating the components. A

determination of the melting point curve of the system, which is shown in Fig. 2, revealed the difficulty. Another physical constant, of course, was used, namely, the density.

These remarks on physical properties as criterions of purity verge very closely on the use of physical properties as analytical methods. For analytical purposes, physical properties may be classified as one-sided properties and common properties. Optical rotation and color are both examples of what I mean by one-sided properties, that is, they are properties possessed by only one component of a mixture. It is quite easy to determine the amount of an optically active substance present in its solution in an optically inactive solvent by well-known polariscopic methods. Similarly, the concentration of a colored substance in a colorless solvent is easily determined by the common colorimetric methods. On the other hand, the common properties are properties which are possessed in common by all components of the mixture, such as melting points, density, refractive indices, and many others. The use of these latter as analytical methods depends upon the knowledge that we have of a definite and limited number of components in the system. For instance, we must know that the system is binary, and contains nothing but its two components, or ternary and contains nothing but its three components, and so on. It is quite easy to see this from a mathematical standpoint. In a binary system we have two variables, namely, the per cent of each component. Two equations are therefore necessary to fix the value of the two variables. One of our equations for a binary system is that the sum of the percentages of the two components is 100; the other equation is that some particular physical property is a function of the amount of each component present. Ordinarily



we plot a curve from experimental data showing the change in the chosen physical property with the composition of the mixture. This, of course, is the way that the curves already shown were obtained. The choice of the particular physical property to be used in the analysis of a given system depends upon the characteristics of the system; for example, the composition of a mixture of *o*- and *p*-nitrochlorobenzol can be determined very easily from its melting-point curve, which is shown in Fig. 3. The upper curve represents the melting point of a mixture of pure, dry *o*- and *p*-nitrochlorobenzol. This was used for a time in determining the composition of the mixture until we recalled that the product we were analyzing was not dry but was saturated with water, whereupon the lower curve was constructed for the same substances saturated with water. This curve illustrates also the necessity of knowing precisely how many components are present in the mixture. On the other hand, a melting-point curve would be of little use for the analysis of *p*-toluidine containing small amounts of *o*-toluidine since the melting point of *p*-toluidine is about 21° below zero. Specific gravity

has been tried for this purpose, but owing to the fact that 0.5 per cent of *o*-toluidine causes a change of only 0.01 per cent in the specific gravity, the method is not very accurate. Further work should be done on this point.

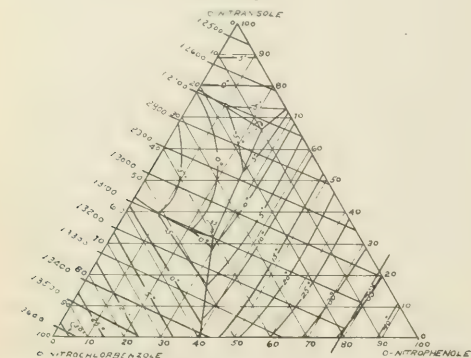
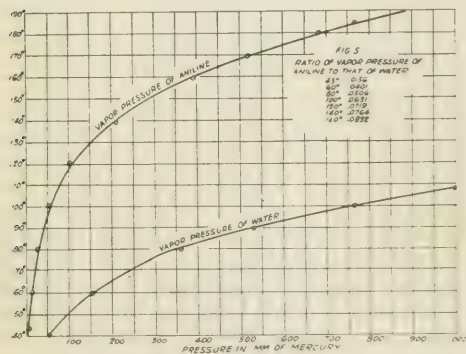


Fig. 4—Specific Gravity and Freezing Points of the System of *o*-Nitranisol, *o*-Nitrophenol and *o*-Nitrochlorbenzol

There are quite a number of physical properties that have up to the present been very little used for analytical methods or as criterions of purity. These offer considerable promise and should by all means be tried. Among them are dielectric constant, magnetic susceptibility, electric birefringence, and magnetic rotation.

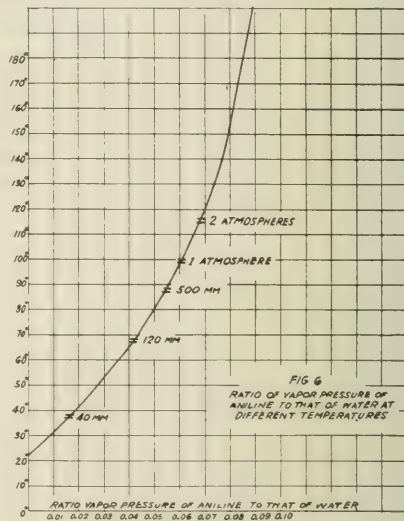
For the same reason that the measurement of one physical property is necessary for the analysis of a binary system, it follows that the measurement of two physical properties is necessary for the analysis of a ternary system by purely physical means. Quite a few ternary systems can be analyzed by the removal of one component whereupon they become binary and the binary methods can be used. A mixture of hydrazobenzol, azobenzol, and azoxybenzol is typical of this situation.



The hydrazobenzol can be removed by treating the system with hydrochloric acid which rearranges it to soluble benzidine hydrochloride. The mixture of azobenzol and azoxybenzol can then be filtered off and their ratio determined by the melting point of the mixture. On the other hand, it is sometimes easier and quicker to measure two physical constants than to attempt any separation. Fig. 4 shows both the melting point and specific gravity of the system *o*-nitrochlorbenzol, *o*-nitranisol, and *o*-nitrophenol plotted as functions of the composition. By measuring both melting point and density, the composition

of the mixture can be read off the curve. By measuring the melting point to within 1° and the density to within 0.001 the composition can be determined within 1 per cent. This method yields good results in the laboratory. As far as I know it does not appear anywhere in the literature.

Physicochemical methods can afford short cuts in the solution of a number of plant problems that otherwise could be solved only by the laborious method of cut and try. The distillation of aniline water, commonly known as oil water, is an interesting example. This is the aqueous portion of the distillate resulting from the steam distillation of aniline. It contains about 3.5 per cent of dissolved aniline which is recovered by distillation—scalping, as it is called. The aim of this process is to distil as large a proportion of aniline as possible and as little of the water. Should it be done under vacuum or atmospheric pressure? The vapor-pressure curves of aniline and water are shown in Fig. 5. The proper conditions for distillation will

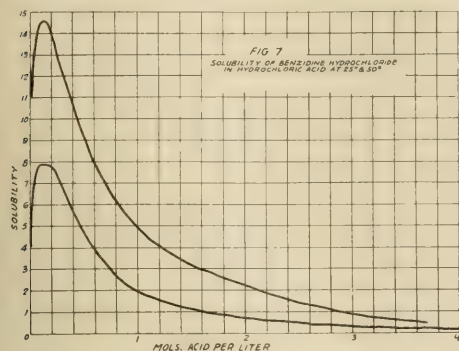


be those under which the ratio of the vapor pressure of aniline to that of water is the highest. Fig. 6 shows the change of this ratio with the temperature. Since the boiling point rises with increasing pressure, it also shows the change of this ratio with increasing pressure. The ratio of aniline is much higher at atmospheric pressure than in vacuum, but not enough higher under two atmospheres to warrant distilling under pressure. Experimental results are in accord with this conclusion. On the other hand, the vapor pressures of *o*- and *p*-nitrochlorbenzol are such that their ratio is constant at all temperatures and, therefore, as far as any separation by distillation is concerned, the pressure is of no importance.

The freezing-point curve affords a perfectly definite guide in the separation of a pure substance from a mixture by crystallization. To obtain a maximum yield the mixture should be cooled to a temperature as near the eutectic as possible. But in order to avoid crystallization of the other components, the process should be so arranged that the mixture will not cool quite to the eutectic point until after it has been centrifuged or filtered.

The curves of Fig. 7, which show the solubility of benzidine hydrochloride in hydrochloric acid, indicate a point of maximum solubility. The solubility in pure water is 4 per cent and in 0.2 normal acid 8 per cent. This is of considerable importance

in view of the cost of wooden vats and the number of such vats required for large-scale production. By choice of suitable acid concentration the vat space may be cut in half. On the other hand, too much acid renders the solution of the hydrochloride very difficult.



As business conditions approach more and more to the normal, efficiency of processes must be more closely watched. Here is one field where a physicochemical study of the mechanism, velocity, and ultimate equilibrium of all reactions is absolutely

essential. Thorough physicochemical study can do more toward the determination of maximum yields and quality of the product than any other line of work.

The time and equipment required to make these physicochemical measurements is frequently overestimated. This has caused some chemists to believe that it is quicker and easier to settle these matters by actual trial in the laboratory or plant. Such a view is incorrect, for the vapor pressures, melting points, and similar physical properties which I have discussed, require no more time or skill than most of the operations of a routine analytical laboratory. We have trained intelligent boys and girls to employ standardized methods for the determination of those physical properties which are most in demand. A complete vapor-pressure curve may be determined in a single day. The data obtained by use of our apparatus and technique have been compared with the results of some of the best experimenters on well-known substances and we agree with them as well as they do with each other. A complete melting-point curve can be measured in two days with an error not exceeding 0.1°. I doubt if the information which can be deduced from these physical data could be obtained by cut and try experimentation in anywhere near this time. Of course, none of these scientific shortcuts can supplant actual laboratory or plant trial as ultimate proof of a method. They do, however, frequently replace much time-consuming experimentation.

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BIBLIOGRAPHY OF THE LITERATURE OF ORGANIC MERCURIALS

By FRANK C. WHITMORE, University of Minnesota, Minneapolis, Minnesota

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The interest in organic mercury compounds has been steadily increasing during the last few years. This is largely due to the growing feeling among medical men that the much-lauded organic arsenicals are not coming up to expectations in the treatment of syphilis. This feeling has led to a rather intensive search for organic mercury compounds which shall lack the toxic effect of the mercuric ion but shall retain the marked spirillicidic properties of the element.

The publication of this bibliography was prompted by the effort of Dr. A. S. Loevenhart, of the University of Wisconsin, to enlist the efforts of a large number of American organic chemists in the making of new organic mercurials to be tested for possible chemotherapeutic uses. It is hoped that the bibliography will be helpful to chemists who may become interested in this field. The chemistry of organic mercurials has nowhere been satisfactorily summarized or reviewed as has that of the organic arsenic compounds. A good grasp of the chemistry of the known organic mercurials can only be obtained by mastering almost all of the individual papers. The beginner in the field will be helped by first reading a few articles which contain most of the typical reactions which occur in many of the other papers. Otto¹ gives a thorough treatment of the chemistry of mercury diphenyl. The reactions of this substance are typical of most compounds in which both valences of the mercury are attached to carbon. Pesci² reviews most of his work published in *Gazzetta chimica italiana* on the introduction of mercury atoms and groups into aromatic amines. Dimroth³ studies "mercuration" as a general reaction of all aromatic compounds, as general as nitration or sulfonation. Brieger and

Schulemann¹ give a good brief history of organic mercurials and make an exhaustive study of new mercury compounds of naphthalene derivatives, chiefly on the substances which are commercially available as dye intermediates. It will be noted that all four of the articles recommended deal with aromatic compounds. This choice was made because the chemistry of the aromatic mercury compounds is much more definitely known and the substances likely to be of chemotherapeutic value are mainly aromatic. Notable exceptions to this rule are the complex mercury thio compounds which have been recently studied by a number of the French chemists.

The first part of the bibliography contains a systematic list of the parent substances from which the organic mercurials are actually prepared or may theoretically be derived. These parent substances are arranged in the order used in the third edition of Beilstein. By comparing the table of contents in the front of a volume of Beilstein with the corresponding part of the bibliography it is possible to tell at a glance what classes of compounds are not represented by organic mercurials. It will be noted that the gaps are many and extensive. Compounds to fill these gaps should be made and thoroughly tested for their pharmacological properties. Of course their purely chemical properties should not be neglected. Too much of the modern work on organic mercurials has aimed at immediate usefulness. The result of this tendency is that we do not know nearly as much of the chemistry of organic mercury as we should, considering the great number of compounds which have been prepared.

The second part of the bibliography consists of a series of references illustrating the important reactions of mercury compounds having either one or both valences attached to carbon.

¹ Ann., 154 (1870), 93

² Z. inorg. Chem., 15 (1897), 208.

³ Ber., 31 (1898), 2154; 32 (1899), 758; 35 (1902), 2032, 2853.

¹ J. prakt. Chem., [2], 89 (1914), 97.

The third and last part contains an alphabetical list of miscellaneous topics related to organic mercurials. In some cases there are groups of references which have not been carefully reviewed and arranged but which may be of use to those interested especially in the medical and pharmacological aspects of the subject.

PART I—SYSTEMATIC CLASSIFICATION OF THE LITERATURE OF ORGANIC MERCURIALS

The references to the articles on organic mercury compounds are listed under the parent substances which are arranged in the order used in the third edition of Beilstein. The four "sections" correspond to the four volumes and the designating numerals

and letters in the margin correspond to those used in the tables of contents in the front of the volumes. The Roman numerals and letter show the particular type of compound dealt with and the page makes it possible to use the fifth supplementary volume of Beilstein as an index to the bibliography. To cite a case—suppose we want to find whether or not a mercury derivative of anisaldehyde is known. The fifth supplementary volume directs us to Volume 3, page 81. Page 81 does not appear in Section 4. The nearest reference to it is "VI C, p. 118." A glance at the table of contents in volume 3 shows us that not only anisaldehyde but all the other aromatic aldehydes are without mercury derivatives in the bibliography.

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IX A, p. 392.
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IX B, p. 500.
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X A, p. 552.
- LACTIC ACID:**
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X B, p. 591.
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X D, p. 627.
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- Mercury Derivatives of Dibasic Acids**
XI B, p. 648.
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XII E, p. 781.
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XXVII A, p. 914.
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XXIX A, p. 978.
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XXXVIII B, p. 1183.
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XXXVIII F, p. 1213.
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XXXIX A, p. 1217.
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Mercury Derivatives of Cyanides:

XLV A, p. 1409.

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See Beilstein, 3rd Ed., I, 1414-1416.

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XLIX, p. 1493.
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LI, p. 1510.

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SECTION 2—MERCURY DERIVATIVE OF AROMATIC HYDROCARBONS, PHENOLS, ALCOHOLS AND ACIDS

Mercury Derivatives of Aromatic Hydrocarbons

I A, p. 14.

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Mercury Derivatives of Aromatic Nitro Compounds

II G, p. 80.

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NITROTOLUENES:

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See under Amines, Phenols, Acids, Etc.

Mercury Derivatives of Sulfonic and Sulfonic Acids

III A and B, p. 108.

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Mercury Derivatives of Higher Aromatic Hydrocarbons

IV B, etc., p. 173.

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Camphors

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PART II—REACTIONS OF MERCURY DIALKYL, DIARYLS, AND ORGANO MERCURIC SALTS WITH THE FOLLOWING CLASSES OF COMPOUNDS

ACID HALIDES:

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ACIDS:

- Buckton, *Ann.*, 112 (1859), 221.
 Schorlemmer, *Ann.*, 132 (1864), 234.
 Otto, *J. prakt. Chem.*, [2] 1 (1870), 179.
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AMMONIA:

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ANTIMONY CHLORIDE:

- Hasenbäumer, *Ber.* 31 (1898), 2911.

ARSENIC CHLORIDE:

- LaCoste and Michaelis, *Ann.*, 201 (1880), 196, 247.

PHENYL ARSENIC DICHLORIDE:

- LaCoste and Michaelis, *Ann.*, 201 (1880), 238.

BORON HALIDES:

- Michaelis, *Ber.*, 13 (1880), 59.
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CHLOROFORMIC ESTER:

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CYANIDE CHLORIDE:

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ELECTROLYSIS IN LIQUID AMMONIA

- Kraus, *J. Am. Chem. Soc.*, 35 (1913), 1732.

GRIGNARD REAGENT:

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 Jones and Werner, *J. Am. Chem. Soc.*, 40 (1918), 1266

HALOGENS:

- Buckton, *Ann.*, 112 (1859), 221.
 Otto, *J. prakt. Chem.*, [2] 1 (1870), 182.
 Sakurai, *J. Chem. Soc.*, 39 (1881), 486.

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ALBUMENS:

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ACIDS:

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 Jones and Werner, *J. Am. Chem. Soc.*, 40 (1918), 1257-1272.

AMMONIA:

- Pesci, *Gazz. chim. ital.*, [I] 39 147; *Chem. Zentr.*, [I] 1909, 1092.

ANTIMONY CHLORIDE:

- Hasenbäumer, *Ber.* 31 (1898), 2911.

ARSENIC CHLORIDE:

- LaCoste and Michaelis, *Ann.*, 201 (1880), 196, 247.

PHENYL ARSENIC DICHLORIDE:

- LaCoste and Michaelis, *Ann.*, 201 (1880), 238.

BORON HALIDES:

- Michaelis, *Ber.*, 13 (1880), 59.
 Michaelis, *Ann.*, 315 (1901), 29.

CHLOROFORMIC ESTER:

- Paterno and Colombo, *Gazz. chim. ital.*, 7 (1877), 421; *Ber.*, 10 (1877), 1749.

CYANIDE CHLORIDE:

- Paterno and Colombo, *Gazz. chim. ital.*, 7 (1877), 421; *Ber.*, 10 (1877), 1749.

ELECTROLYSIS IN LIQUID AMMONIA

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IODIDE CHLORIDES:

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ANALYSIS:

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Chem. Abs., 11 (1917), 67, 171, 665, 848, 850, 1692, 1995, 2117, 2120, 2236, 2500, 2527, 3331; 12 (1918), 953, 1216, 1323, 2014, 2383, 2624.

Z. physiol. Chem., 83, 249.

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"PROPRIETARY" ORGANIC MERCURIALS:

AFRIDOL:

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ASBROL:

Chem. Zentr., [I] 1910, 948.

CONTRALUSIN:

Chem. Abs., 7 (1913), 863.

EMBARIN:

Chem. Zentr., [I] 1914, 137.

ENESOL:

Chem. Zentr., [I] 1914, 137; *Chem. Abs.*, 10 (1916), 951.

HECTINE:

Chem. Abs., 5 (1911), 914.

HYDRARGYROL:

Chem. Abs., 11 (1917), 2713.

MERCINOL:

Chem. Zentr., [I] 1915, 1275.

MERCUROPHEN:

Chem. Abs., 11 (1917), 2247.

MERIODIN:

Z. angew. Chem., 24 (1911), 678. No. 99 Sam: as Mercuriophen.

NOITOL:

Z. angew. Chem., 24 (1911), 678.

PROVIDOL:

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Chem. Zentr., [I] 1914, 137.

SOLUBLE MERCURY COMPOUNDS FROM ORGANIC MERCURIALS AND BASIC ORGANIC SUBSTANCES:

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Chem. Abs., 5 (1911), 2154, 3880.

SYPHILIS, TREATMENT WITH ORGANIC MERCURIALS:

Chem. Zentr., [I] 1912, 598; [II] 1912, 1051-2, 1575; [I] 1914, 137, 481, 804, 1366.

Chem. Abs., 6 (1912), 1034; 7 (1913), 151, 1384; 10 (1916), 640, 784; 11 (1917), 667, 825, 1690, 1992, 2233, 2235, 3334; 12 (1918), 186, 1567, 1797; 13, 1126.

Compt. rend., 153, 304, 1520.

THIO COMPOUNDS OF MERCURY—MISCELLANEOUS:

Ann., 146, 148; 241, 117; 359, 202; 371, 201; *J. Am. Chem. Soc.*, 41, 777.

Bull. soc. chim., [4] 9, 532; [4] 17, 353.

Chem. Zentr., [I] 1910, 1767; [II] 1911, 170; *Chem. Abs.*, 5 (1911), 3129; 9 (1915), 3241; 10 (1916), 2669.

Chem. Ztg., 34, 89; *Gazz. chim. ital.*, [I] 29, 394; *Chem. Zentr.*, [II] 1899, 481.

J. Chem. Soc., 111, 511.

UNSATURATED ACIDS, ACTION OF MERCURIC SALTS:

Ber., 35, 2571; 41, 4340; 43, 568, 695; 44, 1048.

Chem. Abs., 5 (1911), 2307, 3127.

UNSATURATED COMPOUNDS, ACTION OF ALLYL AND PROPENYL BENZENES WITH MERCURIC ACETATE:

Ber., 35, 2995; 36, 3575; *Chem. Zentr.*, [II] 1902, 843; [II] 1906, 120, 126

EDITORIAL CORRESPONDENCE

AN ICEBERG LOOMS OUT OF THE FOG

Unless our pilot, the Congress of the United States, steers a true course, one new ship of our industrial emergency fleet, the American dye industry, may go quickly to wreck upon an iceberg which looms suddenly out of the fog of these rapidly shifting times. I refer to the present greatly depreciated value of the German mark, the unit of currency in that land of dye manufacture. Safety from such a disastrous wreck lies alone in the enactment by Congress of a strict license law for the control of importation of dyes from every country.

I wish to give that message as wide circulation as possible through the columns of *THIS JOURNAL*. It may be that the message is late; that legislation of this character has already been enacted. If so, all is well. If not—then I hope that this letter may be of service to the members of Congress, who, I am confident, are unanimously in favor of protecting this industry, so essential to our economic independence and so intimately bound up in the matter of our future national security. There have been, however, differences of opinion as to how best to accomplish this protection. My sincere hope is that this recent development may lead our representatives in Congress, Republicans and Democrats alike, to unite in unanimous support of a strict license system. The details of that system are of small importance in comparison with the fundamental and urgent importance of the general principle. Let me explain.

At the time of the hearings on the Longworth bill before the Ways and Means Committee of the House of Representatives the rate of exchange with Germany was an unknown quantity and the subject never entered the discussions at those protracted hearings. Soon after the signing of the Peace Treaty at Versailles trading in German marks began. At first this trading was of a private character, but with the lifting of the blockade and the resumption of trade the rate of German exchange began to be quoted publicly, and showed a value of the mark from eight to ten cents, a great depreciation as compared with its pre-war value of a fraction over twenty-four cents. Gradually this rate

has dropped, until to-day the mark is worth only four cents in American money.

What significance has this depreciation for all who are interested in the permanence of the American dye industry? Simply this—if a certain dye sold in Germany before the war for, say, 6 marks per kilo, then \$1.44 was paid for it by the importer. The same dye at the same price now would cost the importer only 24 cents. Or, if cost of production in Germany has doubled during the war, it would still be only 48 cents, one-third of the pre-war cost. Can our manufacturers be expected at the present time to compete with such conditions?

The effect upon our customs duties would be also very marked, for a dye such as a vat dye, which pays 30 per cent ad valorem duty only, would now, because of the change in the rate of exchange, pay only one-sixth of the pre-war duty. It's a pretty good argument for Mr. Fordney's idea of assessing duties at the selling price in America instead of on invoice valuations. It also points clearly to the fact that Mr. Longworth should raise the specific duty rates in his bill. The specific duties are based solely upon poundage, a standard which does not vary with the fortunes of war.

If license legislation is not enacted, "dumping" of a perfectly legitimate character, which no anti-dumping law can reach, will abound and the young American dye industry will be prostrated, though it has so splendidly done its part in carrying our consumers through the war period, though it bids fair to do away completely with the old evil practices of graft, bribery and other forms of commercial corruption, and though it offers an attractive field for a large number of young organic chemists and technically trained workmen who would constitute the chief reserve of our Chemical Warfare Service in times of conflict.

Of course this rate of exchange will eventually approach normal pre-war rates, but the damage to our dye industry would have already been done. An iceberg once melted in the warm waters of the Atlantic ocean—nevertheless the Titanic was sunk.

Again, some one may say that this trading in German dyes by America will tend more nearly to equalize the rate of exchange. Yes, just about like the pouring of a bucket of water into the ocean would lead the promenaders on the boardwalk at Atlantic City to scurry to high ground for fear of a tidal wave.

Not alone from Germany direct will this flood of dyes come, if not controlled by a license law, but from neutral countries wherever dyes may now be stored and possibly also from the countries of our allies in the war, for these, under the Peace Treaty, will be entitled to purchase from Germany their share of the option on 50 per cent of existing stocks. These amounts

may prove in excess of their domestic needs. Why look for any better market than America with its high wages of labor?

No wonder the old German dye agents have been, and doubtless still are, moving heaven and earth to defeat license legislation by Congress. They know this rate of exchange game. With the defeat of this legislation they see visions of an early return to the feeding troughs, with an extra large amount of material on which to gorge thrown in.

I do not believe that any of our representatives in Congress will stand for such a deal.

PARIS, September 21, 1919

CHAS. H. HERTY

NOTES AND CORRESPONDENCE

SHOULD GRANTED PATENTS BE SUBJECT TO ANNUAL FEES?¹

By BERT RUSSELL, Secretary Patent Office Society, Washington, D. C.

The accurate description of some more or less surprising, useful innovation in an industrial means or method is understood to be the essential consideration in return for which American patents are granted. When the inventive contribution happens to interest and please a great multitude or to effect important economies in the execution of methods previously in wide use, the financial return to the successful inventor may be very great; and it seems generally to be regarded as equitable that the return to the patentee should thus be at least roughly proportionate to use which the public makes of his contribution.

Since the term for which patents are granted is very arbitrarily fixed at seventeen years, it would, however, appear inadmissible to assert—even if there were no improper granting of patents and no pirating of inventions—that the inventor's reward is satisfactorily fixed by the operation of anything resembling natural law: for evidently a longer period would work to the immediate advantage of patentees, whereas any shortening of the period would work to the advantage of the public—at least until the discouragement of invention should produce an opposite effect.

The bargain between the inventor and the public being aimed, not directly to the establishment or protection of any natural equity, but rather to the nationalistic or humanistic purpose of "promoting the progress of science and the useful arts," no reason is apparent why (short of killing the goose that lays the golden egg) the public should not drive with the inventor as sharp a bargain as may be found practicable. From this point of view, and bearing in mind that the uses of fees, as a special form of taxation, ordinarily are either regulation, or revenue, it seems to be in order to inquire:

1—Is there some important regulative effect to be best attained by the imposition of annual renewal fees?

2—Should such fees be imposed as a means of raising revenue for the administration of the Patent Office?

3—If such fees are to be imposed, what adjustment thereof can accomplish the most useful effects?

(1) As to possible regulative effects, it should not be forgotten that, however critical one may be of this system that it is our duty to perfect, the system as it stands is still the object of contemporary admiration among industrial nations, and our industrial success may fairly be deemed sufficient to justify hesitancy in any wide departure from the main features of our present law.

The imposition of annual fees seems to count among its supporters chiefly those who would advocate a "compulsory working" clause and who seem to feel that annual fees would be paid

only upon patents that were being successfully worked. It is naturally felt inequitable that an exclusive power "to make and use" should continue lodged in wholly inactive hands, *i. e.*, that a dog-in-the-manger policy should not be tolerated. Thus arises the necessity for a consideration of numerous collateral questions such as:

(a) Should the owner of two or more alternative devices or processes be compelled "to use" even the least satisfactory of these, under penalty of surrendering it free to his rivals in case he prefers to employ only his most economical embodiment? To one who is opposed to any effort at compulsory working; *i. e.*, to one who believes that the public is entitled in advance of the expiration of each patent to nothing whatever but an adequate disclosure of some actual invention clearly defined, it seems especially clear that what might be termed the "right of suppression" should be carefully preserved not only to the inventor but to his "heirs and assigns"—not "forever," but for the agreed statutory term of seventeen years. Any less degree of certitude as to the completeness and stability of rights under a patent would appear inevitably to undermine the value of patents and correspondingly to diminish the incentive to invent and to patent.

(b) Can the inventor of an important improvement, cutting in at (say) about the middle of the term of a basic patent, properly be compelled to choose between making terms with the original inventor, or paying renewal fees on a patent which he cannot independently work until the basic patent shall have run its term? Those who would compel an inventor to work his patent should not forget that he may not have the legal right to do this; or that the owner of the basic rights cannot legally or equitably be compelled to make terms surrendering any portion of his monopoly to the subsequent inventor of an improvement.

(c) Is there any general agreement as to what constitutes "working" of a patent? An inventor of three alternative forms embodying the same broad ideas may take out three separate patents, and he may arbitrarily embody his broadest and most valuable claims in any one of the three grants—but not in all three. The chances may be two to three that the specific form with which his broad claims are associated will *not* be the form that best satisfies market conditions. If the owner of this patent, containing the broad claims that effectively forbid competition, omits to manufacture articles in accord with its specific disclosure, should he be or should he not be deemed to have "suppressed" the invention of this patent?

(d) Is there some distinguishable type or variety of patent that can fairly be referred to odiously as a "blocking" or "protecting" patent? In this connection, should it not be recalled that it is the function of patents to "protect"; and that they can protect only in so far as they "block" competitors from the unauthorized use of the thing patented? The "right to exclude" is of course the essence of patent protection. No doubt the issuance of improper grants is an all too common occurrence; and no doubt it is often only the wealth of corporations that is

¹ Mr. Russell was unable to be present during the discussion of this subject at the Philadelphia meeting of the American Chemical Society, and his manuscript was received too late for inclusion in the account of the symposium in the October issue of THIS JOURNAL. Since this paper was prepared Mr. Russell has left the government service, after many years devoted to chemical application, in order to participate in the chemo-legal work incidental to the patent practice of Messrs. Prindle, Wright & Small, of New York.

adequate to the legal defense of doubtful grants; but the correction of these evils would appear to await an improved administration of the Patent Office, an elevation of the standards of patentability, and the strengthening of the informative resources of the Office by more liberal appropriations and otherwise.

There appears then to be no valid reason to suppose that the imposition of annual renewal fees could be relied on to serve any useful regulative effect. Such fees appear adapted to break no unjust monopoly, to open up no fields to inventive effort. If levied on a "flat" basis, regardless of the value of the patent or the extent of its working, such fees evidently might operate to the discouragement of invention, or of patenting as a means of protection. Renewal fees would operate as a hardship to the poor inventor, without reliably serving any clear economic or technical purpose.

(2) But the Patent Office is poverty stricken; and, perhaps partly for that reason, the Patent Office is ignorant. Legislation now pending (H. R. 7010) proposes specific general increases, long overdue, in the compensation of members of the examining corps, and increased appropriations for books and periodicals. Chairman Nolan, of the House Committee on Patents, has indicated the prevalence of a feeling among congressmen that the Office should continue self-supporting. The patent system being designed to serve the entire public, no rational foundation for this requirement is apparent, nor is it obvious that a moderate increase in the filing fee (as proposed in H. R. 5011) would fail to meet the proposed additional cost. But the circumstances seem to justify a consideration of our third major question:

(3) If annual fees are to be imposed, what adjustment thereof can accomplish the most useful effects?

In the first place, it may be urged that the first seven years, (which might be characterized as the period of development) should be exempt from any additional charge. With reasonable improvement in the appellate system (*e. g.*, such as is contemplated by H. R. 5012) this interval should suffice for the terminating of litigation, as well as the interesting of capital and the development of plant. If a device has merit, or if the claims drawn thereon have value by reason of the breadth of the monopoly created, that fact should be determinable within seven years.

The testimony of those who have observed the operation of fee systems in foreign countries is found to be so conflicting that the arguments herein are intended to be based squarely upon recognized economic principles and the ordinary laws governing human behavior under the guidance of the principle of self interest. No argument would appear necessary to establish that no other tax could appear so equitable to the inventor—that no other tax could so little check the disposition to invent—as would a tax computed as a percentage upon net earnings or upon the market value of patent rights.

To obviate all risk of misunderstanding, it is suggested that every patent grant might well include the words "subject to the pre-existent rights of others and subject to a right of revocation or transfer for non-payment of such annual fees as may from time to time be assessed," and that the official appraisal, due to be made at the end of (say) the seventh year of the life of every patent, might well take into consideration, not only the representations of each owner, but also every bid, regularly received, in response to invitation by advertisement, and constituting a *bona fide* offer for the unexpired term of the patent in question, if the same should become forfeit for non-payment of fees.

The standards of patentability enforced by the Patent Office have fallen so low, and the uncertainties inherent in a form of property that may at any moment be rendered obsolete by the successful efforts of a rival inventor are so great, that probably no value justifying taxation could be assigned to one recent patent in a hundred. It is by no means clear that the rest—

the 99 out of each hundred—should be declared forfeit; and no doubt it may be assumed that any charge made would be redistributed upon the consuming public; but it seems clear that a very small and uniform percentage of the declared or established values of the few successful and important inventions of each year would, under this system, suffice to create and maintain, with hardship to no one, an American Patent Office worthy of the name.

For what are additional fees needed?

It seems proper to conclude this paper with a brief consideration of the needs of the Patent Office, as viewed by one now withdrawing—reluctantly—from its examining corps after some fifteen years of service therein. It seems fair to state that the corps generally is not understood to share the views attributed to the Commissioner of Patents (1) that any grammar-school boy ("copy-puller") can in some two weeks' time be sufficiently trained to pass upon the scientific and legal problems involved in the grant of patents, or (2) that the classification of patents can be tolerably completed without any general plan, or (3) that neither the betterment of working equipment, organization and conditions to permit a genuine specialization on the part of the men nor the increasing of compensation can be relied on to hold the qualified members of the corps for a much longer average term of service.

The salaries of assistant examiners of patents now range from \$1500 to \$2400, with a temporary bonus of \$240 per year, and the salaries of the chiefs of examining divisions are \$2700, with a bonus of \$40. In view of the outside demand for men of technical training versed in patent law, the rate of registration is stated to have risen to 25 per cent per year. Second, third and even fourth assistant examiners are leaving to accept an initial compensation greater than that paid to chiefs of divisions. To meet this situation, many "temporaries" have been added—some 20 per cent of the corps now being men who have never passed an entrance examination—even though it is true that recently entrance standards have been so lowered that a man may now receive a regular appointment without even having taken a college course or passed an entrance examination in physics, chemistry or mathematics. Without adequate informative materials, without an adequate classification *in esse* or in prospect, without effective or appreciative supervision by men really qualified thereof by any profound or detailed knowledge of particular arts, and deeply discouraged and chagrined by the conditions, the standards and the consequent reputation under which they are forced to continue if they remain in the service, even those who would otherwise prefer to be content with a modest competence are finding it more and more of a tax upon their self-respect to continue in this branch of the public service—more and more natural to adopt the current view attributed to those in authority, more and more natural to cut corners in every search, and to ignore imperfections in disclosure, while concentrating attention rather upon those purely legal studies upon which the "powers that be" choose to rely in the making of promotions, and by which the men may earn a larger competence after early resignation. The seriousness of the consequent situation, as viewed from the standpoint of the inventor, can hardly be exaggerated; and its rectification—to make the corps a body of disinterested and competent experts, equipped and qualified to pass promptly an enlightened judgment upon the complex problems incidental to the advance of science and industry—may require, not only the passage of legislation pending (in H. R. 5011, H. R. 5012, and H. R. 7010, upon which it is felt that the members of this Society should concentrate their present effort), but also the finding of very considerable additional funds. And it is believed that a substantial portion of these funds might without serious disadvantage be levied by a wisely-adjusted system of fees collectable during the last decade of the life of each patent.

PROPOSED PROVISION FOR THE CHEMICAL WARFARE SERVICE

The following statement is reprinted from the Senate Committee Print entitled "Army Reorganization Bill—Analytical and Explanatory Statement of the Bill (S. 2715) to Reorganize and Increase the Efficiency of the United States Army, and for Other Purposes, Prepared for the Information of the Senate Committee on Military Affairs," by Senator George E. Chamberlain, of Oregon, dated September 5, 1919.

No provision is made in the pending bill for the maintenance of that important service as developed and organized during the recent war, but it is understood that it is the purpose of the Secretary of War to assign it permanently to the Engineer Corps, under the general powers proposed to be conferred upon the President by this bill.

In consideration of this subject it is of the first importance to bear in mind that such a service must have two separate and distinct functions. One of them is scientific research and the development, production and procurement of necessary materials. The other function is the application of those materials by appropriate troops to military uses, just as the materials developed, produced, and procured by the Ordnance Department are applied to military uses. These two functions of a Chemical Warfare Service should not be combined in one organization or under one head, because there are no officers in the Engineer Corps or elsewhere in the Army whose training and practical experience as chemists fit them either for the performance or the intelligent supervision of the scientific duties of chemical research and production.

There should be established in the Army a department of chemistry, along the lines of the Medical and Ordnance Departments, to be filled from top to bottom with expert professional chemists. To this department should be assigned all duties pertaining to the scientific research required, and to the development, production and procurement of all materials needed for the purposes of chemical warfare, such materials to be supplied to appropriate troops for application to military uses, including the making of the necessary experiments with regard to such uses. To this department should also be transferred, as far as practicable, all work of a chemical nature now done in or under the various bureaus of the War Department.

DEFINITION OF THE TERM "F. O. B. NEW YORK"

Editor of the Journal of Industrial and Engineering Chemistry:

The enclosed material was sent to me as Chairman of the Committee on Foreign Chemical Trade of the AMERICAN CHEMICAL SOCIETY, and it would seem to me to be of such importance that some publicity should be given in your Journal.

WELSBACH COMPANY
CLOUDESTER, N. J.
September 18, 1919

HARLAN S. MINER, *Chairman*

The National Foreign Trade Council has received complaints that American manufacturers and exporters who have quoted "F. O. B. New York" have interpreted that quotation to include merely delivery within the limits of the port of New York, and not necessarily actual delivery of the merchandise on board the overseas vessel. The contention is that the term "F. O. B. port" has only one meaning, namely, "Free on board overseas vessel" at the port named, and that a quotation "F. O. B. port" means that the purchaser has no charges to meet except those connected with ocean freight, and insurance.

It appears that some American manufacturers and exporters who have quoted prices "F. O. B. New York," or other port, have contented themselves with the delivery of the goods within the limits of the port named, instead of onboard overseas vessel, with the result that charges for cartage, litherage, storage and other items, have been passed on to the purchaser who had understood that the "F. O. B. port" quotation covered delivery of the goods on the overseas vessel. The possibility of adverse effect upon American foreign trade in this situation is obvious, and leads the National Foreign Trade Council to urge upon American exporters generally the wisdom of following invariably a practice under which such complaints cannot possibly arise.

There is no question that the original meaning of "F. O. B. port" was "Free onboard ship," and that that is the general and usual interpretation of it among foreigners.

NATIONAL RESEARCH FELLOWSHIPS IN CHEMISTRY

The National Research Council announces the appointment of the following additional Fellowships in Chemistry:

EDWIN J. COHN, of New York City, S.B. (Chicago, '14), Ph.D. (Chicago, '17), formerly assistant in chemistry at Harvard University; First Lieutenant, Sanitary Corps, U. S. A. Mr. Cohn will conduct his researches at the Carlsberg Laboratory, Copenhagen.

MORRIS KHARASCH, of Chicago, Ill., S.B. (Chicago, '17), Ph.D. (Chicago, '19). Mr. Kharasch will conduct his research work at the University of Chicago.

AXEL R. OLSON, of Chicago, Ill., S.B. (Chicago, '15), Ph.D. (California, '17), formerly a Teaching Fellow in Chemistry at the University of California; recently released from military duty. Mr. Olson will carry on researches at the University of California.

A number of Fellowships in Physics and Chemistry are still open. Application for them may be made to the Secretary of the Research Fellowship Board, 1201 Sixteenth St., N. W., Washington, D. C.

UNIVERSITY CHEMISTRY CLUBS

Editor of the Journal of Industrial and Engineering Chemistry:

The Chemistry Club of Akron University desires to communicate with Chemistry Clubs of other universities and colleges. We have a small, but very active Chemistry Club, and it is our hope that by keeping in touch with the doings of other similar societies we shall be able to increase our usefulness to our school and to our own members, and, in a small way, to other societies.

Communications should be addressed to Eugene Haas, 25 Franklin St., Akron, Ohio.

MUNICIPAL UNIVERSITY OF AKRON
AKRON, OHIO
September 29, 1919

EUGENE HAAS

PLATINUM THEFT

During the week of September thirteenth two platinum crucibles and about 25 g. of platinum wire were stolen from the office of Dr. Roy B. Davis, Department of Chemistry, The University of the South, Seawanee, Tenn. The work was evidently that of a professional platinum thief, as several grams of silver and gold foil were not disturbed. The crucibles and covers had a combined weight of approximately 50 g. and were of 25 cc. capacity

THE DETERIORATION OF MANUFACTURED CANE SUGAR BY MOLDS—CORRECTION

In the article of the above title [THIS JOURNAL, 11 (1919), 845], the following correction should be made:

Page 846, second column, second footnote, "Louisiana Bulletin, 196," should read "Louisiana Bulletin, 166."

NICHOLAS KOPELOFF

September 20, 1919

EQUILIBRIUM STUDIES UPON THE BUCHER PROCESS—CORRECTION

In the article of the above title [THIS JOURNAL, 11 (1919), 946] the following correction should be made: Page 946, first paragraph, fifth line, "Carnegie Institute" should read "Carnegie Institution."

ROBERT B. SOSMAN, *Acting Director*

CARNEGIE INSTITUTES OF WASHINGTON
WASHINGTON, D. C.
October 11, 1919

WASHINGTON LETTER

By J. B. McDONNELL, Union Trust Building, Washington, D. C.

Whether Germany is equipped to enter the after-the-war commercial struggle with adequate weapons has, so far as the chemical industry is concerned, been answered in reports which have been received here during the last few days from official sources abroad. Germany has 130,000 tons of dyes and chemicals stored along both banks of the Rhine ready for exportation, these advices state. Thirty thousand tons of these are located in the territory occupied by the allied forces. The remaining 100,000 tons are on the other bank.

Will the Senate enact legislation to protect the American chemical industry in time to prevent this country from experiencing at least the beginning of a flood of German chemicals? The Longworth dye measure, providing increased tariff rates and a peace-time import licensing barrier to unrestricted imports, is in the Senate Finance Committee with no date set as yet for its consideration by that Committee. Passed by the House on September 26, the measure was sent to the Senate and there referred to the Finance Committee. It is necessary for the Committee to take some action upon it and report it to the Senate before that body can act upon it.

Efforts now are being made to have early consideration given to the dye measure by the Committee, of which Senator Penrose, of Pennsylvania, is chairman. There are other tariff measures, and some minor amendments to the revenue law, which are before the Committee, but the prospect for early action upon practically all of them is faint. At a recent meeting the Committee unanimously decided that it would take no action upon any of these measures until after the Treaty of Peace had been finally disposed of by the Senate. This decision presents an interesting situation.

Leading chemists and dye manufacturers have declared that the tariff law now in effect will be entirely inadequate to give them the protection they must have if the American chemical industry is to continue to grow. The war itself was the greatest protective tariff law which the industries of this country ever had. In addition to the natural restrictions and hindrances due directly to the war itself and unavoidable, the industry had, and still has, the benefit of restrictions placed upon imports.

War time restrictions, however, come to an end with the formal coming of peace. The powers of the War Trade Board, which has been merged into the Department of State, cease simultaneously with the proclamation of peace. Should the Senate ratify the Treaty of Peace, and then adjourn, as many leaders now are advocating, without taking action upon any other measure, the American chemical industry will be left stripped of its war-time protection and must depend upon the so-called Hill bill, which has been in force during the last few years.

Actually the Longworth dye measure, H. R. 8078, has a better chance of receiving early consideration than any of the other tariff and revenue measures which the Senate Finance Committee has under consideration. Government officials of the executive branch, who are working to safeguard the industry, still are hopeful that the wisdom of early action will be seen by the Senate. It is probable that action will be taken sufficiently early to prevent the beginning of any flood of German dyes setting in toward this country. The somewhat precarious position of the American industry was recently pointed out in a short speech by Senator Smoot, of Utah, member of the Finance Committee, on the floor of the Senate when he introduced an anti-dumping measure.

An effort will be made to attach this anti-dumping measure as an amendment to either the dye measure or one of the other more important tariff bills before the Committee. It is possible that a movement against the licensing feature of the Longworth measure is concealed behind this. Passage of the Longworth bill, with an import licensing provision in it, by the Senate, however, is expected before adjournment of this session of Congress.

The Longworth bill embodies the forty-five amendments to the present law which were recommended by the United States Tariff Commission. These amendments practically rewrite the present law, correcting errors, and are designed to stop the existing loopholes through which it is possible to escape payment of the rate of duty it was obviously the intention of Congress to impose on certain chemicals.

A forty per cent ad valorem duty is imposed on chemicals and dyes in Group II, and an ad valorem duty of 45 per cent is levied upon Group III. In addition to these ad valorem duties there

is assessed, upon Group II a specific duty of six cents per pound and upon Group III a specific duty of seven cents per pound, based upon standards of strength to be fixed by the Secretary of the Treasury. Upon all importations which shall exceed such standards of strength the special duty of seven cents per pound shall be computed upon the weight of the article if it were diluted to the standard strength. In no case, however, shall the duty paid be less than seven cents per pound.

As passed by the House the bill would permit imports only under licenses to be issued by the Tariff Commission. It was originally proposed to set up a new and separate dye licensing commission. This, however, was changed at the last minute and the Tariff Commission substituted, in spite of the vigorous opposition of Representative Moore, of Pennsylvania, Representative Fordney, of Michigan, and a few other members who knew practically nothing of the subject they attempted to discuss.

Former importers are taking advantage of every opportunity that offers to create dissatisfaction among the dye consumers, principally among the textile manufacturers. Their fight against the licensing provision is a determined one, and, while it is at present removed from Washington, there is little doubt but that there will be a renewed effort made to defeat the licensing section of the House dye bill when it comes up for action in the Senate. Supporters of this provision, however, feel confident of summoning enough support for it to pass it in the Senate and have it written upon the statute books. It gives the industry the protection of import restrictions for a period of two years. Thereafter, imports will be subject solely to the ad valorem and specific duties, unless new legislation is enacted.

Plans for obtaining a quantity of German dyes and chemicals desired by consumers in this country are rapidly approaching completion. Under an agreement made between the Inter-allied representatives acting under the Reparation Commission and the German representatives, dyes will be obtained at prices lower than were asked for by the Germans in the open commercial market. Each of the allied countries will obtain the dyes they want, dealing with Germany as a whole.

The War Trade Board Section of the Department of State has issued import licenses to consumers. Each consumer was allowed a six months' supply, based upon his consumption during the year 1914, the last pre-war year. The total amount applied for, and for which licenses were issued, however, amounts to more than half the imports during that year, a reasonably increased amount being allowed to each consumer when requested, in order to provide for the expansion which has taken place in the dye and chemical consuming industries of this country during the war.

Licenses also are being issued by the War Trade Board for other than vat dyestuffs. Issuance of these licenses, of course, will depend to a large extent upon the question whether dyes requested are available of American manufacture.

Under the plan which has been agreed upon by the Allied and German representatives in Paris, for purchase of a supply of German chemicals, the Textile Alliance, Inc., will act as the consignee for the German dyes in this country. Those to whom import licenses have been granted, however, are free to obtain their dyes in such manner as they deem best. Selection of the Textile Alliance to act as consignee for those consumers who surrender to it their import licenses and request the corporation to act for them was decided upon as the best means of dealing with German chemical interests as a whole.

That the business world at large deems the situation in which the allied world, as a whole and by individual countries, finds itself at the close of the war with regard to the chemical industry is shown in the program arranged by the United States Chamber of Commerce for the International Trade Conference, to be held at Atlantic City. A special committee, headed by Charles H. MacDowell, president of the Armour Fertilizer Works, Chicago, has been named by the Chamber to meet with foreign delegates to the conference who are interested in chemicals and discuss with them the many changes in the chemical industry which have taken place during the war. Adjustment of the industries of the various countries from a war to a peace basis will be one of the important subjects which will be discussed.

E. T. Connelly, acting secretary of the Manufacturing Chemists' Association, will be vice chairman and secretary of the committee, and Alfred P. Perkins, assistant secretary.

Other members of the committee, as named in the program, are: Horace Bowker, secretary, American Agricultural Chemical Company; Albert R. Burnker, president of the Liquid Carbonic Company; M. F. Chase, consulting chemical engineer, Leonard Construction Company; E. R. Grasselli, Grasselli Chemical Company; William Hamlin Childs, president of the Barrett Company; H. H. Dow, general manager, Dow Chemical Company; H. H. S. Handy, vice president, Semet-Solvay Company; Henry Howard, vice president, Merrimac Chemical

Company; Wilbur C. Miller, president, Davison Chemical Company; J. D. Pennock, Solvay Process Company; Chas. L. Reese, E. I. du Pont de Nemours & Company; A. G. Rosengarten, Powers-Weightman-Rosengarten Company; E. M. Sergeant, second vice president, Niagara Alkali Company; Alonzo E. Taylor, University of Pennsylvania; Henry Wigglesworth, General Chemical Company, and Francis P. Garvan, Alien Property Custodian and president of the Chemical Foundation, Inc.

October 16, 1919

INDUSTRIAL NOTES

Among Germany's requirements in the list presented to the Reparation Commission are: Fertilizer and forage for the next twelve months: Meal cakes, 900,000 tons; "Thomas" phosphates, 1,000,000 tons; raw phosphates, 1,500,000; bone, 4,200 carloads; turpentine, 3,000 tons; raw glue, 3,400 carloads; gum copal, 350 tons; lacquer gum, 300 tons.

The Southern Agricultural Chemical Co., Atlanta, Ga., recently organized with a capital of \$1,000,000, has acquired a site for the erection of a large chemical plant. This will be the first of a number of such plants that the company plans to build in different southern cities.

Fire on Monday, September 15, destroyed warehouse No. 4 of the J. C. White Engineering Corporation at Muscle Shoals, Ala., the government nitrate plant, the loss being estimated at \$2,000,000. The major portion of the loss was on electrical equipment.

The Canadian Government has, through its Department of Statistics, prepared a Directory of Canadian Chemical Industries. The information is complete to January 1919, and is the first publication of this kind to be issued in the Dominion. Some 634 firms are listed, and their names and products are given alphabetically. The directory also gives a very complete summary of the chemical industries of the Dominion and of the business done during the last six years.

The St. Louis Chamber of Commerce has announced that, with the exception of the automobile and motor truck industry, the chemical and drug industry occupies more floor space than any other single industry in St. Louis. The total is 2,057,000 sq. ft. One-fourth of this is additions within the last year.

The immediate development of the borax fields of Death Valley, California, is assured by a recent decision of a Los Angeles judge in which full title to contested property is vested in the F. M. Smith interests of San Francisco. The decision brings to a close three years of bitter litigation. Involved in the decision is property in the desert valued at \$20,000,000 to \$100,000,000.

A bill has been introduced in the House of Representatives providing for the incorporation of the United States Platinum Corporation, with capital stock of \$30,000,000. The object of the corporation is to secure a concession from the Government of land areas in Alaska containing platinum sands, and to pay for such privileges, as a royalty or subsidy, one-eighth of the net products obtained from the working of the concession. The operation would be under the jurisdiction of the Treasury Department. The measure provides that there shall be selected and appointed by Congress five commissioners to be known as United States Government Commissioners of Platinum and its Allied Industries, and that a sum shall be set aside from the gross receipts of the corporation to maintain and support the commission.

The Universal Packing Co., of Fresno, Cal., has disposed of its plant to the California Products Company and the factory will be converted for the manufacture of vegetable oil products. Copra will be imported and oil will also be extracted from local products.

Plans are under way for holding the spring term of the Lyons Fair, at Lyons, France, from March 1 to March 15, 1920. This Fair is a business exchange open to all manufacturers and wholesale buyers of allied and neutral countries.

PERSONAL NOTES

Mr. T. J. Parker, for several years a Director of the American Chemical Society, died at his home in Bayonne, N. J., on October 9, after a long illness.

Mr. F. W. Barker, Jr., of Wilmington, Del., formerly plant superintendent of the Marcus Hook plant of the National Aniline & Chemical Co., Inc., has been transferred to the general offices of the same company at New York City.

Mr. G. C. Swan has resigned from his position in the Jackson Laboratory of E. I. du Pont de Nemours & Co., Wilmington, Del., and is now with the Leather & Paper Laboratory, Bureau of Chemistry, Washington, D. C.

Dr. W. H. Rodebush has left the research laboratory of the U. S. Industrial Alcohol Company, South Baltimore, Md., to take a National Research Council Fellowship at the University of California, Berkeley, Cal.

Mr. Christian Weaver, who for the past fourteen years has been connected with the chemistry department of Cooper Union Institute as instructor, has severed his connection with that institute and has accepted the position of chief metallurgist with the Doehler Die-Casting Co., of Brooklyn.

Mr. Berry V. Bush, formerly head of the chemistry department at Friends Central School, Philadelphia, is research chemist in the organic research laboratories of the Eastman Kodak Co., Rochester, N. Y.

Mr. Grady P. Oakley, who for six years has been assistant to Secretary Chas. L. Parsons in connection with the work of the AMERICAN CHEMICAL SOCIETY, recently joined the staff of the Vasil Steam Systems Company, Washington, D. C., to be in charge of their accounting department.

Mr. Allan J. Field, formerly research chemist and supervisor of dyestuffs and intermediates with the G. Siegle Company, Rosebank, S. I., N. Y., is now connected with the Sherwin-Williams Company, Chicago, Ill.

Mr. Eldon B. Flu, formerly with Ricketts & Company, of New York, is now employed by the Columbia Graphophone Manufacturing Co., Bridgeport, Conn.

Mr. Ralph L. Horst has resigned from the chemical laboratory of the Bureau of Animal Industry, U. S. Department of Agriculture, Chicago, where he was working with oil fats and edible oils used in packing-house products, and will teach chemistry and physics at the Mendota Township High School, Mendota, Ill.

Mr. Sidney D. Kirkpatrick, formerly 1st Lieutenant in the Sanitary Corps, U. S. Army, A. E. F., and later transferred to the staff of the American Commission to Negotiate Peace, where he was assigned to the committee on chemicals and dyes, has returned from overseas and has resumed his former position as assistant to Dr. Grinnell Jones on the chemical staff of the U. S. Tariff Commission, Washington, D. C.

Dr. Horace G. Byers, formerly of the University of Washington and more recently chemist in charge of the soil investigations of the Bureau of Soils, has accepted the position as head of the department of chemistry at Cooper Union Institute, New York City.

Dr. R. R. Renshaw, formerly associate professor of organic chemistry at Iowa State College, has accepted an assistant professorship of chemical research in pharmacology at the Harvard Medical School, Boston.

Dr. F. W. Skirrow, for the past four years assistant professor of chemistry at McGill University, has resigned this position to take up the duties of chief chemist to the Shawinigan Laboratories, Ltd., the newly founded research organization of the Shawinigan Water and Power Co., Shawinigan Falls, Que.

Dr. Homer Adkins, instructor in organic chemistry at Ohio State University, 1918-19, is at present doing research work on azo dyes at the Jackson Laboratory of E. I. du Pont de Nemours & Co., Wilmington, Del.

GOVERNMENT PUBLICATIONS

By R. S. McBRIDE, Bureau of Standards, Washington

NOTICE—Publications for which price is indicated can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. Other publications can usually be supplied from the Bureau or Department from which they originate. Commerce Reports are received by all large libraries and may be consulted there, or single numbers can be secured by application to the Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington. The regular subscription rate for these Commerce Reports mailed daily is \$2.50 per year, payable in advance, to the Superintendent of Documents.

SMITHSONIAN INSTITUTION

Explorations and Field-Work of Smithsonian Institution, 1918. Publication 2535; Smithsonian Miscellaneous Collections, 70, No. 2. 122 pp. Paper, 25 cents.

FOOD ADMINISTRATION

Production of Meat in the United States, and Its Distribution during the War. S. CHASE. 1919. 85 pp.

WORKING CONDITIONS SERVICE, DEPARTMENT OF LABOR

Safeguarding Workers in Tanning Industry. R. S. BONSH. 121 pp. Paper, 25 cents.

SUPERINTENDENT OF DOCUMENTS

Mines, Explosives, Fuel, Gas, Gasoline, Petroleum; Publications for Sale by Superintendent of Documents. June 1919. 24 pp. Price list 58, 6th edition.

Soils and Fertilizers; Publications for Sale by Superintendent of Documents. May 1919. 22 pp. Price List 46, 12th edition.

CONGRESSIONAL COMMITTEES

The following congressional committee reports, principally by the House of Representative Ways and Means Committee, of June and July transactions, relate to subjects of chemical interest:

Manufacture, Distribution, Etc., of Explosives. Tentative draft of bill to Amend Explosives Act of October 6, 1917, House Document 127. 4 pp. Issued June 20, 1919.

Dyestuffs. Hearings on H. R. 2706 to amend act to increase revenue approved September 8, 1916; June 18–20, 1919. These hearings were continued on H. R. 6495 which was substituted for H. R. 2706. Hearings on H. R. 6495 to regulate importation of coal-tar products, to promote establishment of manufacture thereof in United States, and as incident thereto, to amend act of September 8, 1916, to increase revenue; July 14 to 18, 1919. 712 pp.

Tax on pure fruit-juice beverages. Report to accompany H. R. 7840; submitted by Mr. Hawley. July 26, 1919. 4 pp. House Report 159.

Establishing and maintaining in United States manufacture of laboratory glassware, etc. Report to accompany H. R. 7785 to provide revenue for Government, to establish and maintain in United States manufacture of laboratory glassware, laboratory porcelain ware, optical glass, scientific and surgical instruments, submitted by Mr. Bacharach. July 26, 1919. 4 pp. House Report 157.

Duty on magnesite ore. Report to accompany H. R. 5218 to provide revenue for Government and to establish and maintain production of magnesite ores and manufactures thereof in United States submitted by Mr. Hadley. July 29, 1919. House Report 177.

Potassium salts. Hearings on H. R. 4870 to provide revenue for Government and safeguard, by license control of imports of potassium salts and by imposing import duty thereon, interests of domestic potash producers, June 20 to July 21, 1919. 137–255 pp. (Parts 1–3 of these hearings were also issued bound together.)

Information concerning pyrites and sulfur industry (with bibliography). Compiled by Tariff Commission. 31 pp.

Tungsten ore in United States. Report to accompany H. R. 4437 to provide revenue for Government and to promote production of tungsten ores and manufactures thereof in United States submitted by Mr. Timberlake. July 28, 1919. 5 pp. House Report 161.

Information concerning zinc ore. Compiled by Tariff Commission. 46 pp.

Report on dyes and related coal-tar chemicals, 1918. Compiled by Tariff Commission. 1919. 127 pp.

Chemical and optical glassware and scientific apparatus. Hearings on H. R. 3734, to provide revenue for Government and to establish manufacture of optical glassware in United States; H. R. 3735, to provide revenue for Government and to establish manufacture of chemical glassware in United States; and H. R. 4386, to provide revenue for Government, and to establish manufacture of philosophical, scientific, and laboratory apparatus in United States, June 11–13, 1919. 139 pp.

Information concerning optical glass and chemical glassware. Compiled by Tariff Commission. 1919. 35 pp.

Information concerning magnesite industry (with bibliography). Compiled by Tariff Commission. 23 pp.

Magnesite. Hearings on H. R. 5218, to provide revenue for Government and to establish production of magnesite ores and manufactures thereof in United States, June 16 and 17, 1919. 212 pp.

Information concerning manganese ore (with bibliography). Compiled by Tariff Commission. 28 pp.

Information concerning potash industry. Compiled by Tariff Commission. 52 pp.

Potassium salts. Hearings on H. R. 4870 to provide revenue for Government and to safeguard, by license control of imports of potassium salts and by imposing import duty thereon, interests of domestic potash producers, June 10–17, 1919. 135 pp.

Tungsten ores. Hearings on H. R. 4437 to provide revenue for Government and to promote production of tungsten ores and manufacture thereof in United States, June 13–17, 1919. 84 pp.

Zinc ore. Hearings on H. R. 1246 to provide tariff and obtain revenue in connection with metal contents of zinc ore, June 18, 1919. 31 pp.

GEOLOGICAL SURVEY

Petroleum in 1917. J. D. NORTHROP. From Mineral Resources of the United States, 1917, Part II. 219 pp. Issued August 4, 1919.

The quantity of petroleum marketed from the oil fields of the United States in 1917, which aggregated 335,315,601 bbls. of 42 gal. each, established a new record for output of petroleum in this country that is more than 11 per cent greater than the former maximum yield of 300,767,158 bbls., attained in 1916.

The average price received for this oil at the wells was \$1.56 a bbl. and the total market value of the output was \$522,635,213, a gain of 46 cents in average unit price and of \$191,735,345, or 58 per cent, in gross market value, compared with 1916.

PERCENTAGES OF PETROLEUM MARKETED IN THE SEVERAL FIELDS, 1916–1917

FIELD	1916	1917
Appalachian.....	7,650	7.44
Lima-Indiana.....	1,298	1.09
Illinois.....	5,890	4.70
Mid-Continent.....	45,528	48.76
Gulf.....	7,238	7.26
California.....	30,240	28.00
Rocky Mountain.....	2,153	
Other Fields.....	0,003	2.75
	100,000	100.00

Despite the fact that the United States is the world's principal producer and distributor of petroleum and petroleum products, its import trade in those commodities is steadily increasing. This is especially true with regard to grades of oil desired for use as fuel, including both crude petroleum and "topped crude," available from Mexico and Trinidad. Demand for fuel oil along the Atlantic and Gulf seabords of the United States resulted in an increase of about 10,000,000 bbls., or 50 per cent in the quantity of crude petroleum imported for consumption

in the United States in 1917, compared with 1916, and an increase of some 32,000,000 gals., or 218 per cent, in the quantity of "other products" consisting for the most part either of "topped crude" or of "tops," in the same period.

In the matter of motor fuels, available statistics show an increase of nearly 8,000,000 gals., or 288 per cent, in the quantity of gasoline, naphtha, and benzine, imported for consumption in the United States in 1917, compared with 1916. Although Canada profited slightly by this increase, Peru was the principal beneficiary, its deliveries of these products at United States ports increasing from 2,703,000 gals. in 1916 to 10,425,000 gals. in 1917.

Imports of paraffin wax increased slightly in 1917 compared with 1916, whereas imports of material classed as ozokerite and ceresine decreased abruptly from about 3,000,000 lbs. in 1916 to 899,000 lbs. in 1917.

The essential monopoly by domestic refiners of the market for paraffin oil in the United States is indicated by the steady decrease in importation of that commodity since the beginning of the war. The quantity imported in 1917 was 93 bbls., compared with 902 bbls. in 1916 and with 3,676 bbls. in 1913, the last normal year before the war.

The total declared value of petroleum and petroleum derivatives imported into the United States in 1917 was \$21,334,381, compared with \$14,598,329 in 1916.

The export trade of the United States in petroleum and its liquid products in the calendar year 1917 shows gain of 1.6 per cent in quantity and of 25 per cent in declared value over that in 1916 and establishes a new record for annual exports of mineral oils. The principal gain both in quantity and in value, compared with 1916, was in the item gasoline and naphtha, though moderate increase was credited to the items crude, lubricating, paraffin, gas oil and fuel oil, and residuum. Exports of illuminating oil decreased markedly both in quantity and in declared value compared with 1916.

Gains in quantity in 1917 over 1916 were 0.05 per cent on crude petroleum, 17 per cent on gasoline and naphtha, 7.5 per cent on lubricating and paraffin oils, and 17 per cent on gas oil and fuel oil, and residuum, the aggregate being a little more than enough to offset the loss of 23 per cent on illuminating oils.

Corresponding gains in declared value amounted to 9 per cent on crude petroleum, 36 per cent on gasoline and naphtha, 34 per cent on lubricating, and 68 per cent on gas oil and fuel oil, and residuum, whereas the corresponding loss on illuminating oils was 12 per cent.

Prices of fuel oil ranged appreciably higher in 1917 than in 1916, reflecting not only the growing demand for that commodity but also the steady advance in prices of crude oil at the well. The market was unusually firm throughout the year in all parts of the country though some weakness developed near the end of 1917 from rumors of proposed Government control of the petroleum industry, with fixation of prices.

Complete statistics of the consumption of fuel oil in the United States are not available. Data compiled from the reports of pipe-line companies show that 46,681,430 bbls. of crude petroleum were delivered for use as fuel direct from the sources of domestic production in 1917. Reports of oil producers show that 4,857,000 bbls. of crude oil were consumed mainly in drilling and pumping operations in the oil fields of the country. Data compiled by the Bureau of Mines show that no less than 149,725,000 bbls. of fuel oil and gas oil were produced and sold by refiners of crude petroleum in the United States in 1917, and that refinery stocks of these products were reduced to the extent of a further 3,397,000 bbls. during that year.

The records of the Bureau of Foreign and Domestic Commerce show that 30,138,773 bbls. of petroleum, the greater part of which was for fuel, was imported, chiefly from Mexico, in

1917; and that 30,872,508 bbls. of crude oil, gas oil, fuel oil, and residuum were exported from the United States in the same period. From these data, such as they are, the consumption of fuel oil, including gas oil, in the United States in 1917, would appear to have amounted to about 204,000,000 bbls., a quantity equivalent to 61 per cent of the marketed production of petroleum in the entire country in that year.

The immense increase in railroad traffic due to the active participation of the United States in the war increased to some extent the quantity of petroleum and petroleum distillates consumed as locomotive fuel in 1917, though the increase in that year was only about one-half the rate of increase in 1916, because of mounting costs and growing scarcity of liquid fuel. Reports submitted by all railroad companies that operated oil-burning locomotives in the United States show that the quantity of fuel oil consumed by them in 1917 was 45,700,576 bbls., a gain of 3,574,159 bbls., or 8.5 per cent, over 1916, and a larger consumption than in any other year.

COMMERCE REPORTS—AUGUST 1919

The Swedish Color Material Industry Company has acquired the plants of a number of drug and chemical plants, but has not yet started the manufacture of dyes. (P. 682)

There has been a serious decline in the production of camphor in Taiwan, Japan, owing to the destruction of wild trees and menace of savage tribes. Efforts are being made to systematize the cutting of camphor trees and eliminate waste. Trees which have been planted by the government will not be available for 10 or 15 years longer. (P. 712)

In order to encourage the application of science in industry the Italian government has established or will establish experiment stations for the following industries: paper, fats, leather, ceramics, essential oils, perfumes, beet sugar, gas and fuels, dyestuffs, photographic and electrical supplies. Twenty vocational laboratory schools to be supported jointly by the national and local governments and the manufacturers will also be established. (P. 734)

The report of the British Coal Industry Commission upon the nationalization of the coal mines is presented in detail. A Department of Mines is suggested to control the industry and conduct researches. (Pp. 771-9, 806-13, 823-7)

The proposed revision of the British patent law is given in detail. (Pp. 903-8)

Practically the entire mercury production of Spain is exported to Great Britain. (P. 926)

It is reported that the refining of oil from shale in Scotland is no longer profitable and that the plants will be used for the refining of Persian petroleum. (P. 937)

In consideration of the Chinese tungsten industry, it is pointed out that American buyers are overstocked, leading to a lull in Chinese exports. The question is discussed as to whether in the future America should depend upon cheap Chinese ore or upon less accessible American ores. (Pp. 970-2)

During the war extensive chemical industries have been developed in Italy, especially sulfuric and nitric acids and cyanide. There is still, however, a great demand for foreign chemicals, drugs and dyes. (Pp. 989-92)

A new Italian alloy of copper and zinc, known as Brak-metal is claimed to have greater strength and resistance to thermal and chemical action than copper, brass, or bronze. (P. 1114)

STATISTICS OF EXPORTS TO THE UNITED STATES AMSTERDAM—Supplement 9a

Cinchona bark	Kapok
Cocoa butter	Linoleum
Copal gum	Macne-site
Decolorizing carbon	Milk sugar
Diamonds	Essential oils
Drugs	Potash
Chemicals	Quinine
Hides	Rubber

NEW PUBLICATIONS

By CLARA M. GUPPY, Librarian Mellon Institute of Industrial Research Pittsburgh

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- Coverages and Their Adulteration.** H. W. WILEY. 8vo. 421 pp. Price, \$1.50. P. Blakiston's Son & Co., Philadelphia.
- Chemistry: Guide pour les Manipulations de Chimie Biologique.** J. AND PIERRE THOMAS. 3rd Ed. 468 pp. Price, 1 fr. 50. E. Pinat, Paris.
- Tables for Laboratory Use.** H. L. WELLS. 2nd Ed. 43 pp. Price, \$1.35. John Wiley & Sons, Inc., New York.
- Chemical Engineering Catalog, 1919.** 4th Ed. 1194 pp. The Chemical Catalog Co., Inc., New York.
- Chemical Literature and Its Use.** M. E. SPARKS. 46 pp. Price, \$0.60. University of Illinois, Urbana, Ill.
- Chemistry: College Textbook of Chemistry.** W. A. NOYES. 12mo. 370 pp. Price, \$2.00. Henry Holt & Co., New York.
- Chemistry: The Condensed Chemical Dictionary; A Reference Volume for All Requiring Quick Access to a Large Amount of Essential Data Regarding Chemicals and Other Substances Used in Manufacturing and Laboratory Work.** Compiled and edited by the Editorial Staff of the Chemical Engineering Catalog. 8vo. 525 pp. Price, \$5.00. (Limp Cloth with Thumb Index, \$6.00.) The Chemical Catalog Co., Inc., New York.
- Chemistry: Manipulations Chimiques Qualitatives et Quantitatives.** L. L. DE KONINCK. 5th Ed. 177 pp. Price, 2 fr. 50. Ch. Béranger, Paris.
- Chemistry: Notes on Qualitative Analysis.** L. A. TEST and H. M. McLAUGHLIN. 12mo. 92 pp. Price, \$0.80. Ginn & Co., Boston.
- Chemistry: Organic Type Formulas.** ALEXANDER LOWY. 2 pp. D. Van Nostrand Co., New York.
- Chemists' Year Book.** F. W. ATACK, Editor, assisted by L. WHYNATES. 2 vols. 4th Ed. 1146 pp. Price, 15s. 6d. Sherratt & Hughes, Manchester.
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- Benzol: Use of Benzol and Benzol Mixtures as Motor Fuel.** I. C. MACKIE. *The Canadian Chemical Journal*, Vol. 3 (1919), No. 9, pp. 295-297.
- Blast Furnace Refractories.** R. M. HOWE. *Bulletin of the American Institute of Mining and Metallurgical Engineers*, 1919, No. 153, pp. 1791-1802.
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- Colloidal Tin-Calcium Aluminate.** A. J. PHILLIPS. *Journal of the American Ceramic Society*, Vol. 2 (1919), No. 9, pp. 708-743.
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- Glucinum: An Introduction Intended to Encourage the Metallurgical and Chemical Development of the Industry.** J. S. NIGRO. *Chemical and Metallurgical Engineering*, Vol. 21 (1919), No. 6, pp. 353-359.
- Leather Belting: Inspection of Leather Belting; Methods for the Determination of Performance and Durability.** H. A. HEV. *Industrial Management*, Vol. 58 (1919), No. 4, pp. 273-281.
- Leather Dyeing: Different Kinds of Tannage; Dyeing Properties of Leather; Formulas for Different Colors.** L. G. HAYES. *Color Trade Journal*, Vol. 5 (1919), No. 4, pp. 108-114.
- Nitrobenzene: Determination of Nitrobenzene in Commercial Nitrobenzols.** CHARLES SIMPSON and W. J. JONES. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 16, pp. 325f-326f.
- Oleic Acid: Formation of Solid Iso-Oleic Acids by the Hydrogenation of Ordinary Liquid Oleic Acid.** C. W. MOORE. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 16, pp. 320f-325f.
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- Potash: The Alsatian Potash Industry.** F. K. CAMERON. *The Chemical Engineer*, Vol. 27 (1919), No. 9, pp. 209-213.
- Potash Recovery at Cement Plants.** A. W. G. WILSON. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 15, pp. 314f-318f.
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- Pulverized Coal for Stationary Boilers.** F. A. SCHEFFLER and H. G. BARNHURST. *Mechanical Engineering*, Vol. 41 (1919), No. 8, pp. 650-652.
- Refrigeration: Industrial Applications of Refrigeration.** C. L. HUBBARD. *Industrial Management*, Vol. 58 (1919), No. 4, pp. 289-294.
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- Silico-Manganese for Steel Castings; Experiences of American Foundrymen in the Use of One Alloy Instead of Two. Advantages and Disadvantages.** E. F. CONE. *The Iron Age*, Vol. 104 (1919), No. 13, pp. 855-857.
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- Sulfuric Acid: Methods of Lifting.** S. J. TUNYAY. *The Chemical Age*, Vol. 1 (1919), No. 12, pp. 326-328.
- Wulfenite: Notes on the Metallurgy of Wulfenite; Source and Importance of Wulfenite; Description of Its Metallurgical Treatment.** J. P. BONARDI. *Chemical and Metallurgical Engineering*, Vol. 21 (1919), No. 6, pp. 364-369.

MARKET REPORT—OCTOBER, 1919

WHOLESALE PRICES PREVAILING IN THE NEW YORK MARKET ON OCTOBER 15, 1919

INORGANIC CHEMICALS

Acetate of Lime, Basis 80%.....100 Lbs.	2.00	@	2.05
Alum, ammonia, lump, U. S. P.....100 Lbs.	4.25	@	4.50
Aluminum Sulfate, (iron free) Works.....Lb.	2 1/2	@	2 1/4
Ammonium Carbonate, domestic.....Lb.	13	@	13 1/2
Ammonium Chloride, white.....Lb.	19	@	20
Aqua Ammonia, 26°, drums.....Lb.	7 1/4	@	8
Arsenic, white.....Lb.	10	@	11
Barium Chloride.....Ton	65.00	@	85.00
Barium Nitrate.....Lb.	12	@	14
Barytes, prime white.....Ton	30.00	@	35.00
Bleaching Powder, 35 per cent, Works.....100 Lbs.	2.50	@	3.00
Blue Vitriol.....Lb.	8 1/4	@	8 1/2
Borax, crystals, in bags.....Lb.	8 1/4	@	10 1/2
Boric Acid, powdered crystals.....Lb.	13 1/4	@	14
Bromine, crude, domestic.....Long Ton	28.00	@	35.00
Bromine, technical, bulk.....Lb.	75	@	
Calcium Chloride, lump, 70 to 75% fused.....Ton	20.00	@	24.00
Caustic Soda, 76 per cent.....100 Lbs.	3.30	@	3.40
Chalk, light precipitated.....Lb.	nominal		
China Clay, imported.....Ton	18.00	@	23.00
Feldspar.....Ton	8.00	@	15.00
Fuller's Earth, foreign, powdered.....Ton	nominal		
Fuller's Earth, domestic.....Ton	20.00	@	30.00
Glauber's Salt, in bbls. Technical.....100 Lbs.	1 1/2	@	1 1/4
Green Vitriol, bulk.....100 Lbs.	2.00	@	2.25
Hydrochloric Acid, commercial, C. P.....Lb.	10	@	11
Iodine, resublimed.....Lb.	4.50	@	4.55
Lead Acetate, white crystals.....Lb.	14	@	15
Lead Nitrate, C. P.....Lb.	85	@	
Litharge, American.....Lb.	9 1/4	@	10
Lithium Carbonate.....Lb.	1.50	@	
Magnesium Carbonate, U. S. P.....Lb.	21	@	22
Magnetite, "Calcined".....Ton	60.00	@	65.00
Nitric Acid, 40%.....Lb.	6.50	@	6.75
Nitric Acid, 42%.....Lb.	7.25	@	7.50
Phosphoric Acid, 48/50%.....Lb.	24	@	26
Phosphorus, yellow.....Lb.	35	@	40
Plaster of Paris.....100 Lbs.	2.00	@	2.50
Potassium Bichromate.....Lb.	27	@	28
Potassium Bromide, granular.....Lb.	1.25	@	1.30
Potassium Carbonate, calcined, 80 @ 85%.....Lb.	24	@	26
Potassium Chlorate, crystals, 98-99 per cent.....Lb.	19c	@	
Potassium Cyanide, bulk, 98-99 per cent.....Lb.	nominal		
Potassium Hydrosulfide, 88 @ 92%.....Lb.	30	@	33
Potassium Iodide, bulk.....Lb.	3.50	@	3.60
Potassium Nitrate.....Lb.	13 1/2	@	16
Potassium Permanganate, bulk, U. S. P.....Lb.	59	@	60
Quicksilver, flask.....75 Lbs.	103.00	@	
Red Lead, American, dry.....100 Lbs.	11.00	@	13.00
Salt Cake glass makers'.....Ton	12.00	@	15.00
Silver Nitrate.....Oz.	73	@	73 1/2
Sesquioxide, in bags.....Ton	10.00	@	12.50
Soda Ash 58%, in bags.....100 Lbs.	2.10	@	2.25
Sodium Acetate, broken lump.....Lb.	6 1/2	@	7
Sodium Bicarbonate, domestic.....100 Lbs.	2.25	@	2.40
Sodium Bichromate.....Lb.	12 1/2	@	13 1/2
Sodium Chlorate.....Lb.	15	@	
Sodium Cyanide.....Lb.	29	@	30
Sodium Fluoride, commercial.....Lb.	13	@	14
Sodium Hyposulfite.....100 Lbs.	3	@	4
Sodium Nitrate, 95 per cent, spot.....100 Lbs.	2.85	@	2.90
Sodium Silicate, liquid, 40° Bé.....Lb.	2 1/2	@	2 1/2
Sodium Sulfate, 60%, fused in bbls.....Lb.	4 1/4	@	5
Sodium Bisulfite, powdered.....Lb.	5	@	7
Strontium Nitrate.....Lb.	25	@	30
Sulfur.....100 Lbs.	3.30	@	3.50
Sulfuric Acid, chamber 66° Bé.....Ton	16.50	@	18.50
Sulfuric Acid, oleum (fuming).....Ton	24.00	@	
Talc, American, white.....Ton	18.00	@	22.00
Terra Alba, American, No. 1.....100 Lbs.	1.25	@	
Tin Bichloride, 50%.....Lb.	18	@	20
Tin Oxide.....Lb.	60	@	63
White Lead, American, dry.....Lb.	8 1/4	@	9 1/4
Zinc Carbonate.....Lb.	18	@	20
Zinc Chloride, commercial.....Lb.	12	@	13

ORGANIC CHEMICALS

Acetanilid, C. P., in bbls.....Lb.	47	@	48
Acetic Acid, 56 per cent, in bbls.....100 Lbs.	5.75	@	6.00
Acetic Acid, glacial, 99 1/2%.....100 Lbs.	12.00	@	12.25
Acetone, drums.....Lb.	13 1/4	@	14
Alcohol, denatured, 180 proof.....Gal.	52	@	53

Alcohol, Ethyl, non-beverage, 190 proof.....Gal.	4.70	@	4.95
Alcohol, wood, 95 per cent, refined.....Gal.	1.33	@	1.36
Amyl Acetate.....Gal.	3.75	@	3.85
Aniline Oil, drums extra.....Lb.	32	@	33
Benzoic Acid, ex-toluol.....Lb.	90	@	1.00
Benzene, pure.....Gal.	36	@	
Camphor, refined in bulk, bbls.....Lb.	3.60	@	3.75
Carbolic Acid, U. S. P., crystals, drums.....Lb.	12	@	
Carbon Bisulfide.....Lb.	9	@	10
Carbon Tetrachloride, drums, 100 gals.....Lb.	11	@	12
Chloroform, U. S. P.....Lb.	30	@	31
Citric Acid, domestic, crystals.....Lb.	95	@	97
Cresosote, beechwood.....Lb.	2.00	@	2.10
Cresol, U. S. P.....Lb.	17	@	18
Dextrine, corn (carload, bags).....Lb.	9	@	9 1/4
Dextrine, imported potato.....Lb.	17	@	17 1/2
Ether, U. S. P. 1900.....Lb.	23	@	24
Formaldehyde, 40 per cent.....Lb.	24	@	24 1/2
Glycerin, dynamite, drums extra.....Lb.	20	@	
Oxalic Acid, in casks.....Lb.	24	@	25
Pyrogallol Acid, resublimed, bulk.....Lb.	2.37 1/2	@	
Salicylic Acid, U. S. P.....Lb.	50	@	
Starch, corn (carload, bags) pearl.....100 Lbs.	5.77	@	6.02
Starch, potato, Japanese.....Lb.	9 1/2	@	10
Starch, rice.....Lb.	24	@	25
Starch, sago flour.....Lb.	9 1/4	@	10
Starch, wheat.....Lb.	9	@	
Tannic Acid, commercial.....Lb.	60	@	65
Tartaric Acid, crystals.....Lb.	73	@	75

OILS, WAXES, ETC.

Beeswax, pure, white.....Lb.	62	@	63
Black Mineral Oil, 29 gravity.....Gal.	20	@	22
Castor Oil, No. 3.....Lb.	18	@	18 1/2
Ceresein, yellow.....Lb.	16	@	17
Corn Oil, crude.....Lb.	18	@	18 1/2
Cottonseed Oil, crude, f. o. b. mill.....Lb.	19.00	sales	
Cottonseed Oil, p. a. y. Nov. option.....100 Lbs.	22.80	@	22.85
Menhaden Oil, crude (southern).....Gal.	1.10	@	
Neat's-foot Oil, 20°.....Gal.	2.25	@	
Paraffin, crude, 118 to 120 m. p.....Lb.	7 1/2	@	8
Paraffin Oil, high viscosity.....Gal.	38	@	40
Rosin, "F" Grade, 280 lbs.....Bbl.	18.50	@	18.60
Rosin Oil, first run.....Lb.	88	@	89
Shellac, T. N.....Lb.	nominal		
Spermaceti, cake.....Lb.	31	@	33
Sperm Oil, bleached winter, 38°.....Gal.	1.95	@	1.97
Spindle Oil, No. 200.....Gal.	38	@	40
Stearic Acid, double-pressed.....Lb.	29	@	29 1/2
Tallow, acidless.....Gal.	1.65	@	
Tar Oil, distilled.....Gal.	58	@	59
Turpentine, spirits of.....Gal.	1.69	@	1.70

METALS

Aluminum, No. 1, ingots.....Lb.	33	@	
Antimony, ordinary.....100 Lbs.	8 1/2	@	8 1/2
Bismuth, N. Y.....Lb.	nominal		
Copper, electrolytic.....Lb.	22 1/2	@	23 1/2
Copper, lake.....Lb.	22 1/2	@	24
Lead, N. Y.....Lb.	6.15	@	6.45
Nickel, electrolytic.....Lb.	55	@	56
Platinum, refined, soft.....Oz.	130	@	135
Silver.....Oz.	1.18 1/2	@	
Tin.....Lb.	54 1/4	@	55 1/2
Tungsten (WO ₃).....Per Unit	6.75	@	7.25
Zinc, N. Y.....100 Lbs.	7.75	@	7.80

FERTILIZER MATERIALS

Ammonium Sulfate.....100 Lbs.	3.75	@	
Blood, dried, f. o. b. New York.....Unit	7.35	@	
Bone, 3 and 50, ground, raw.....Unit	40.00	@	
Calcium Cyanamide.....Unit of Ammonia	5.15	@	10.00
Calcium Nitrate, Norwegian.....100 Lbs.	—	@	
Castor Meal.....Unit	—	@	
Fish Scrap, domestic, dried, f. o. b. works.....Unit	6.60	@	10.00
Phosphate Rock, f. o. b. mine.....Ton	nominal		
Florida land pebble, 68 per cent.....Ton	nominal		
Tennessee, 78-80 per cent.....Ton	nominal		
Potassium "muriate," basis 80 per cent.....Ton	nominal		
Pyrites, furnace size, imported.....Unit	16 1/4	@	17
Tankage, high-grade, f. o. b. Chicago.....Unit	6.75	@	10.00

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EDITORIALS

A MISSION, A NEAR FAILURE, AND ULTIMATE SUCCESS

We have had a holiday; our readers have had a two months' relief from the usual outpouring in this section of the JOURNAL, while we have had opportunity to get a broader vision by actual presence on the scenes where so vital a chapter of the world's history has been written. But it is good to be back, back in that land of lands which we call our own.

Why did we forsake our post? Last August the shortage of vat dyes became very acute; American manufacturers of dyes were not yet ready to supply the home market, so the War Trade Board Section of the Department of State decided to grant licenses for imports of vat dyes of enemy origin in quantities sufficient to cover consumers' needs for six months. The experience of France, Belgium, and Italy in securing limited supplies of German dyes suggested that American consumers might also be supplied, possibly through the Committee on Organization of the Reparations Commission and from the stocks of dyes being held in Germany to meet the terms of the Treaty of Peace. Under Annex VI of the Treaty the Allies are given an option to buy 50 per cent of the existing stocks of dyes within sixty days after the proclamation of the ratification of the Treaty, and for five years thereafter will have an option on 25 per cent of the total amount manufactured, the option to be exercised at six-month intervals.

With the approval of President Wilson and upon the solicitation of the president of the Chemical Foundation, Inc., we undertook the work of ascertaining in what manner, and by what machinery this six months' supply could be obtained, fully conscious of the irony of the situation. On the day of arrival at Paris an important interallied conference was being held in London, and there it was decided to invite the German manufacturers to a conference at Versailles to arrange for a partial release of stocks. If this proposal was agreed to, France, Belgium, and Italy were to withdraw not more than 2200 tons of dyes, with the further provision that not more than 30 per cent of the 50 per cent of each color was to be withdrawn. The United States and Great Britain were to have the privilege of withdrawing not more than 1500 tons each, under the same conditions, thus giving the right to not more than 20.45 per cent of the 50 per cent of each color. Later, in order to insure the participation of the Germans in the conference, for it was not a matter of treaty enforcement but of joint agreement, it was decided to offer to the Germans the release for free sale, from their half of the stocks, of a quantity corresponding to the kind and amount of each dye taken by the Allies. The proposal brought the Germans to Versailles for a preliminary conference with representatives of the Allies on October 2, 1919.

A few days before the conference took place information as to the total poundage required by our con-

sumers was cabled. It was immediately evident that only about 30 per cent of these needs could be provided for under our percentage share of each dye. To supplement this and to complete the block it was determined to seek a direct offer from the Germans to supply the balance from their released stocks, or by immediate manufacture.

On October 4, 1919, the conference was held at Versailles, M. Mauclere, of France, presiding for the Allies, Herr Dr. C. von Weinberg, the present head of the kartel acting as chairman of the eight representatives in the German group. The outcome was satisfactory to all parties concerned. Immediately after adjournment we held a personal conference with Dr. von Weinberg and secured from him, after his consultation with his associates, an offer to complete American needs at prices for each dye to be reckoned by dividing by four, in the case of vat dyes, the price per kilo in marks on the inventory list of August 15, 1919. The quotient represented American dollars per kilo. In the case of general colors the divisor was to be five.

With this proposition we returned to Paris, happy in the thought that the mission which had taken us to Europe was finished. To complete the transaction there remained only the transmittal of the proposals to the consumers at home, and, if they met approval, to have a representative leave America at once, provided with purchasing authority and funds.

As quickly as possible a cable was prepared giving the details. While it was being typewritten a messenger handed us a cable containing the information that on October first the allocation cards had been given out to consumers with authorization to import through any commercial channel.

The split among consumers as to methods of importation brought utter confusion into the situation, and from a quarter least expected, for we had been told before leaving home that the vat dye consumers would be organized into an association which would purchase the dyes, and that the dyes would be handled as a block proposition. We could not tell how great would be the split among consumers or on what basis we could further work. One thing was certain: Delay in receipt of the dyes would inevitably ensue so far as the consumers were concerned.

As the days passed the situation seemed to become worse, though meanwhile the Textile Alliance had been designated as the agency through which the reparation dyes would be imported. We gave up hope and started the journey home bluer than the purest indanthrene.

At the end of the thirteen-day voyage we were met at the gang plank of the ship by a representative of the Textile Alliance, and received the news that harmony and uniformity again prevailed, that assignments of allocation certificates to German importing agencies had been cancelled by consumers, and that they had united

upon the Textile Alliance as the sole medium of importation. Some greeting that! There had been unexpected and unnecessary delay, but there could now be no doubt of an early and successful termination of the whole matter. And so it turned out, for in a few days a meeting was held, as a result of which a message, which must have taxed the capacity of the cables, was sent by the Alliance to its European representative, ordering the dyes.

THE BATTLE IS ON

"Unless the spirit of independence is dead in the hearts of Americans, our people will never be satisfied until the American dye industry has been developed to a point where it can take care of every American need and stand as a bulwark of reserve for any future conflicts in which our nation may be compelled to engage." This was the remark we made to the vice president of the Textile Alliance as we left the offices of the Badische Anilin und Soda Fabrik at Ludwigschafen on October 30. His instant agreement with the sentiment, in words much more picturesque and emphatic than we had used, convinced us that we had read aright the signs of the times evidenced during the two-hour interview we had just had with the high officials of that greatest of all German dye manufacturing establishments.

On the previous day we had had a very pleasant meeting at Frankfurt with Dr. C. von Weinberg, the head of the German dye Kartel, and were beginning to feel that after all matters were shaping nicely. We proceeded to the Badische plant in a comfortable mood. But the first few moments of the interview with the officials of that plant brought out from Director Krell the volunteered information that the lines had broken at home, that already he had in hand orders from individual consumers with authority from the United States Government to ship through their American agents to the consumer. "Cocky" is the only word to describe the attitude of the director. He had no desire to discuss any matter in which we were interested, but with characteristic German psychology he endeavored at once to secure our assistance in persuading our Government that this whole matter could and should be handled only through the American agents of the German dye works. "Yes," he said, "We are going to get back our old business in America, and through the medium of our former agencies. This is the only way it should be done, and this is the way it will be done." The remark was so illuminating that we asked him to repeat it, which he did.

There we sat listening to this statement in the offices of the chief plant of that great combination of manufacturers whose former control of our dyestuff supplies had led von Bernstorff to suggest to the Kaiser that through shutting off these supplies he could throw four million Americans out of employment; perhaps in the very room where millions of dollars had been voted to corrupt American industrial life; and near

the spot where tons of material had been produced for poison gas by whose deadly action many a gallant doughboy had "gone west" and now slept beneath French soil. Smoke was pouring from all but two of the many tall stacks of that establishment. The industrial war was on; the words of Director Krell left no doubt about that.

The same supreme confidence characterized the industrial German as had been recorded of the military German in his first advance through Belgium, the same utter contempt shown of American capacity to do things as was shown during 1917. But 1918 showed that the German had missed his guess and we make the prediction that he has missed again. Only one thing is needed to insure the correctness of that prediction, namely, that the mass of our people understand just what the situation is. To that understanding we are confident the American press will continue to contribute, as it has already done so splendidly during the past three years. That understanding will reflect itself in sympathetic protective legislation and time will do the rest, for the American chemist needs only time to forge the missing links in the chain of a complete self-sustained American dye industry.

In the commercial struggle that is now on, the way is not plain sailing for the German manufacturer. In addition to what Americans have already accomplished and are determined to complete, the German faces a winter in which the coal supply is destined to prove a more serious obstacle to contend with than was the food problem resulting from the blockade. Transportation problems are also very acute, though the Rhine will furnish the natural transportation for dyes to Rotterdam if the winter rains come early enough to restore the volume of water in the river, now so low as to require light loading of the steamers and barges which carry so much of German commerce. Finally, the German is badly worried over the situation created by the seizure of those patents by which he had throttled American industry for so many years. He signed the Treaty of Peace, agreeing that these seizures were valid, but already he is beginning to whine and to try carefully to manufacture sentiment against the splendid work in behalf of American commercial freedom so courageously carried out, under the authority of Congress, by the Alien Property Custodian.

In spite of these handicaps the German dye manufacturer is strong to-day. His plants are even greater than before the war, the personnel of those plants is practically intact, large stores of material are accumulated and he is determined to regain his markets.

It would be foolish to belittle the German's ability or his fighting strength, but in the light of the accomplishments of the past four years, and indeed of the brilliant achievements during the short period of our absence, our mind turns back with supreme confidence in the correctness of the prediction of the Swiss professor who twenty years ago said to us, "The natural house of the dye industry is America, and some day it will be there." Speed the day, oh ye chemists of America!

HOT AIR—BUT WHY?

Life has its surprises; and one of these which greeted our return to the editorial office was a mass of clippings setting forth in flaring headlines the views of Mr. Irving A. Keene, of London, as to the present very limited supplies of stocks of German dyes, based upon a survey which he made during a September visit to the German dye plants.

Honesty compels the admission that at first sight of these clippings we laughed heartily, because of the memories of an evening spent with Mr. Keene in Paris. A closer reading of the clippings, however, showed that the material had been put out by the American Chamber of Commerce in London, and had received its official sanction and endorsement. Furthermore we learned yesterday that copies of this matter had been put into the hands of members of the U. S. Senate, and that much importance was attached to these views.

The matter had thus taken on a much more serious aspect than we had ever dreamed possible. In the interest of truth, let us narrate the story of that evening in Paris.

While in London on September 16 and 17 we had heard of a group of Americans in Berlin, representing the American Chamber of Commerce. This was very interesting. Returning to Paris, we looked up the Commercial Attaché of the American Embassy to learn, if possible, more details about this pilgrimage. To our surprise we found that the "group" consisted of one man, Mr. Irving A. Keene.

Then on September 26, 1919, there appeared in the Paris edition of the *Chicago Tribune*, under conspicuous headlines, a dispatch from Berlin, covering an interview with Mr. Keene, in which he set forth at length how limited was the supply of German dye stocks, as based upon his personal survey, and how little prospect there was of the dumping of German dyes.

The interview was extremely important, if the facts were correct, for the lists of these stocks furnished by the Germans themselves, and our knowledge of the extent of licenses for the sale of daily output granted by the Interallied Rhineland Commission, did not indicate any such paucity of stocks as Mr. Keene proclaimed. The inference was that if Mr. Keene was correct in his estimate, surreptitious leakage of these stocks was taking place rapidly. We determined to investigate, to go into the Rhineland, to consult with the Commissioners and to get the facts through any available channel. While completing passport arrangements for the trip, our Commercial Attaché informed us by telephone that Mr. Keene was in Paris. Later in the day we were introduced to Mr. Keene, and after a few words of greeting we invited him to dinner that evening, for the stated purpose of discussing his experiences in Germany. At eight o'clock we dined at the Café Boeuf à la Mode.

Mr. Keene was a delightful dinner companion, but within ten minutes we were convinced that his views about German dye matters were not worth a tinker's dam. However, we wanted that opinion confirmed by positive and definite statements from

Mr. Keene, so we sought by many questions to draw him out. Space does not admit of a detailed narration of that conversation, but all connected with the dye industry can judge Mr. Keene's competence by two bits.

Replying to a request for details concerning dyes being manufactured by the Bayer Company, after somewhat exhaustive efforts with generalities which had no meaning, he finally ventured the suggestion that the company was manufacturing some colors whose name sounded like "algerole."

Having completed the journey through the lower Rhine region without eliciting any definite information, we moved with conversational steps higher up the river in the hope that recollection of experiences there might be more definite. Many stories were told, but again no definite data and no description of plants visited. The evening was drawing to a close; we began to press matters. The word "Badische" had not been mentioned, so we asked: "What about the Badische plant?" That was a strange word which brought forth no intelligent gleam. We explained in detail the importance of that plant in Germany's dye régime and the manifold character of its products. Suddenly Mr. Keene broke in and explained that that plant was over to the right, and there was a little railroad that ran off to it, but that he had passed the junction point and did not have time to go back when he learned of it. That finished us. We didn't know anything about the junction point, but we did know where Mr. Keene got off as a dye expert, and how much reliance was to be placed on his views of the status of the German dye industry.

However, we still wanted a definite statement about those stocks, so as we walked up the Rue de Rivoli, we put a question so direct to Mr. Keene it could not be evaded, and in reply he frankly stated that he had gone through no warehouses, as there would have been no use in it, for, as he explained, he would not have known a dye from a soap box. There, we had it at last!

A GOOD SIGN

One of the most joyful sights that greeted us on returning was a large sign conspicuously placed in one of the most crowded portions of New York City, bearing the inscription:

WANTED

1000 MEN FOR THE CHEMICAL WARFARE SERVICE
ENLISTMENT FOR ONE OR THREE YEARS

That sounded like business. Evidently we are on the road to an Army which will be provided and equipped with all that is modern in war developments.

This feeling was strengthened by the good news received in Washington that it is the opinion that members of Congress are practically unanimous in their determination that there should be a Chemical Warfare Service as an independent unit and provided with every facility.

CONTRIBUTIONS FROM THE CHEMICAL WARFARE SERVICE, U. S. A.

ANTI-DIMMING COMPOSITIONS FOR USE IN THE GAS MASK^{1,2}

By P. W. CARLETON

Received August 9, 1919

As long as the gases used in warfare affected only the respiratory organs, a gas mask needed only to protect those organs, and the main question was one of absorbents. When lachrymatory gases were used the eyes needed protection and the situation then became such that a complete protective unit was necessary. With this enlarged function a gas mask necessarily became a more complicated piece of apparatus. Researches were undertaken by the warring nations to simplify and improve the masks. When this country entered the war, each nation had its own type of mask and the United States Army adopted the type which the English were using.

Good vision was one of the most important properties of the gas mask. The following data obtained by A. L. Keller indicate that a mask seriously limited the field of vision of the wearer, and show the improvement in the later type of mask. The masks named are: old SBR, an early model of the mask used by the American forces practically entirely, although made in several styles closely resembling one another; the old type French mask (M_2) used by the French until the last year of the war; the newer American mask (Tissot) modeled on the principle of the French Tissot mask. The total width of the field of vision, in degrees, the width of that part of the field seen by both eyes (binocular), and the extent of the downward vision, also in degrees from the horizontal, are shown in the following table:

TABLE I—FIELD OF VISION AS AFFECTED BY GAS MASKS

	Total Width of Vision Degrees	Binocular Vision Degrees	Downward Vision Degrees
Old SBR Mask.....	60	50	30
French (M_2).....	80	50	35
Akron Tissot.....	120	50	40
Naked Eye.....	190	120	65

The field of vision was, therefore, being enlarged in the newer types of mask, but restriction of the field of vision was not the only way in which vision was limited. Because ordinary glass lenses were not safe and the safety glasses could not be manufactured in sufficient quantity on such short notice, lenses of celluloid had to be used. These scratched easily, thus making the vision poorer. Experiments conducted at the American University Experiment Station showed the effect of poorer defining power of eyepiece materials on efficient use of vision. Rifle sighting (not shooting which involves other factors), color discrimination and

tests involving coordination of vision and motion showed that these functions were not seriously affected in good light by decreased defining power of a lens until the lens had a defining power, as measured by a reading chart, of about 40 per cent. Similar experiments at different degrees of low illumination showed that in poor light the defining power of an eyepiece was very important, and one could not afford to sacrifice this at all. Since much work at the front was performed at night obviously the masks should be provided with a material which would not scratch. As fast as possible, therefore, safety glass eyepieces were being made the entire production for gas masks.

For a very considerable time the most serious vision difficulty was not that of scratching the lens, or even the limitation of the field of vision by the mask, but rather the elimination of vision by the fogging or dimming of the lens by droplets of moisture condensing on the inside surface.

Before discussing the various solutions of this difficulty which were attempted, it should be noted that the conditions were not identical in the different types of mask. In general, masks may be divided into two classes, as follows:

1—Masks having an unventilated facepiece, such as the English and American box respirators.

2—Masks having a ventilated facepiece, such as (a) the early French (M_2) and the German masks in which the air entered and passed out through the same path, and (b) the Tissot type masks in which the air passed out by a different path than it entered.

The dimming problem of the German and early French (M_2) masks resembled that of the unventilated masks more closely than it did that of the Tissot masks. This was because the exhaled breath saturated with moisture passed through the same path, absorbent included, as the air entered on inhalation so that this path soon became saturated with moisture and then the inhaled air became loaded with moisture and could not evaporate it from the eyepieces.

The masks used by the American forces were unventilated. The moisture condensing on the fabric and lenses was due to evaporation from the eyes and skin plus any due to breathing into the facepiece, as when talking while wearing the mask. The amount of moisture thus distilled from the face of an active man was very appreciable. The large amount of this water made it impossible to dry the atmosphere in the mask and thus lower the dew-point so that no fogging of the lens could take place. The early French (M_2) and German masks caused more moisture to condense on the lenses than did the English or American box respirators because in them the lenses were affected by the moisture of the breath in addition to that evaporated from the face and eyes.

Since the clouding of the eyepieces occurred because the temperature of the lens was below the dew-point

¹ The work outlined in this report was carried out either by or in co-operation with the Eyepiece Unit of the Defense Section of the Research Division of the Chemical Warfare Service at the American University. This article has been approved for publication by Major-General William L. Sibert, Director of the Chemical Warfare Service, U. S. A.

² The following men of the Eyepiece Unit participated in this work and each has contributed to it: F. F. Berg, H. K. Cummings, K. Flynn, W. S. Hughes, A. L. Keller, L. W. Nichols, C. N. Richardson, L. D. Smith, G. W. Wilson, T. H. Woodside.

of the atmosphere within the mask, prevention of dimming could be accomplished (a) by raising sufficiently the temperature of the lenses, (b) by lowering the dew-point of the atmosphere within the mask, (c) by using a material for the lens which would absorb water, (d) by the use of such a material that water condensing on it would form a thin transparent film instead of droplets. Obviously, combinations of these methods are possible. Following a suggestion of Dr. A. B. Lamb an American box respirator was modified by Dr. W. L. Argo, who died a Lieutenant in the Chemical Warfare Service, so that dimming did not occur, by using a combination of the first two methods mentioned above. This mask was not developed for production.

The last method was the one used during the war by the American forces. The first material intended to prevent clouding of the eyepieces was far from satisfactory, and its improvement was undertaken by the American University Experiment Station and was only part of the problem of the betterment of the vision properties of the mask, a problem which was continuously shifting with change in style of mask.

Some of the requirements which a satisfactory anti-dimming composition had to meet were as follows:

It must be soluble in water and reduce the surface tension of water so that moisture would not form drops on the lens.

It must be easy to apply.

Its method of application must be "foolproof," so that, if possible, an unsuccessful application would be impossible.

One application of it must last a long time, several hours of consecutive use.

It must function properly several days after its application.

It should be put up in a convenient outfit which should have but few parts and should not be fit for other uses. Obviously the unit should be cheap.

METHODS OF TESTING

The final test of any composition was its use in masks worn in a cold room. Out of doors conditions were more severe at the same temperature due to the wind, but as they were not reproducible the rooms were used for all but the large tests.

Several machines were made to imitate mask conditions, for instance, boxes having warm moist air on one side of the eyepieces and cool air (or water) on the other. These devices were satisfactory for rough results only. They were used in testing moisture-absorbing eyepiece materials, cellulose and gelatin. The difficulty of reproducing data on consecutive tests and even at different positions in the same test pointed to the non-uniformity of moisture conditions and flow of the air at the testing positions. Many attempts were made to eliminate this trouble. Two machines were built by the Eastman Kodak Company for testing the gelatin eyepieces which it was developing. These machines were altered (one in Rochester, the other by C. N. Richardson in Washington) and the final forms were identical in principle. The materials to be tested were held in holes in a disc which revolved slowly so that each lens could be examined with the disc in motion. Warm, moist air was on one side of the disc and cold air on the other. The temperatures

were maintained by circulating the air by vacuum cleaner motors, the warm air bubbling through water heated to the desired temperature, and the cold air passing through coils of pipe in ice. These machines were not satisfactory until they were modified to have the revolving disc. All attempts to make a machine capable of testing several lenses at once which operated by holding the lenses stationary, and controlling the temperature and velocity of the air passing them gave variable results both for different positions in the same run and for the same positions in different runs. It was necessary to have every lens traverse the same path to be subject to identical conditions. With this type of machine results were reproducible within the variation of the material being tested.

Because of the lack of a satisfactory mechanical test only a few such tests of anti-dimming compositions were made. Materials showing promise were given mask tests by an experienced squad at different temperatures in cold storage rooms.¹ The men of this squad deserve great credit for four months of tedious, disagreeable work. There was considerable advantage in having such experienced men available for criticism of the different materials which were tested as in this way different points of view were obtained. In these tests both the old French (M_2) and the American box respirator (SBR) masks were used. The French mask was preferred since it gave a more severe test of the material and was more comfortable.

It is improbable that the man test of these materials could be entirely eliminated as the psychological side of their use by all sorts of men under widely varying conditions would require some experimental study. A few large tests, perhaps one, would give this information if a satisfactory machine test were available.²

THE SEARCH FOR AN ANTI-DIMMING COMPOSITION

The study of anti-dimming compositions was undertaken in cooperation with Dr. H. M. Ittner, of Colgate and Company. Experimental preparations were made in their laboratories for a month or more until it was possible also to prepare samples at the American University Experiment Station. All testing was done in Washington.

One of the early ideas, and one which was suggested by many persons, was that the true function of an anti-dimming composition was to clean the lens, and that moisture would condense as a transparent film on such a surface. This was not the case even with glass. It is true that we did not go to extreme lengths in cleaning the surfaces of lenses but it would be impossible to guarantee clean surfaces for lenses of masks being worn at the front.

The chief difficulty with the anti-dimming composition being manufactured at that time for the Army was the danger of rubbing it all off the lens. This

¹ The Central Market Cold Storage Company of Washington allowed the use of its rooms for this purpose.

² An apparatus for this purpose is described by H. N. Holmes in the following article. If this device were tested, using gelatin lenses in the different positions, it is not to be doubted that there would be marked differences in the conditions at different positions, but that does not mean that it might not be useful for testing anti-dimming compositions, if many tests were made.

preparation, called the "paste," consisted of chalk, water, glycerin, and soap. The chalk made it opaque, so that one was compelled after placing some of it on the lens to rub most of it off and clean the lens in so doing. The instructions for the use of this material were printed on the containers as follows:

Wipe the inner surface of the eyepieces of the box respirator or sponge goggles until clean and dry. Apply a little of the composition from the tube to the cleaned surface, rub it in with the finger, then polish gently with a soft rag until the eyepiece is clear. Do not use the mask material for polishing.

The criticism of this composition was not that it never gave perfect results, but that even a trained man could not guarantee that his application would be any improvement over none at all. This statement is based on the actual performances of the testing squad not once but many times in the course of more than three months. The failures occurred with every individual of the squad. An improvement in the wording of the directions was suggested, but was not put into effect as the contract for such of these units as had not been manufactured was cancelled, because it was evident that a much better composition would be very soon available.

The experiment was tried of applying the soap dissolved in volatile solvents so that no rubbing would be necessary. This idea also was a common thought both in the Unit and outside of it. While there is some doubt as to the desirability of this method of application, the failure to prevent dimming in the tests was undoubtedly largely due to the fact that the anti-dimming composition had to be used on celluloid lenses, as a large proportion of the gas masks at this time necessarily had such lenses and the prevention of dimming on celluloid was much more difficult than on glass. Even in the summer of 1918, months after this question had been left behind, any routine testing of material suggested for the prevention of dimming was made with celluloid lenses to avail ourselves of the experience already gained, and because the test was more severe, and gave more definite results. All our work had shown that if a material prevented dimming on a celluloid lens it would do so on glass. This made it unnecessary to make all the tests with both materials, but many tests were made using glass lenses. Whether the later type of soaps dissolved in a volatile solvent would have successfully prevented dimming was not tried, as on repeated application the solvent etched the surface of the celluloid.

Another idea which failed to give the expected favorable results was that glycerin in large amounts would be beneficial. Alone it did not prevent dimming, and a soap containing about 25 per cent was not good. It was recognized that some glycerin was desirable.

The use of soap-impregnated paper rings to be used as washers and clamped into the eye cup with the lens was not successful.

The earlier compositions tested included:

Anti-dimming paste, the material manufactured for the Army. "Fog Killer," a commercial preparation for keeping an automobile windshield clear from rain drops, which was early suggested for use in the gas mask.

Several special commercial soaps, to see whether something already on the market would be efficient.

Experimental preparations made by Colgate and Company to investigate the effect of solubility of the soap on its efficiency in the prevention of dimming, potassium oleate as well as acid soaps, and soaps containing added glycerin.

The composition made by leaving out the chalk in the anti-dimming paste was also tried.

In the Washington laboratory soaps were made from cottonseed and coconut oils with soda and with sodium and potassium hydroxides mixed, neutral soaps, those with excess of alkali and those containing added glycerin. All these compositions were unsatisfactory. They were not all of the same grade, but none was sufficiently desirable to substitute for the one already in use.

The suggestion had been made that the failure of anti-dimming compositions was due to carbonic acid in the mask atmosphere setting free the fatty acid and so making the composition useless, and that the use of the soap of a strong acid, Turkey red oil soap for instance, would solve the problem. It is not possible to accept this explanation of the failure of these compositions, but the material suggested proved to be the best so far obtained.

In cooperation with the American University and the Gas Defense Service samples were made according to the following directions by Colgate and Company, A. Klipstein and Company, and the Southern Cotton Oil Company:

To 100 cc. of 50 per cent Turkey red oil add 10 g. of dry sodium carbonate, stir in well and heat on water bath until it forms a hard mass on cooling.

These directions are for the product called No. 7, and the other, called No. 9, is the same except that 3 cc. of thick paraffin oil (as used medicinally) are added.

At the time it was supposed that the Southern Cotton Oil Company used sulfonated cottonseed oil, hence the designation in the data given later, but it was subsequently learned that they had purchased and used sulfonated castor oil as they did not manufacture sulfonated oils. A. Klipstein and Company prepared samples from both sulfonated castor oil and sulfonated corn oil. The Washington laboratory also used both these oils. The products obtained from the different sources using identical directions varied from two per cent to 30 per cent moisture, and from a thin paste to a hard mass.

When materials tested were all poor the result of the test was merely the rejection of the composition, but these preparations all proved to be much more satisfactory and it became necessary to differentiate between such preparations. In order to accomplish this, the results of each test were reported in writing, including quantitative measurement of vision for each eye at different times during the test and the general description of each lens, how much it was fogged, how badly, etc. These reports were examined by one man, who gave the result for each lens a letter grade which applied to the anti-dimming composition used. The grade "failure" meant that at some time during the test, lasting always at least an hour, the eyepiece was badly dimmed over two-thirds of its area. "Excellent"

meant that the vision through the lens was not harmed at all as shown by the reading chart tests. Numerical values were assigned to the grades, and the average value for each preparation was calculated and called its index number. The following table shows the index numbers obtained in some of the preliminary work. All samples labeled "W" were prepared at the American University by T. H. Woodside.

TABLE II—INDEX NUMBERS OF ANTI-DIMMING COMPOSITIONS

MATERIAL	NO. OF TESTS	NO. OF FAILURES	INDEX NO.	CONSISTENCY
Cotton 9.....	5	0	9.6	Hard
Cotton 7.....	7	0	9.4	Hard
E-7.....	14	1	9.0	Very hard
Corn 7.....	25	0	8.7	Soft
L-8.....	18	1	8.7	Thin paste
Corn 9.....	19	1	8.2	Soft
Castor 7.....	21	2	8.1	Soft
I-7.....	20	1	8.1	Thin paste
E-9.....	11	2	7.3	Very hard
"Paste".....	38	12	5.5	Thin paste
W-4.....	10	0	9.6	Rather hard
W-6.....	11	0	8.0	Rather hard
W-5.....	38	0	8.6	Hard

NOTE.—E-7 contained 4 per cent moisture; Corn 9, 33.5 per cent moisture; and E-9 only 2.3 per cent water. These are all, save "Paste," Turkey red oil preparation.

These results showed that compositions made from the sulfonated oils were far better than the material being furnished the Army, and it was necessary to obtain knowledge for the specifications for the new compositions.

EFFECT OF VARIATION IN COMPOSITION

The effect of variation of the amount of alkali was investigated and the following data were obtained.

TABLE III

SAMPLE NO.	NaOH G.	NO. OF TESTS	NO. OF FAILURES	INDEX NO.
W-38.....	0	10	1	7.2
W-39.....	5	8	1	7.3
W-40.....	10	10	0	9.0
W-41.....	15	10	0	8.0
W-42.....	20	12	0	9.7
W-43.....	30	10	0	8.8

In every case the soap was made from 100 g. of 85 per cent Turkey red oil bought on the open market and 5 g. of water glass (sirup) plus the amount of caustic soda given in the table. The mixture was warmed on the water bath to evaporate the excess water.

These results indicated that at least ten parts of caustic soda should be used and that twenty were better. Since the composition was to be used on celluloid it seemed better to avoid a large excess of alkali, although such a soap made with fifteen parts of sodium hydroxide did not visibly etch celluloid in three days' exposure to air, even when moistened occasionally.

It was tentatively decided to use ten parts of caustic soda but this was increased to fifteen parts, on the basis of the following data and also of machine tests in which the composition containing only ten parts of soda gave unreliable results. The data for W-38 and W-39 are repeated for comparison.

TABLE IV—SHOWING UNRELIABILITY OF COMPOSITIONS WITH INSUFFICIENT EXCESS OF ALKALI

SAMPLE NO.	PARTS Na ₂ CO ₃ PER 100 PARTS OIL	NO. OF TESTS	NO. OF FAILURES	INDEX NO.
W-6.....	19	11	0	8.4
W-11.....	9	2	2	8.3
W-8.....	9	22	4	6.0
W-3.....	9	15	4	5.9
W-9.....	9	23	11	3.6
PARTS OF CAUSTIC SODA				
W-5.....	5	38	0	8.6
W-13.....	7.5	20	0	8.9
W-38.....	0	10	1	7.2
W-39.....	5	8	1	7.3

The results should be taken to indicate not that the use of sodium carbonate is undesirable, but that if no excess of alkali is present the composition is unreliable. The oil used had an apparent saponification value, *i. e.*, including the free acid present, of 67 mg. caustic soda (89 mg. anhydrous sodium carbonate) per gram.

The fact that W-5 proved to be an excellent anti-dimming composition indicates that the excess of alkali is not the only reason for the excellence of these soaps, but that the nature of the oil is a factor. Samples of neutralized Turkey red oil, called alizarine oil, submitted by A. Klipstein and Company, gave less satisfactory results, but no index number was calculated. Sulfonated corn oil was used in the preparation of W-9 instead of sulfonated castor oil, but the poor quality of the product was not attributed to the corn oil but rather to the low alkali content, for this oil required alkali more than did the sulfonated castor oil. The apparent saponification value for the corn oil was 105 mg. anhydrous sodium carbonate per gram. Evidently in this preparation the oil was not completely saponified.

To determine whether the use of water glass was beneficial, the following series of samples were tested. All the samples were made from 100 parts of 85 per cent sulfonated castor oil and 15 parts of caustic soda. It was decided to use five parts of water glass.

TABLE V—EFFECT OF WATER GLASS

SAMPLE NO.	WATER GLASS SYRUP CC.	NO. OF TESTS	NO. OF FAILURES	INDEX NO.
W-30.....	0	10	0	9.2
W-31.....	2	10	0	9.8
W-32.....	5	12	0	9.5
W-33.....	10	12	0	9.7

Another series of samples was made to test the desirability of the use of paraffin oil, "Nujol" was used. These were all made from 100 parts of the 85 per cent oil, 15 parts caustic soda, and 5 parts water glass.

TABLE VI—EFFECT OF NUJOL

SAMPLE NO.	PARTS NUJOL	NO. OF TESTS	NO. OF FAILURES	INDEX NO.
W-34.....	0	14	0	8.4
W-35.....	2	8	0	8.0
W-36.....	5	10	0	9.2
W-37.....	10	8	0	9.8

These data indicated that the use of paraffin oil was desirable. This was, perhaps, due to the fact that celluloid surfaces were being used.

Duplication of preparation was important. The following samples were tested, the data for most of which have been given, but they are repeated in Table VII to indicate the reproducibility of such preparations. These samples were all made using 100 parts Turkey red oil, 15 parts NaOH, 5 parts water glass, and no Nujol.

TABLE VII—REPRODUCIBILITY OF GOOD MATERIAL

SAMPLE NO.	WATER PER CENT	NO. OF TESTS	NO. OF FAILURES	INDEX NO.
W-32.....	22.8	12	0	9.5
W-34.....	21.8	14	0	8.4
W-41.....	1.7	10	0	8.0
W-44.....	0.7	10	0	8.8

The index number obtained for sample W-41 is low. It will be noted that this sample fits poorly into Table II, also. The reason for this rather low value is not known. The variation shown by the index numbers in Table VII was rather greater than was

expected, but as the value 9.5 was unexpectedly high, the average was satisfactory. Even the minimum, 8.0, represented a very much better product than the paste then being manufactured. The attempt to attribute the low value for sample W-41 to its dryness was unsuccessful, as W-44 contained even less moisture. These results showed that the amount of moisture present in the preparation was unimportant. This was to be expected from the method of use. In order to avoid scratching the celluloid lens in applying the composition, it was felt that considerable moisture should be present, especially as the material tended to become hard when too dry. Although these series of preparations were made from the same sample of commercial Turkey red oil, three samples purchased at different times were used in making compositions which gave satisfactory results. Commercial samples of this oil from different manufacturers were analyzed by T. H. Woodside with the following results:

SAMPLE	COMMERCIAL STRENGTH PER CENT	WATER PER CENT	TOTAL ACIDITY MG. NaOH	APPARENT SAPONIFICATION MG. NaOH
	OIL			
A.....	75	23.2	37	62
B.....	75	23	45	62
C.....	85	19	42	67

W. S. Hughes studied the sulfonation of castor oil especially to determine whether insufficient washing would be detrimental to the anti-dimming composition, and found that even leaving 3 per cent of free sulfuric acid in the oil did not harm the anti-dimmer, which, of course, contained excess of alkali. He found that two washings normally reduced the free acid to less than one per cent.

The method of application was also investigated. The material in use was a paste and, to the extent that the troops were familiar with any anti-dimming composition, they were accustomed to a paste. These new materials had been tested in the form of strong solution, salve, stick and powder, and found successful. The strong solution and salve which were intended to be used from a tin tube were eliminated, although the vaseline consistency was preferred by the men doing the testing, because of the danger of hardening due to freezing in cold weather. The powder, used in a small talcum powder can, was found practicable for use even on a windy day, in a test involving about seventy men at the American University, but was not adopted because of the danger of the container dropping into water, which would cause the soap to cake together in the container and become useless.

It was decided to use the soap in the form of a small cylinder, called a "stick" in imitation of the shaving stick, but smaller. This material, wrapped in tin foil, was indifferent to temperature change, and was put up in a simple kit consisting of the stick and a cloth contained in a small cylindrical box.

Colgate and Company manufactured a supply of these sticks according to the formula

100 parts 85 per cent Turkey red oil
15 parts caustic soda
5 parts water glass
5 parts paraffin oil

the product having 10 to 20 per cent moisture. In manufacture it was found desirable to substitute

sodium carbonate because of the harmful effect of the caustic alkali on the hands in wrapping the sticks with tin foil. The composition so manufactured was tested in the regular way and gave in 28 tests no failures and an index number of 9.1.

Military tests of these sticks and the paste then being used were made at Camp Devens. The men were instructed by their commanding officer in the use of the particular material they had, and to wear the masks until ordered to remove them. The improved directions for the use of the paste were given to them. For the new stick the instructions for use were as follows:

Wipe the inner surface of each eyepiece clean with the soft rag. Breathe on the cleaned surface and on the anti-dimming stick to moisten them and rub twice across the eyepiece. Again breathe on the eyepiece and rub the anti-dimming composition evenly over the whole surface with the tip of the finger.

In the detachment using the old anti-dimming paste there were some cases where both the eyepieces dimmed so badly that it was necessary to remove the mask and again apply the paste. As it was not possible to have the data represent these cases, the figures given for the paste are too high.

A comparative idea of the merits of the respective compositions was obtained by inspection of the masks by the observers, but quantitative data were obtained by means of reading tests. The detachment was formed in skirmish line at a considerable distance from the row of reading charts and instructed that each man should advance until he could just read the top row of letters on the charts and halt, remaining in position until the corporal of his squad had recorded his distance from the chart. This operation was carried out before the masks were put on, again just after they were adjusted, in the middle of the interval, *i. e.*, after about three-quarters of an hour, and at the end just before the masks were removed, *i. e.*, one and one-half to two hours from the start. Some men tried to "beat the game" as they suspected they might be undergoing some kind of an examination, but with fifty-six men wearing the masks, using each anti-dimming compound for three days, the averages obtained gave a fair comparison.

The attempt was made to have the men apply the composition to the lenses at the end of the period, and so have the masks ready for use the next day. This was not completely successful as the masks were taken to quarters by the men and there were subject to a variable treatment. The third day showed much improvement in this regard over the second, indicating that training was necessary.

TABLE VIII—CAMP DEVENS TESTS OF ANTI-DIMMING COMPOSITIONS ON CELLULOID LENSES

DATE	MATERIAL	No. of Masks	GLASS LENSES			No. of Masks	ANTI-DIMMING COMPOSITIONS CELLULOID LENSES		
			Start	Middle	End		Start	Middle	End
Apr. 8	Paste.....	33	80	70	74	24	76	65	67
	New Stick.....	17	86	91	94	39	79	89	86
Apr. 9	Paste.....	39	74	74	76	17	74	74	75
	New Stick.....	14	83	90	90	41	79	86	84
Apr. 10	Paste.....	42	78	69	78	17	79	69	70
	New Stick.....	14	89	82	90	41	79	87	87
Av.	Paste.....	..	77	71	76	..	76	69	71
Av.	New Stick.....	..	88	88	91	..	79	87	86

NOTE—The figures represent percentage vision by reading chart method at start, middle and end of time the masks were worn.

The reading distances for each man with mask on were calculated as the percentages of his distance

without his mask. Table VIII contains the condensed data computed in this way. The number of masks with glass and with celluloid lenses are shown. The word "paste" indicates the anti-dimming paste containing chalk then used by the Army, while the new material is called "new stick."

It was impossible entirely to prevent men from rubbing the lenses to clear them but inspection of the masks showed that although this was not infrequently the case in the detachment using the paste, it was unnecessary for the men using the new stick. Since the man could use both eyes, and it is natural to look through the best part of the eyepieces, it is evident that these data do not represent the true average behavior of these compositions but rather the average best behavior of each. One lens may have been completely dimmed, but if the other were at all clear a good reading distance would be possible. This was not true of the routine testing where the vision for each eye was observed. These data show a considerable advantage to be gained by using the new stick anti-dimming composition on both glass and celluloid lenses. A greater difference between the preparations was observable by the inspection of the respective detachments.

Since the marked superiority of the new composition was shown and the instructions for use were found adequate, the new material was recommended to the Gas Defense Service and at once put into manufacture so that more than nine million units had been delivered at the time of the signing of the armistice, while fewer than a half million units containing the paste were made. Besides being a better anti-dimming composition, the new material had the advantage of saving for other uses two substances which were important in the war program, tin and glycerin, for the paste contained about 25 per cent glycerin and required pure tin tubes. Fortunately, also, the new anti-dimmer was somewhat cheaper.

TISSOT TYPE MASK

The new anti-dimming composition had not gone into manufacture when it became necessary to eliminate the disadvantage of alternate dimming and clearing in the Tissot type mask in which conditions were different. As with the older type of mask, the use of an anti-dimming composition was not the only solution of the problem, but such a material could probably be obtained quickest, so that time could be spared to develop the mask in which no dimming should occur at any time.

Neither the new stick nor the paste was serviceable in this mask as there was less moisture deposited on the lens and this was evaporated on inhalation. At the next exhalation the moisture did not form a smooth film, but one containing small holes, so that vision through it was not good. It has been the experience that, when the soap film was thoroughly wetted and allowed to dry without rubbing, moisture did not usually deposit again in a transparent film. The exact reason for this was not clear. It might be due to a crystallization of the active material but that should only make it slower in action. In the case of the ordinary soaps one might expect the formation of an acid

soap, but this phenomenon occurred with the soaps made from the sulfonated oils also.

The solution of the dimming problem in the Tissot mask seemed to be the prevention of the complete evaporation of the liquid from the lens, so that an unbroken film would always remain. The addition of more water to the soap would not prevent the evaporation of the film because of the large volume of rather dry air passing over the eyepiece with each inhalation. Evidently a liquid of low vapor pressure, completely miscible with water, was needed. The obvious material to try was glycerin, and the addition of this to the new stick proved to be effective. This soap was not the only preparation which was fairly efficient but it was the best one and had the further advantage of being only a slight modification of the composition which was being manufactured.

The composition called "anti-dimming composition for use in Tissot masks" was made according to the following formula:

100 parts	85 per cent Turkey red oil
15 parts	caustic soda
5 parts	water glass
5 parts	paraffin oil
23 parts	glycerin

The product was dried to contain 20 to 25 per cent moisture. Actually sodium carbonate was substituted for the caustic soda as in the other soap. This material was also manufactured in small sticks and put up in the same unit. The directions for applying the composition in this type of mask were different, as a very thin film, was necessary.

The instructions for use were as follows:

Wipe the surfaces of the eyepieces of the mask clean. Breathe on the inside surfaces and apply a little of the composition, rub it in thoroughly with the finger, then polish gently with the rag.

The anti-dimming composition for use in Tissot masks was recommended to the Gas Defense Service in June, and before the armistice was signed more than two million units had been made. Although the outfit closely resembled that used in the older type mask, the compositions were not interchangeable. The stick containing no added glycerin was not successful in the Tissot mask. While the material for use in this mask could be used in the older mask, it was not excellent for that purpose as it contained too much glycerin. The percentage of glycerin in this material was a little over half that in the paste first used.

OTHER WORK

Some work was started on an investigation of the reasons for success or failure of materials for use in the prevention of dimming, but was interrupted by the pressure of other work, so that it never was completed.

One of the properties of these compositions, the rate at which the dried material absorbed water from an atmosphere saturated with moisture, was studied by L. W. Nichols for three materials. About 0.1 g. of the preparation was applied to a glass eyepiece and dried at 100° C., after which it was exposed to moist air at 35° C., and weighed at frequent intervals. The following data were obtained using the previously

mentioned anti-dimming compositions. The third material, R₁₀, was one of many commercial preparations which had been tested.

TABLE IX—PERCENTAGE GAIN IN WEIGHT OF DRIED COMPOSITION WHEN EXPOSED TO MOIST AIR AT 35° C.

TIME MIN.	NEW STICK	PASTE	R ₁₀
15	18 ¹	4.3	9.9
30	42	6.6	13.2
60	..	..	24.0
120	..	14.9	56.5
210	..	24.5	...

¹ Time was 10 min. This sample could run only 35 min. (gain 48 per cent) as the surface tension of the film was so low that the water ran off the eyepiece.

The materials are arranged in the order of their efficiency in preventing dimming, the new stick being the best. These data show that the composition best for use in the gas mask absorbed moisture most rapidly and lowered surface tension most, but for the other two materials moisture absorption did not run parallel to efficiency in preventing dimming.

Another line of work in which some progress was made was the attempt by K. Flynn to evolve a rapid method for control testing of the product for its inspection before acceptance. Air, at measured velocities, was bubbled through hot water and then passed through a jet to impinge on the eyepiece to which the material to be tested had been applied. The temperature of the water was maintained at the approximate temperature desired, by regulating the size of flame. Inside the boiler the air had to pass through water at an approximately constant level and through screens above the water to aid in saturation. The eyepiece was held in a frame soldered into the wall of a tin can having a glass window directly opposite. The can contained ice and water which were stirred. The temperature was measured by a thermometer directly in front of the eyepiece and in the path of the jet of warm, moist air.

The following results were obtained using W₁₀, a laboratory preparation made with Turkey red oil. The time given was from the start until the soap film had broken on two-thirds of the lens, so that the water condensed in drops.

TABLE X—METHOD FOR CONTROL TESTING

A—Effect of Rate of Flow of Moist Air

RATE OF FLOW L. per Min.	TIME IN MINUTES 94° F.	120° F.
2	48	..
6	38	29
8	..	19
11	30	12 (12 l. per min.)
15	26	9
18	26	5

B—Effect of Temperature

TEMPERATURE Deg. F.	TIME IN MINUTES 11 L. per Min.	18 L. per Min.
90	..	30
94	30	26 (95° F.)
98	28	16 (100° F.)
110	15	10
120	10	5

Rates of flow above 18 l. per min. or temperatures above 120° F. gave variable data. The time became somewhat greater with either change, due to the fact that in these cases a smaller fraction of the moisture carried by the air was being condensed by the lens because more escaped to the sides.

Using this method three compositions were tested with the following results:

	TIME IN MIN.
Stick	34, 35, 28
W ₁₀	6, 5, 8
Paste	73, 77, ..
T = 120° F.; flow = 18 l. per min.	

The method in this form was, therefore, not suitable for testing, as the order of merit for these materials was: stick, W₁₀, paste, the last being the poorest one. At least one trouble lay in the definition of the end-point, but further work was interrupted by other problems.

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ANTI-DIMMING PREPARATIONS FOR GAS MASKS

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The National Research Council requested that a study of anti-dimming preparations be taken up in order to supplement the work of Captain Carleton, Private Woodside, and others of the Research Division of the Chemical Warfare Service. In particular it was suggested that the function of sulfonic acid groups be investigated, the effect of their number, position, etc., and also the effect of molecular weight. In general it was desired that the theory of the action of anti-dimmers be worked out as far as possible, to the end that in the light of a clear understanding of their action better and cheaper products might possibly be devised.

To this end a somewhat detailed study was planned as follows:

- 1—Of the sulfonated glycerides of saturated and unsaturated fatty acids as well as sulfonated fatty acids.
- 2—Of the relative merits of potassium, sodium and lithium salts of sulfonated fats.
- 3—Of soaps of saturated and unsaturated fatty acids.
- 4—Of Twitchell's sulfo derivatives.
- 5—Of the effect of excess base, glycerol, mineral oils, water glass and fillers in preparing anti-dimming sticks.
- 6—The relation of surface-tension lowering to the desired anti-dimming effect.
- 7—The influence of solubility on the lasting power of anti-dimming sticks.
- 8—The effect of varying thickness of the anti-dimming film.
- 9—More rapid and more accurate methods of testing.

DROP-SPREAD TESTS OF SURFACE-TENSION LOWERING

As a method of rapid preliminary testing the "drop-spread test" was designed. This was based on the theory that anti-dimmers lowered the surface tension of the drops of moisture condensing on the eyepieces so that these drops spread to a smooth film permitting clear vision. Therefore, any method of measuring surface tension could indicate the possible value of a given substance as an anti-dimming material. The rise of solutions in capillary tubes was too tedious. The spread of a falling drop of water on a glass plate which had been rubbed with an anti-dimming preparation served as a very rapid, though approximate method of selecting materials for the subsequent slower but more accurate tests. The drop was allowed to fall a distance of 8 mm. from a burette to a level plate. The film of material on the plate was rubbed by rotary

motion until thin and nearly dry. A wet plate causes the falling drop to spread. We found that drops spreading to a diameter of about 20 mm. or more indicated a substance of such good surface-tension lowering power that further testing was advisable. On clean, dry glass a drop spreads to a diameter of 8 or 9 mm., slightly less on a celluloid or cello surface.

WINDOW PANE TESTS

It is evident that all methods of testing with gas masks are inconvenient because if a single observer does the work the time involved in a large number of tests is excessive. Moreover, the physical discomfort is great. With a long series of comparative tests lasting days, weeks or even months, the observer's own standards of visibility fluctuate. With one observer only very few tests in a day are possible. If, as was done by previous investigators, a number of men made the various observations, then the personal differences in eyesight, standards of visibility, etc., made any very accurate comparison impossible.

The ideal method for the preliminary testing, then, demanded that a single observer make a large number of readings within the space of an hour or less, and also that the observer should not be severely taxed physically.

It occurred that the use of a small room with many small window panes, a pan of boiling water, films of anti-dimmers on the windows, an observer in the room and an assistant outdoors to hold a printed chart and measure distances along a steel tape, met all these requirements.

Preliminary trials showed that a large window pane was of no use as the moisture condensing above a treated spot ran down, spoiling the test. Hence the value of windows containing many small panes. Two or three different anti-dimmers could be rubbed on each pane just under the horizontal framing at the top. As a result each spot held or ran on its own merits. It was a simple matter to boil enough water into the air of the small room to insure condensation on the windows in any desired amount. Cold weather favors such condensation, of course. The windows must be tightly packed around all cracks as a current of incoming air drives the moisture from the windows. In this connection we found an excellent endorsement of the placing of the air intakes in the Tissot mask directly against the eyepieces. In the room selected for our experiments the upper window contained small panes but the lower held only one large pane so we reversed the windows. To our surprise parts of the surfaces on the lowered window would not condense a dew even where no anti-dimmer was applied. Investigation revealed a wide crack between the two windows. When this was stuffed with rags condensation became normal. The current of cold, dry air from outdoors falling down over the glass had effectually prevented condensation. Cracks at the side of the window frame also needed stuffing.

The assistant outdoors measured off distances along a tape and moved a chart as signaled from the observer in the room. When letters on the chart could be read with difficulty the distance was noted. A compari-

son of these distances for any given set of readings furnished a measure of the relative film-forming efficiency of anti-dimming substances tested. By taking sets of readings at intervals of 20 min. the lasting qualities of the films were plainly shown.

Although moist, the room was comfortable, and, in fact, the observer could leave the room for rest intervals in a dry atmosphere. After some practice we learned to make 56 readings in 15 min. Quick decision and effective signaling were necessary.

The great advantage, in accuracy of comparison, of such a large number of observations made in 15 min. by a single observer is evident. In that short interval errors from changes in the light outdoors are small. Of course, the actual distances are not to be compared in readings made on different days, due to changes in the light, but the order of merit in successive series of readings may fairly be used for comparison.

In a word, the room serves as a giant mask with windows for eyepieces, but with 56 eyepieces instead of one pair. The observer is within the great mask, although not fitting it very tightly, and is decidedly more comfortable than the masked soldier. Instead of laboring to perspire, a steam pan saturates the atmosphere for him.

The anti-dimming material should cover a spot about 4 in. wide, so that both eyes can be used in reading. The material is applied with a glass rod, or cork, and rubbed with soft tennis flannel to a layer almost invisible, aided by occasional blowings of moist breath on the glass. The official method of rubbing with the finger obviously leads to mixed results when several different substances are studied at once. We found 2-in. squares of the flannel quite suitable.

INFLUENCE OF THE SULFONIC ACID GROUP

Using the "drop-spread" device we discarded

Sodium ethyl sulfate
Potassium ethyl sulfate
Aniline sulfate
Sodium and potassium sulfanilate
Sodium β -naphthalene sulfonate
Potassium isobutyl sulfate
Light and heavy petroleum oils
Fats
Saccharine
Many esters, alcohols, aldehydes, amides, sugars, hydrocarbons, and phenols
Several naphthalene products containing the $-\text{NH}_2$, $-\text{OH}$ and $-\text{SO}_3\text{H}$ groups.

Good drop-spreads induced us to test further the following:

Sodium benzene sulfonate, to which we added the di- and trisulfonic derivatives
Sodium toluene sulfonate
Glycerol
Sodium products of egg albumen
Saponin
Sodium ethyl sulfonate
Twitchell's sulfo derivatives
Soaps
Alkali salts of sulfonated fats
A naphthalene derivative containing the amino, hydroxyl, and sulfonic groups in 1,2,4-positions.

These were tested repeatedly on the windows of the steaming room. None of the true sulfonic acid

compounds stood the window test, in some cases because of too great solubility.

From the drop-spread and window tests it is evident that organic sulfates are not necessarily effective as a class; that the mere presence of a sulfonic acid group, either in aliphatic or aromatic compounds, has but little to do with film-forming capacity; that the number and position of sulfonic acid groups are of small importance, in fact sodium benzene disulfonate and trisulfonate were worse than sodium benzene monosulfonate; that the naphthalene ring sulfonates are no better than the benzene ring sulfonates; that the presence of the amino and hydroxyl groups is of no material aid.

It is admitted that a few of these substances functioned moderately well as anti-dimmers for a few minutes, but they had no staying powers.

INFLUENCE OF FATS, OILS, ETC.

A number of mineral oils were tested, vaseline included. We were tempted to try them because of the smooth transparent films formed. As film-formers they were all decided failures.

Liquid fats seemed worth trying for the same reason, but they also were failures.

The moderate film-forming efficiency of glycerol and the high efficiency of saponin solutions indicated that the film-forming effect is not a function of any particular class of compounds except the group that lowers surface tension considerably. Saponin and glycerol have this effect, as is well shown by the rise of their solutions in capillary tubes.

At this stage it became clear that all anti-dimmers must lower surface tension of water decidedly but that those that dissolve too rapidly fail because of their quick removal from the eyepiece. Also those that dissolve too slowly may fail.

Twitchell's benzene-stearosulfonic acid and the similar compound made by treating oleic acid and naphthalene with concentrated sulfuric acid seemed very promising, but as film-formers they were only fair. Drop-spreads were good, and their high molecular weight and sulfonic acid groups and fatty acid residue combined to make a careful test interesting.

INFLUENCE OF SOAPS

Since alkali soaps as a class lower surface tension decidedly they were tested carefully. As a class, soaps derived from glycerides of the saturated fatty acids gave poor results and soaps of unsaturated fatty acids were superior, some of them showing up in the window tests even better than the anti-dimmer officially adopted. But there were exceptions. Cod soap was not effective, yet the clupanodonic acid and therapeutic acid of cod oil are more unsaturated than any other fatty acids.

Linseed soap and rape soap were excellent, making a better showing than the official anti-dimmer. The acids of linseed oil are highly unsaturated, and the oil has a high iodine number, but rape oil has only about half the iodine value of linseed, and yet its soap was found to be just as effective. Corn soap and castor soap were very good indeed, as might have been

predicted, for their acids are unsaturated. Yet peanut oil has almost as high an iodine number as rape oil and peanut soap was poor. Soy bean soap (the oil has a rather high iodine number) was moderately effective. Ivory soap was ineffective but a "super tar" transparent soap made by Armour and Company was fully as effective in our tests as was the official anti-dimmer. It had one serious fault, otherwise it might be considered as a substitute for the anti-dimmer now used, since it makes a solid stick and the film lasts well. Unfortunately, however, a whitish deposit is left on the glass and with repeated applications this might accumulate to a disturbing extent.

A number of soaps were distinctly improved by the presence of a little glycerol, either left in by limited washing or some added to a well-washed soap. Corn soap serves as a good illustration. One sample of corn soap was acidified to liberate the acids. These washed acids were then neutralized with sodium hydroxide, thus forming a soap free from glycerol. This soap had very poor film-forming power but if a few per cent of glycerol were added the results were greatly improved.

Soaps in general were improved by the addition of from 10 per cent to 15 per cent of sodium hydroxide.

A "marine oil" secured from the Standard Oil Company improved soaps, if present to the extent of about 3 per cent. This oil, which emulsifies in water with wonderful ease, has itself very fair film-forming power, especially if a water emulsion of it is applied in a very thin film.

To make solid sticks of soap, about 3 per cent water glass syrup was helpful, acting as a binder as well as a solution restrainer. In making these soap sticks we weighed the ingredients, dissolved the soap in a little hot water, stirred in the concentrated sodium hydroxide, water glass syrup, marine oil, and glycerol, and evaporated off water until the mixture became the right consistency to press into molds. As a laboratory device we used a cork borer 8 mm. wide for the mold. Filling this with the mixture we held it firmly against a block of wood and hammered in a steel rod that fitted the mold. Then it was a simple matter to push out the stick of soap mixture on a glass plate to dry. Wrapped in tin foil it was ready for use. Some soaps are brittle when dried, so a stick 12 mm. in diameter is recommended, as it is less likely to break with rubbing. Rape soap makes a brittle stick but linseed soap and corn soap sticks are strong.

The relative merits and composition of these soap sticks will be listed with the sulfonated products on a later page.

SULFONATED FATS

Although Turkey red oil is termed a "sulfonated" fat it is really a primary ester of sulfuric acid mixed with some other products. On boiling with water, free sulfuric acid and a hydroxy acid are formed.

Sulfonated castor oil, wholly or partly neutralized by sodium hydroxide or ammonia, is the product preferred in the dye industry but similar Turkey red oils have been and are made from olive oil, cotton oil, corn oil, etc.

In practice the concentrated sulfuric acid is allowed

to run into the oil slowly, with constant stirring, taking care that the temperature of 35° C. is not exceeded. This temperature regulation is most important. The product is then rinsed with a small quantity of water and the dilute acid allowed to settle out. The lower layer is drawn off and the oil washed with a solution of Glauber's salt until the washings are only slightly acid. The commercial product is often only partly neutralized. We prepared our own sulfonated oils and neutralized completely with sodium hydroxide. Most of our products contained about 35 per cent water. Much of this was added in neutralization as it is not difficult to obtain an 85 per cent Turkey red oil (acid).

The free fatty acids may also be sulfonated but not so easily as the glycerides. Glycerides of *saturated* fatty acids are not readily sulfonated. The attack is on the double bonds of unsaturated acids forming primary esters of sulfuric acid. Castor oil differs from other fats in that its acids (chiefly ricinoleic) are not only unsaturated but hydroxy acids. If the excellent film-forming properties of salts of this Turkey red oil are due to hydroxy unsaturated acids then no other sulfonated fat could compare with it. And if the effect is due merely to the presence of unsaturated acids then almost any sulfonated unsaturated fat should have value in this connection. This conclusion led us to test Turkey red oil soaps made from

Castor oil	Linseed oil
Cotton oil	Olive oil
Rape oil	Cod oil
Corn oil	Olein

All of these, except cod oil, yielded effective film-formers. We do not understand the failure of cod oil as it has a very high iodine number. Possibly further work might clear up this point.

The free acids from cotton oil were sulfonated and the sodium salt proved effective as a film-former. Ricinoleic acid was isolated from castor oil and sulfonated. The sodium salt showed up well as an anti-dimmer, but no better than a number of other products.

Previous workers had declared the effect of sulfonated castor oil was improved by adding 15 parts sodium hydroxide to 100 parts of 85 per cent sulfonated oil. We varied the proportions and finally adopted 15 parts sodium hydroxide to 100 parts of 65 per cent sulfonated fats (alkali salt). In the case of sulfonated rape oil we increased the proportion of base to 20 parts. This makes our products more alkaline than that officially adopted.

We found 3 parts of water glass syrup to 100 parts sulfonated oil sufficient for binding purposes. Contrary to the experience of the previous workers we found glycerol (about 3 parts to 100) a distinct help. Also contrary to the experience of previous workers we found paraffin oil (such as Nujol) of very little value. It has no film-forming properties of its own, in fact has no effect in lowering surface tension. We replaced it by another oil with all the good properties of paraffin oil and none of its defects. This was "marine oil," made by the Standard Oil Company. It has fairly good film-forming properties of its own and another value mentioned later. About 3 parts of this oil to 100 of sulfonated fat worked best.

Sodium, potassium, and lithium salts of these Turkey red oils were compared, but the differences were not important except in the case of sulfonated cotton oil. In this case the potassium salt seemed enough better to warrant using it in preference to the sodium salt.

In mixing the sulfonated oil with base, etc., it was not possible to boil the mixture as this would have hydrolyzed the product. Long-continued stirring and grinding were necessary.¹ When the paste was thick enough, after partial drying in some cases, it was molded into sticks, as were the soaps.

FINAL RESULTS

Fully three hundred tests were made by the window device and the order of merit given below is the result of many revisions. The same series was run again and again. Absolute accuracy is so difficult from the nature of the case that it is unfair to form an opinion from one or two trials.

It is to be hoped that an official trial of the following two products may be made, since by many of the tests here recorded they display properties indicating that they may prove decidedly better than the present official anti-dimmer.

Sulfonated Rape Oil	100 parts sodium salt of 65 per cent sulfonated rape oil, 35 per cent water
	20 parts sodium hydroxide
	5 parts water glass syrup
	3 parts glycerol
	3 parts marine oil
	Dried to form a solid stick when compressed
Sulfonated Cotton Oil	100 parts potassium salt of 62 per cent sulfonated cotton oil, 38 per cent water
	15 parts sodium hydroxide
	3 parts water glass syrup
	3 parts glycerol
	3 parts marine oil
	Dried to form a solid stick when compressed

Not quite equal to the two just given, but better in film-forming efficiency than the present anti-dimmer were:

Sulfonated Castor Oil Stick	100 parts sodium salt of 65 per cent castor oil, 35 per cent water
	15 parts sodium hydroxide
	3 parts water glass syrup
	3 parts glycerol
	3 parts marine oil
Corn Soap Stick	100 parts sodium corn soap, 10 per cent water
	15 parts sodium hydroxide
	3 parts water glass syrup
	3 parts glycerol
	3 parts marine oil
Rape Soap Stick	100 parts sodium rape soap, 10 per cent water
	10 parts sodium hydroxide
	3 parts water glass syrup
	3 parts glycerol
	3 parts marine oil
Linseed Soap Stick	100 parts sodium linseed soap, 39 per cent water
	10 parts sodium hydroxide
	3 parts water glass syrup
	3 parts glycerol
	3 parts marine oil

The four described above would be recommended for official test if it were not for the superior merit of the first two named.

Better in film-forming effect than the anti-dimmer now used, but not practicable because of mechanical

¹ Captain Dudley's directions for mixing English 7 and 9 include heating on the water bath. This seems questionable for sulfonated fats.

difficulties or expense, and the existence of two better products, are the following:

Rape soap
 Linseed soap
 Saponin, water solutions
 Sodium salt of sulfonated ricinoleic acid
 Sodium salt of sulfonated cotton oil
 Sodium salt of sulfonated olein oil
 Sodium salt of sulfonated olein
 Sulfonated linseed, hydrolyzed and dried and sulfonated again (sodium salt)
 Sulfonated olein, hydrolyzed and dried and sulfonated again (sodium salt)

As good as present anti-dimmer in film-forming effect are:

Armour's super-tar shampoo soap
 Corn soap containing 3 per cent glycerol
 Sodium salt of sulfonated cotton oil acids
 Sodium salt of sulfonated castor oil
 Sodium salt of sulfonated olive oil
 Sodium salt of sulfonated rape oil
 Sodium salt of sulfonated corn oil

Sodium soap of soy bean oil is nearly as good a film-forming anti-dimmer as the present.

Distinctly inferior are:

Glycerol (does not last)
 Sodium salts of Twitchell's sulfo compounds
 Sodium salt of sulfonated cod oil
 Cod soap
 Ivory soap
 Peanut soap

Decided failures as anti-dimmers are:

Glycerol with 5 per cent of paraffin oil
 Glycerol with 5 per cent of water glass syrup
 Corn soap absolutely free from glycerol
 Sodium stearate
 Anti-dimmer "IV" (submitted by earlier workers)
 Anti-dimmer "I. 10" (submitted by earlier workers)
 Paraffin oil
 Vaseline
 Benzene sulfonate, sodium salt
 Benzene disulfonate, sodium salt
 Benzene trisulfonate, sodium salt

Many others were tried, especially combinations with different proportions of sodium hydroxide, glycerol, water glass, marine oil, salts, saponin, etc.

DISCUSSION

The method of testing above described is vastly superior to tests with the actual gas masks for the preliminary comparison of anti-dimming substances. In comparing the official anti-dimmer with the two products especially recommended, it should be remembered that the window test comparison was repeated many times. We made a few gas mask tests and the products we recommended also seemed in these tests to be quite superior to the official anti-dimmer. Differences in the thickness of film sometimes spoil a test, but in a series this error is neutralized. A heavy film is poor at first but as the excess dissolves away the eyepiece clears. Too thin a film does not last. In general, the film should be rubbed until it is barely noticeable. In the Tissot mask it should be thinner than in the older non-ventilated type.

Salts that dry to a white powder are poor, even if they lower surface tension considerably. The amount needed to do any good clouds the glass in a Tissot mask until enough moisture condenses to dissolve the white powder. Soaps and sulfonated fats are highly hy-

drated so they form a transparent film, even before moisture condenses.

The fundamental essential of all good film-formers is that they lower surface tension of water greatly. By tests in capillary tubes we found this to be true of the best anti-dimming materials we made. The second essential is that even when dry the film shall be optically clear. The third essential is that the film shall not dissolve too rapidly. It is also desirable that the sticks should not dry out too much, and that they should be strong enough not to break with rubbing. Most soaps and sulfonated fat products fill these requirements.

In the official anti-dimmer,

100 parts 85 per cent sulfonated castor oil
 15 parts sodium hydroxide
 5 parts water glass syrup
 5 parts paraffin oil

the paraffin oil added anti-dimming qualities of its own but it formed an emulsion with the water present, serving as a filler, giving body to the stick. This was of some slight value with a liquid sulfonated fat such as that made from castor oil. Possibly it also added some smoothness to the film before water began to condense and restrained the active material from too rapid solution, yet the sodium hydroxide excess thickened the sulfonated fat to a marked degree. Water glass of course served as a binder and also, with the mineral oil emulsion, as a restrainer of too rapid solution of the active material.

We tried sodium caseate as a substitute for water glass but with no success. The stick must not contain insoluble gritty particles when old for these serve as breaking points in the water film.

Glycerol makes a smoother film and prevents drying out of the material. Sodium hydroxide also prevents drying.

The substitution of marine oil (probably a mixture of blown rape oil with a heavy mineral oil) for paraffin oil is a distinct improvement. It has every good quality of the paraffin oil and in a thin film of water emulsion has very fair film-forming properties of its own.

It is to be noted that film-forming properties do not vary with molecular weight. If they did sulfonated peanut oil would lead, rivaled by peanut soap, and the Twitchell products. It was desirable to compare only pure, simple fats but this proved too difficult for our limited time. However, we did have pure olein. The sulfonated product from this was noticeably superior to sulfonated olive oil. Castor oil is largely composed of the glyceride of ricinoleic acid.

At one time we thought it best to make mixtures of a vaseline consistency and tie in a bag of tennis flannel. By pressure the mixture oozed through the cloth which also served as a polisher. Unfortunately the contents of the bags dried to solid cakes in spite of the hygroscopic qualities of glycerol and sodium hydroxide. Apparently the stick form is best.

Except for cost the addition of 5 per cent saponin to any of the mixtures would be worth while. We found it raised the film-forming power of any mixture.

In this work we sulfonated our own fats and made our own soaps.

SUMMARY

I—A convenient and rapid method was devised for comparing the film-forming properties of possible anti-dimmers. By this method one observer made 56 tests in 15 minutes.

II—Organic sulfates as a class are not effective; the presence of the sulfonic acid group does not guarantee effectiveness; the position of sulfonic acid groups is of little importance; sodium benzene trisulfonate is less effective than the di- or monosulfonate; naphthalene ring sulfonates are no better than benzene ring sulfonates; the amino and hydroxyl groups are of no material value.

III—High molecular weight is not a vital factor as shown by poor results with Twitchell's benzene stearo-sulfonic acid and similar compounds. Since moisture should condense in films, rather than in drops, for good visibility, the best anti-dimmers should lower the surface tension of water greatly. They must be soluble, but not too soluble or they have no staying powers. They should also be deliquescent enough to prevent drying out.

IV—Alkali soaps of unsaturated fatty acids are much superior in film-forming power to soaps of saturated fatty acids.

V—Soaps in general are improved by the addition of a few per cent of glycerol, 10 to 15 per cent sodium hydroxide and a few per cent of marine oil. Water glass in small amount serves well as a binder.

VI—Turkey red oil soaps were made from castor oil, cotton oil, rape oil, corn oil, linseed oil, olive oil and olein. All showed excellent film-forming properties. Since castor oil is the only one containing a glyceride of a hydroxy unsaturated acid the good results cannot be due to the hydroxy group in this type of glyceride.

VII—A number of unsaturated fatty acids were sulfonated. The alkali salts were effective.

VIII—There is but little difference in the value of different alkali soaps of the Turkey red oils. However, the potassium soap of sulfonated cotton oil gave us better results than did the sodium soap.

IX—It is recommended that an official field trial of the two following products be made with a large number of men, since the method of testing here recorded indicates that these two products may prove decidedly better than the present official anti-dimmer:

Sulfonated Rape Oil	100 parts sodium salt of 65 per cent sulfonated rape oil, 35 per cent water
	20 parts sodium hydroxide
	5 parts water glass syrup
	3 parts glycerol
Sulfonated Cotton Oil	3 parts marine oil
	Dried to form a solid stick when compressed
	100 parts potassium salt of 62 per cent sulfonated cotton oil, 38 per cent water
	15 parts sodium hydroxide
	3 parts water glass syrup
	3 parts glycerol
	3 parts marine oil
	Dried to form a solid stick when compressed

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ORIGINAL PAPERS

PHTHALIC ANHYDRIDE. II—THE MELTING POINT OF PURE PHTHALIC ANHYDRIDE. THE SYSTEM: PHTHALIC ANHYDRIDE-PHTHALIC ACID

By K. P. MONROE

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An interesting consequence of the recent development by Gibbs and co-workers¹ of a catalytic process for air oxidation of naphthalene to phthalic anhydride has been that the consistent melting point (131°) of the purified product² exceeds by three degrees that previously recorded in the literature.³ Both practical

¹ See first article of this series, "Phthalic Anhydride, I," by H. D. Gibbs, THIS JOURNAL, 11 (1919), 1031.

² Phthalic anhydride derived from both laboratory and factory operation of the air oxidation process was tested in the usual capillary tube manner by various workers. In each case the crude product was purified by re-sublimation; the material was chemically pure so far as could be detected by titration.

³ Beilstein, *Handbuch d. org. Chem.*, 2 (1794) (3rd Ed.), gives 128° , with references to the following:

Laurent, Liebig's *Ann. d. Chem.*, 19 (1836), 38, gives 105° , presumably on the Reaumur scale (131° C.). Phthalic anhydride was prepared from phthalic acid by sublimation at atmospheric pressure.

Lossen, *Ibid.*, 144 (1867), 76, gives 128° . Phthalic anhydride was prepared from phthalic acid by sublimation at atmospheric pressure. This melting point was verified by testing phthalic anhydride from phthalic acid prepared by various methods, which are not enumerated.

Anschütz, *Ber.*, 10 (1877), 326, gives 127° . Phthalic acid was dehydrated by acetyl chloride, which was removed by absolute alcohol; crystals of phthalic anhydride were pressed between filter paper.

Lachowicz, *Ibid.*, 17 (1884), 1283, gives 128° . Phthalyl chloride was warmed with lead nitrate; phthalic anhydride was recrystallized from benzene.

Stohmann, *J. prakt. Chem.*, 40 (1889), 139, gives 128° . Phthalic anhydride prepared by distillation of commercial phthalic acid was recrystallized from benzene-ligroin mixture.

and theoretical considerations led to the present investigation, with the object of establishing the melting point of pure phthalic anhydride and also of observing the melting points of known mixtures of phthalic anhydride with phthalic acid, the impurity most likely to be found in the technical anhydride as well as in the samples examined by the earlier observers.

Although numerous titrations of re-sublimed phthalic anhydride derived from the air oxidation process indicated a high degree of purity, it was first determined to adopt a still more rigorous purification. This material¹ was warmed in a vacuum oven for 5 hrs. at 80° , fused carefully in a casserole and decanted into a mortar. For the purpose of decomposing possible traces of phthalic acid and separating any non-volatile impurities, the pulverized anhydride was twice re-sublimed *in vacuo* in the presence of phosphorus pentoxide. The apparatus designed for this sublimation is illustrated in Fig. 1. A glass tube, A, sealed at one end and widened to thrice its diameter at the other was fitted co-axially inside a longer tube, B, also sealed at one end, with a ground glass joint. Through a phosphorus pentoxide bulb, C, the system was evacuated to a pressure of approximately four millimeters by a vacuum pump. On warming B, phthalic anhydride contained in the lower portion vaporized and after filtering through a tight plug of glass wool was condensed on the lower portion of A, which was cooled by an air stream.

¹ This crystallized in long, colorless glistening needles.

Results of a large number of sublimations indicated that the only detectable impurities were occasional minute traces of tar filtered out by the glass wool, and a trace of nonvolatile residue. Titration and combustion¹ established the chemical purity of the final sublimate. No difference between the first and second vacuum sublimate could be detected either by analysis or by melting point test in the accurate manner to be described later.

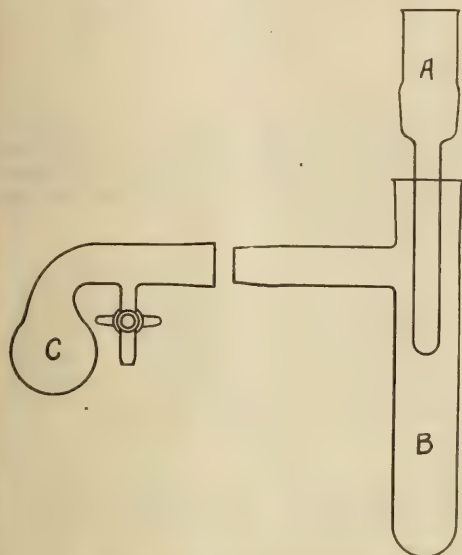


FIG. 1—VACUUM SUBLIMATION APPARATUS

It will be noted, however, that the method of *total*² titration leaves much to be desired as a test for the presence of minute amounts of phthalic acid in the anhydride, for the difference between the molecular weight of phthalic anhydride (148.07) and that of the acid (166.09) is so slight (18.02) that with usual analytical accuracy this method cannot detect with certainty less than approximately 1 per cent of acid. A number of attempts at *differential* titration of acid in the presence of anhydride, in which mixtures were dissolved in nonaqueous solvents and titrated with *N/10* NaOH, indicated that the anhydride is rapidly hydrated in the presence of excess alkali. The following method was finally devised by E. Q. Adams,³ of this laboratory, and is a remarkably sensitive test for traces of phthalic acid in the anhydride:

A half gram sample of the anhydride is dissolved

¹ 0.5320 g. and 0.5956 g. sublimate required 7.206 and 8.042 millimoles NaOH. Calculated weights anhydride: 0.5333 g. and 0.5952 g.

² 0.3233 g. sublimate gave on combustion 0.6765 g. CO₂ and 0.0905 g. H₂O. Per cent C = 64.8, per cent H = 3.1. Calculated: Per cent C = 64.9, per cent H = 2.7.

³ This method involves the addition of excess *N/5* NaOH to weighed samples of the anhydride in glass stoppered flasks, which are warmed on the steam bath for an hour. The excess alkali is then titrated by *N/5* HCl.

⁴ Dr. Adams is continuing the investigation of this and other methods for differential titration of phthalic acid in the presence of the anhydride.

in 50 cc. of acetone, a few drops of a solution of bromophenol blue¹ are added, and the acetone solution is titrated with *M/10* solution of normal potassium phthalate in 80 per cent alcohol. If phthalic acid is present the end-point of the titration is reached when sufficient normal phthalate solution has been added just to produce the acid phthalate, and further addition of normal phthalate solution causes a color change to indigo blue. The original color in the acetone solution is pale yellow, while the tint at the end-point is greenish blue. Unfortunately, the end-point is not sharp, since it is difficult to reproduce the exact shade of green. Nevertheless, this is a very sensitive test for the absence of traces of phthalic acid in the anhydride. When the second sublimate was tested in this manner, a single drop (0.03 cc.) of normal phthalate solution caused a color change to indigo-blue, showing that the end-point must have been exceeded, and that this sample of anhydride must have contained less than 0.1 per cent acid.

To determine the melting point of the second sublimate, approximately 15 g. were placed in a wide test tube, which was closed by a stopper in which were inserted a Reichsanstalt "Centigrade-Normal" short stem thermometer² and a glass guide tube for the platinum stirring rod. The test tube was placed in a snugly fitting stoppered glass air-bath³ clamped vertically in a liter sulfuric acid bath, which was stirred by a turbine. After fusion the temperature was lowered slowly to the point of incipient crystallization while the melt was stirred constantly by a mechanical device. The equilibrium temperature of crystals and liquid was 130.84°.⁴ A melting point identical within experimental error was obtained under similar conditions for the original anhydride which was the source of the carefully purified material, confirming the previous conclusion that no more than traces of impurities were contained in this.⁵

In an effort to search out sources of discrepancy between the values previously recorded in the literature and the melting point of pure phthalic anhydride, which seemed now definitely established, samples of Kahlbaum's "Phthalsäure Anhydrid"⁶ were examined in the usual capillary tube manner. It was, indeed, observed that the material began to sinter at 128–129°, that a liquid meniscus appeared near 131°, but that the solid phase did not completely disappear until 178°. On examining a larger quantity in the manner described for the pure anhydride a well defined freezing point was observed at 159.8°, but

¹ This is the abbreviated name for tetrabromophenolsulfonaphthalein.

² This was graduated to fifths of degrees, and recently calibrated by the Bureau of Standards.

³ For description see Phthalic Anhydride, III, the accompanying third article of this series (p. 1119).

⁴ Under these conditions no correction is necessary, for the exposed stem was but 15°, and the portion of thermometer not submerged in the melt was surrounded by air and vapor in the inner tube at a temperature differing but slightly from that of the melt.

⁵ Through the courtesy of Prof. G. A. Hulett the writer obtained a sample of phthalic anhydride prepared by sublimation from pure phthalic acid which was dehydrated *in vacuo* at 115°. This anhydride melted at 131° when tested in the capillary tube.

⁶ Presumably obtained by sublimation from phthalic acid derived by one of the "wet" oxidation methods, which was the universal method of preparation before development of the air oxidation process.

after this lag the temperature fell steadily with continual separation of crystals to 129.6° , where the appearance of a distinctly different solid phase was observed and the thermometer halted until solidification was complete. Since the impurity most likely in phthalic anhydride prepared by sublimation from phthalic acid is the acid itself, it seemed probable that the Kahlbaum material contained a considerable admixture of phthalic acid, and that 129.6° would lie near the eutectic temperature of acid and anhydride. Analyses¹ confirmed the former conclusion, and subsequent determination of the eutectic temperature, using pure materials, gave the value 129.74° .

To obtain additional evidence upon the melting point of pure phthalic anhydride, the Kahlbaum product was twice re-sublimed in the vacuum apparatus. The second sublimate was observed to have a constant freezing point at 130.8° .²

Since the behavior of Kahlbaum's "Phthalsäure Anhydrid" confirmed the previous conclusion that presence of phthalic acid is a factor which must be considered in observations upon anhydride prepared by sublimation from the acid, mixtures of the pure anhydride with very pure phthalic acid³ were weighed into the test tube and the freezing points were determined as for the pure anhydride.⁴

Unfortunately the limitations of this method were such that only a very restricted region of this system could be explored, for, as will be observed from the steep slope of the right-hand curve in Fig. 2, the temperatures necessary to fusion soon became so high that satisfactory checks could not be obtained. Only those experiments in which close duplicate freezing points could be obtained are noted in the graph and table. Although it was not feasible to seed the melt, very great care was taken to lower the temperature exceedingly slowly⁵ in the neighborhood of the freezing point while the walls of the tube were continually scratched by the platinum stirring rod, operated by a mechanical device.

In the light of these data it is obvious that any mixture of pure phthalic anhydride with the pure acid will, when tested in the capillary tube, begin to sinter at the eutectic temperature (129.74°), which may obviously be depressed by other impurities in the an-

TABLE I—FREEZING POINTS OF MIXTURES OF PHTHALIC ANHYDRIDE AND PHTHALIC ACID

WEIGHT PER CENT ACID	MOL. PER CENT ACID	Solid Phase: Anhydride	FREEZING POINT
0.0	0.0		130.84
0.29	0.26		130.7
0.98	0.87		130.4
1.44	1.30		130.1
		Eutectic	
1.96 (interpolated)	1.75 (interpolated)		129.74
		Solid Phase: Acid	
2.02	1.81		130.0
2.44	2.18		131.9
2.70	2.41		133.2
3.02	2.70		136.3
3.47	3.10		137.2
3.91	3.50		139.7
4.27	3.83		141.1
4.80	4.30		143.8
5.57	5.00		146.4

hydride. It may be pointed out that the capillary tube method is a sensitive criterion for presence of acid in the anhydride if the temperature at which solid acid completely disappears is noted, for in the capillary tube solid acid usually survives much above the true melting point of the mixture.

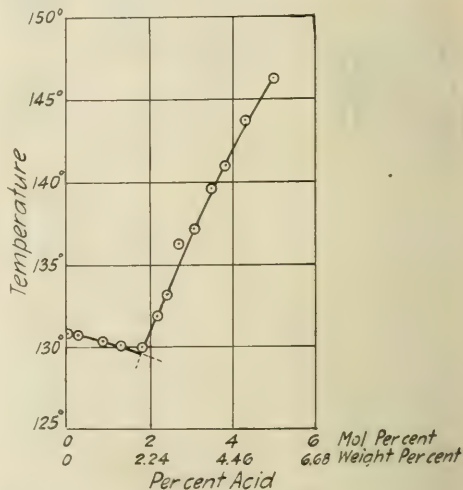


FIG. 2—FREEZING-POINT CURVES FOR SYSTEM PHTHALIC ACID-PHTHALIC ANHYDRIDE

It is of interest to note the bearing of the results in Table I upon the melting point of pure phthalic acid, for on account of the readiness with which this decomposes near its melting point into the anhydride and water, the melting point may be approximated only roughly by direct measurement.¹ Direct extrapolation of the right-hand curve in Fig. 2 is not feasible,

¹ The early impression that phthalic acid melted at 184° (Lössen, *Loc. cit.*), near which its water vapor tension reaches atmospheric pressure and the acid decomposes rapidly to a mixture containing anhydride, was first corrected by Ador, *Ann.*, **163** (1872), 230, who states that pulverized phthalic acid melts at 203° , while whole crystals melt at 213° .

In an attempt to verify Ador's results a quantity of very pure phthalic acid was sealed in an evacuated glass tube, which was attached to a thermometer and immersed in a paraffin bath which was vigorously turblined. On heating the bath very slowly, in order to prevent thermal lag, the material in the tube was observed to melt at $199-200^{\circ}$. This must, however, be regarded as merely a rough minimum value, for at this temperature the water vapor tension exceeds one atmosphere and the melt must contain very appreciable amounts of dissolved anhydride and water.

¹ 0.6165 g. and 0.4423 g. Kahlbaum's "Phthalsäure Anhydrid" required 8.202 and 5.902 millimoles NaOH. Calculated weights anhydride: 0.6089 g. and 0.4368 g. Calculated per cent phthalic acid: 10.0 and 10.3.

² 0.2891 g. Kahlbaum's "Phthalsäure Anhydrid" gave on combustion 0.6729 g. CO_2 and 0.0729 g. H_2O . Per cent C = 63.7, per cent H = 2.8. Calculated for mixture containing 10 per cent phthalic acid: per cent C = 64.1, per cent H = 2.8.

³ 0.5126 g. and 0.6465 g. sublimate required 6.936 and 8.748 millimoles NaOH. Calculated weights anhydride: 0.5134 g. and 0.6475 g.

⁴ This was prepared by boiling the pure anhydride with distilled water, subsequent recrystallization from hot water, and thorough drying at room temperature *in vacuo* over phosphorus pentoxide.

⁵ 0.7694 g. phthalic acid so prepared required 9.268 millimoles NaOH. Calculated weight acid: 0.7697 g.

⁶ For discussion of the applicability of this method to mixtures of substances which sublime readily at the melting point see Phthalic Anhydride, III, the accompanying third article of this series. No appreciable sublimation was observed during the composition range given.

⁷ This procedure was especially necessary in determining the freezing points on the right-hand curve in Fig. 2, for since each mixture contained a relatively minute mol. fraction of acid, separation of this as solid phase caused a rapid change in composition of the melt.

but if one plots on a large scale the reciprocals of the absolute freezing points against the logarithms of the mol. fractions of phthalic acid a straight line results, from which the melting point of pure phthalic acid is indicated to be $208^{\circ} \pm 2^{\circ}$. This linear relation is predicted on the assumption that the freezing-point curve conforms to the law deduced for ideal systems, for it follows from Equation 1 in the accompanying third article of this series that

$$\frac{1}{T} = \frac{1}{T_0} - \frac{\log_{10} x}{C} \quad (1)$$

when

$$C = \frac{0.4343 L}{R} \quad (2)$$

and T = freezing point of the mixture, T_0 = freezing point of pure phthalic acid, x = mol. fraction of phthalic acid in the mixture, L = molecular heat of fusion of phthalic acid, and R = the gas constant.

SUMMARY

The melting point of pure phthalic anhydride has been determined to be 130.84° , and the freezing curves for the system: phthalic anhydride-phthalic acid have been established within the limits of composition for which the experimental method is applicable. By graphical extrapolation the melting point of pure phthalic acid is indicated to be $208^{\circ} \pm 2^{\circ}$.

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PHthalic ANHYDRIDE. III—THE SYSTEM: NAPHTHALENE-PHTHALIC ANHYDRIDE

By K. P. MONROE

Received September 13, 1919

Investigation of the freezing-point curves of this system was undertaken in order to assist the solution of certain problems arising in fractional sublimation of the mixture of naphthalene and phthalic anhydride which is the crude product of the air oxidation process developed by Gibbs and co-workers.¹ Apart from their practical value, the results are of interest in that they offer striking conformation to the familiar thermodynamic law which determines the freezing-point curves of ideal systems, while the following experimental method which has been devised would seem particularly well adapted to the investigation of similar systems of substances which sublime readily at the melting point:

Mixtures of pure naphthalene² and phthalic anhydride³ were weighed into a wide test tube. After closing the tube by a stopper in which were inserted a "Tycos" short stem thermometer⁴ and a glass guide tube for the platinum stirring rod, the whole was lowered into a cylindrical glass air-bath which fitted snugly the length of the test tube, but was widened

near the upper end and so extended that when the air-bath was clamped vertically in a liter sulfuric acid bath the test tube was entirely below the acid level.

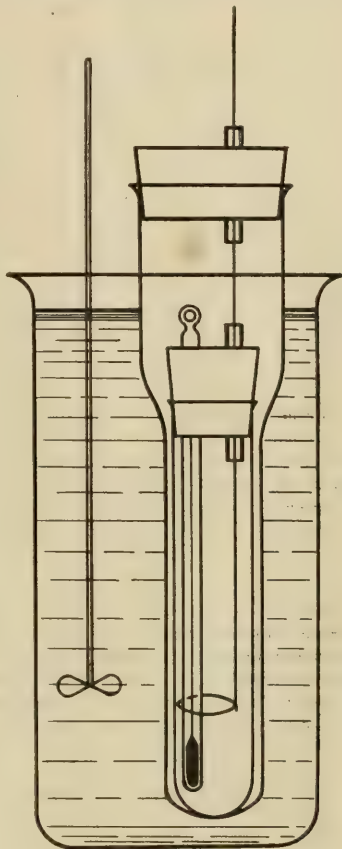


FIG. 1

Since the air-bath was also stoppered, with but a narrow opening to the atmosphere through a glass guide tube, practically no sublimation was observed throughout the entire range of mixtures examined; for the test tube was thus surrounded by air at a temperature differing but slightly from that of the melt, and there was practically no convection current through the two guide tubes.¹

After fusing to a clear, homogeneous liquid, the temperature was permitted to fall slowly to the point of incipient crystallization while the melt was stirred constantly by a mechanical device. The freezing point was determined in the usual manner from the time-temperature curve. Although it was not feasible to seed the melt, care was taken to lower the temperature exceedingly slowly in the neighborhood of the

¹ THIS JOURNAL, 11 (1919), 1031.

² The Bureau of Standards' purest naphthalene was used. Compare the observed melting point, 80.05° , with 80.09° , the value obtained by Washburn and Read, *Proc. Nat. Acad. Sci.*, 1 (1915), 191.

³ The fused phthalic anhydride described in the accompanying second article of this series, Phthalic Anhydride, II, was used.

⁴ This was graduated to tenths of degrees, and calibrated by comparison with a Reichsanstalt "Centigrade-Normal" thermometer.

¹ The vapor required to saturate the free space was negligible, for the mixtures averaged 20 g. in weight and the free space was less than 60 cc.

freezing point, while the walls of the tube were continually rubbed by the platinum stirring rod. Under these conditions duplicate determinations within 0.1° were obtained without difficulty. Supercooling never exceeded 0.2° .

TABLE I—FREEZING POINTS OF MIXTURES OF NAPHTHALENE AND PHTHALIC ANHYDRIDE

WEIGHT PER CENT ANHYDRIDE	MOL. PER CENT ANHYDRIDE	FREEZING POINT
Solid Phase: Naphthalene		
0.0	0.0	80.05
9.21	8.07	75.1
17.30	15.24	71.2
24.21	21.66	67.3
27.96	25.14	65.2
Eutectic		
29.0 (interpolated)	26.1 (interpolated)	64.9
Solid Phase: Anhydride		
30.11	27.24	66.3
32.82	29.71	70.1
35.45	32.21	73.5
36.00	32.74	74.3
40.64	37.21	80.4
48.42	44.82	88.9
59.15	55.62	99.6
70.80	67.73	109.2
75.96	73.21	113.4
82.82	80.67	118.5
91.70	90.53	124.8
100.00	100.00	130.84

No evidence was obtained pointing to the existence of solid solutions.

Since the molar heat of fusion of naphthalene has been accurately determined,¹ the freezing points on the left-hand curve of Fig. 2 may be calculated readily by the Schröder-LeChatelier formula²

$$T = \frac{T_0}{1 - \frac{R}{L} \log_e x} \quad (1)$$

when x = mol. fraction of naphthalene in the mixture; T_0 = freezing point of pure naphthalene; T = freezing point of the mixture; L = molal heat of fusion of naphthalene; R = the gas constant. The calculated values in Table II are based upon the assumptions that L = 4,560 calories and R = 1.9852 calories per degree.

TABLE II—COMPARISON OF CALCULATED AND OBSERVED FREEZING POINTS (NAPHTHALENE AS SOLID PHASE)

x	$T-273$ (observed)	$T-273$ (calculated)
0.7486	65.2	65.1
0.7834	67.3	67.3
0.8280	71.2	71.3
0.9193	75.1	75.6

Although the freezing points on the right-hand curve may not be calculated in similar fashion, for the heat of fusion of phthalic anhydride is unknown, Equation 1 may be cast readily into a form suitable for testing this curve:

$$C = \frac{-T_0 T \log_{10} x}{\Delta t} \quad (2)$$

when C = a constant; x = mol. fraction anhydride in the mixture; T_0 = freezing point of pure anhydride;

¹ Alluard, *Ann. chim. phys.*, [3] **57** (1859), 476; Pickering, *Proc. Roy. Soc. London*, **49** (1890-1), 18.

² See Roozeboom, "Die Heterogenen Gleichgewichte," II, I, p. 272; Washburn, "Principles of Physical Chemistry" (McGraw Hill Book Co., New York, 1915), p. 169. Dahms, *Wied. Ann.*, **64** (1898), 507, and Washburn and Read, *Loc. cit.*, have obtained striking experimental verifications of this formula in case of systems of organic substances. The systems: benzene-naphthalene, benzene-diphenyl, and naphthalene-diphenyl investigated by the latter two authors are particularly well adapted to a conclusive test, since they would appear to approach the ideal condition very closely from the viewpoint of chemical similarity.

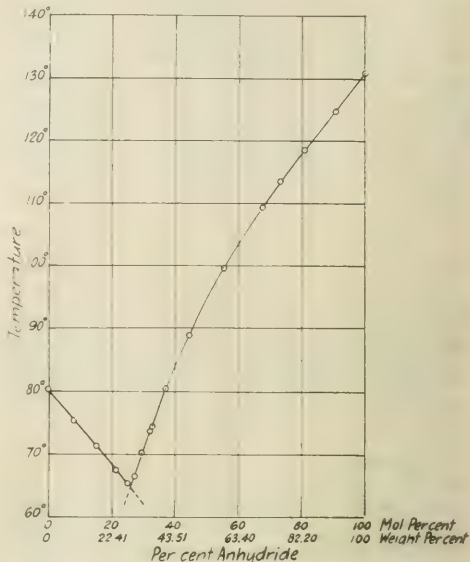


FIG. 2 FREEZING-POINT CURVES FOR SYSTEM PHTHALIC ANHYDRIDE-NAPHTHALENE

T = freezing point of the mixture; $\Delta t = T_0 - T$. The constancy of the calculated values of C in Table III indicates that the right-hand curve also conforms to the law.¹

TABLE III—CALCULATED VALUES OF C IN EQUATION 2, BASED UPON EXPERIMENTAL VALUES OF T

x	T	Δt	C
0.2724	339.3	64.6	1198
0.2971	343.1	60.8	1201
0.3221	346.5	57.4	1200
0.3274	347.0	56.9	1194
0.3721	353.4	50.5	1214
0.4482	361.9	42.0	1213
0.5562	372.6	31.3	1225
0.6773	382.2	21.7	1204
0.7321	386.4	17.5	1208
0.8067	391.5	12.4	1190
0.9053	397.8	6.1	1138
			1199

Since

$$L = \frac{RC}{0.4343} \quad (3)$$

the molal heat of fusion of phthalic anhydride is determined by the data in this table within the same percentage limits of accuracy as the constant C . Assuming the average value of C and the value of R previously mentioned, the molal heat of fusion is calculated to be 5,480 calories.

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¹ Additional evidence that phthalic anhydride behaves as a normal liquid has been obtained by application of the criterion recently suggested by Hildebrand (*J. Am. Chem. Soc.*, **37** (1915), 970). From an unpublished determination of the vapor-pressure curve, the value 13.6 is obtained for the entropy of vaporization divided by R at the temperature (near 218°) at which the concentration of vapor is 0.00507 mole per liter; this value coincides with the average obtained from Hildebrand's table based upon the vapor-pressure curves of fifteen normal liquids.

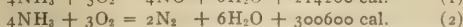
HEAT OF REACTION OF AMMONIA OXIDATION¹

By GUY B. TAYLOR

Received July 9, 1919

When a mixture of ammonia gas and air is brought in contact with a suitable catalytic surface maintained above a certain temperature, the predominating reaction which occurs is the formation of nitric oxide and water. The temperature most favorable to this reaction lies above 800° C. It is, then, of considerable interest to calculate the heat of the reaction, in order to determine how much external energy must be added to maintain the catalyst at the required temperature.

A general formula has been developed for calculating the theoretical heat of reaction for any mixture of ammonia and air at any conversion efficiency, taking into account also the degree of humidity of the mixture. This calculation is based on the following equations:



The heats of reaction were obtained from heats of formation as follows:

Ammonia, NH_3	+12000 calories
Nitric oxide, NO	-21600 calories
Water, H_2O	+58100 calories

The temperature rise is expressed by the formula

$$t = \frac{Q}{C}$$

where t is degrees Centigrade, Q the heat of reaction in calories, and C the specific heat of the products of reaction.

The specific heats at constant pressure of the products involved, taken from Landolt and Börnstein's tables, in calories per mole are

Nitrogen.....	7.00 (Holborn and Henning)
Oxygen.....	7.36 (Holborn and Austin)
Nitric oxide.....	6.93 (Regnault)
Water vapor.....	8.03 + 0.000781 (Holborn and Austin)

Over the range 0°-800° C., water vapor is the only gas of the four having an appreciable temperature coefficient. For the calculation a mean value of 8.34 may be used without appreciable error.

In an ammonia-air-water vapor mixture containing oxygen in excess of the stoichiometric proportion, let

x = fraction in moles of NH_3 in ammonia-air mixture

y = fraction in moles of NO produced by Reaction 1

$\frac{x-y}{2}$ = fraction in moles of N_2 produced by Reaction 2

$\frac{y}{x}$ = yield

Then in every mole of gas after the reaction there will be y moles nitric oxide

$$0.79(1-x) + \frac{x-y}{2} \text{ moles nitrogen}$$

$$0.21(1-x) - \frac{5}{4}y - \frac{3}{2}\left(\frac{x-y}{2}\right) \text{ moles oxygen}$$

$$\frac{3}{2}x + \frac{V}{B-V} \text{ moles water vapor}$$

where V is partial pressure of water vapor and B the total pressure of the ammonia-air-water vapor

mixture. Multiplying each of the above fractional moles by its specific heat and adding the results, the value of C in the equation $t = \frac{Q}{C}$ is obtained. This equation reduces to the form:

$$t^\circ = \frac{75150x - 21600y}{7.08 + 3.41x - 0.25y + 8.34 \frac{V}{B-V}}$$

The third term in the denominator is small and may be neglected; the fourth term becomes zero when the mixture is dry.

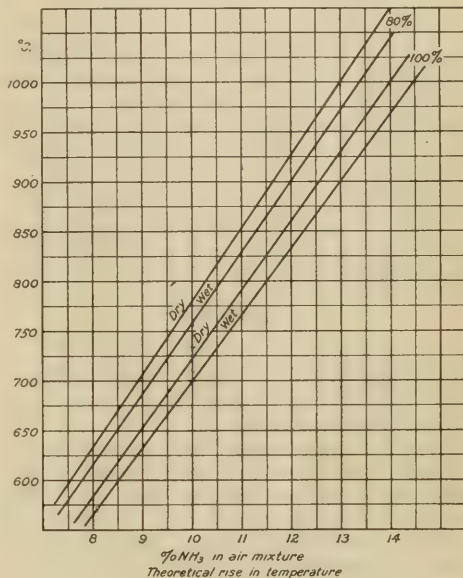


FIG. 1

In Fig. 1 are plotted the temperature rises for ammonia concentration in air from 8 to 14.4 per cent (dry basis) for 100 and 80 per cent conversion efficiencies for both wet and dry gas mixtures. The value of the term $\frac{V}{B-V}$ is assumed to be 0.03 which

corresponds to the humidity when ammonia liquor is used as the source of ammonia gas. From the plot it will be noted that the four lines are very nearly parallel, diverging slightly as they rise. There is an increase of about 50° at 80 per cent yield over that of complete conversion.¹

All the experimental evidence obtained in the Bureau of Mines laboratories, which has been corroborated by plant experience,² tends to show that for

¹ It may be considered doubtful whether in actual practice the oxidation of ammonia to elementary nitrogen and water takes place on the catalyst surface, or at least wholly on this surface, and thus contributes to maintaining the gauze temperature. There are some grounds for believing that the nitrogen is formed after the gases pass the catalyst by interaction of ammonia and nitric oxide. See Baxter and Hickey, *Am. Chem. J.*, **33** (1905), 300.

² C. L. Parsons, *This Journal*, **11** (1919), 541.

¹ Published by permission of the Director of the U. S. Bureau of Mines.

high yields the temperature of platinum catalyzers should not fall below 800°C . and the ammonia concentration should not exceed 10 per cent. This is almost certainly equally true of any catalyzer for ammonia oxidation. A glance at the flame temperature of Fig. 1 shows clearly why the reaction will not sustain itself unless external energy is supplied or converters are properly designed to recover a portion of the sensible heat carried away with the reaction products.

All types of commercial converters utilizing platinum catalyzers resort to various expedients for maintaining proper temperatures. Converters of the Ostwald type preheat the ammonia-air feed by means of a heat transfer from the hot reaction products (plants at Vilvorde, Angouleme and Dagenham abroad); others supply the extra energy required by electrical means (Frank Caro and Landis types).¹ The Bureau of Mines type utilizes the hot reaction products to heat a shell surrounding a cylindrical gauze. The shell by radiating heat back to the gauze keeps its temperature up.

A third method of maintaining temperatures is to add oxygen to the mixture and increase the ammonia concentration. This method was successfully applied to non-platinum catalyzers in laboratory experiments by the writer in 1916.

EXPERIMENTAL

It is the purpose of the present paper to describe experiments carried out in the Bureau of Mines laboratories with a platinum gauze converter, comparing results obtained by electrical heating, preheating, and the addition of oxygen.

APPARATUS AND METHODS—The apparatus utilizing a 3×6 in. platinum gauze with provision for electrical heating has been described elsewhere.² Temperature of the gauze was observed through a mica window with a Holborn-Kurlbaum optical pyrometer, using the maker's black-body calibrations, and making the necessary corrections³ for deviation from black-body conditions by making additions according to the following table:

Actual temp. Deg. C.	Add Deg. C.
600	35
700	45
800	55
900	85

The temperature of the gauze varied from 10° to 30° in different places when electrical heating was used. The richer the mixture in ammonia, the more uniformly was the gauze heated.

Efficiencies were determined by the vacuum-bottle method of Taylor and Davis.⁴

In preheating experiments, a royal Berlin porcelain tube, 3 ft. long and $2\frac{1}{2}$ in. outside diameter with walls $\frac{3}{16}$ in. thick, was fastened by means of a metal collar to the cover plate of the top section of the aluminum oxidizer body. A 2-ft. section of this tube about 3 in. above the cover plate was heated by means of an elec-

tric resistance furnace. The ammonia-air mixture on its way to the platinum gauze passed through the heated porcelain tube, coming in contact only with porcelain and aluminum surfaces. The top section of the oxidizer was lagged with asbestos board.

In experiments using oxygen enrichment, this gas was separately metered and passed into the ammonia-air stream coming from the ammonia vaporizing drums. Preheating was not employed in these tests and electric current was used only to ignite the gauze.

The platinum gauze used in all experiments reported in this paper was 100 mesh to linear inch, 0.0020 in. diameter wire. It contained some iridium as impurity.

The ammonia gas used was derived from "A" grade liquor of coke-oven origin furnished by the Smet-Solvay Company.

DISCUSSION AND RESULTS

PREHEATING VERSUS ELECTRIC HEATING—The importance of the nature of the surface and time of contact on the destruction of ammonia at high temperatures has been shown by the investigations of Ramsey and Young,¹ Perman and Atkinson,² and White and Melville.³ These experimenters showed that ammonia may be easily decomposed under certain conditions at moderately elevated temperatures. In spite of the fact that Ostwald's⁴ original patent provided for preheating and that the conditions to be met in preheating are quite different from those obtaining in the experiments of the above-named investigators, there seemed to be a pretty general impression at the time the Bureau of Mines began its experiments that preheating was likely to result in decomposition of ammonia and therefore should be avoided. Two United States patents lent support to this idea, that of Landis⁵ for precooling the ammonia-air mixture, and another issued to Kaiser⁶ for preheating the air separately and previously to its admixture with ammonia gas. Kaiser states in his patent that by preheating the mixture in quartz to 320°C . he obtained a yield of 66.8 per cent but when he preheated the air separately he obtained 99.8 per cent. These figures are nothing short of ridiculous. Is this another example of German camouflage patents?

Among the very first experiments performed in the laboratory was one in which a 10 per cent mixture of ammonia and air was passed through a column of bits of firebrick about 30 cm. long and 2 cm. in diameter contained in a glass combustion tube heated in an electric furnace to 700°C . At a rate of about 1 l. per min. there was no destruction of ammonia whatever in three separate trials. Tests on other materials have been given in Dr. Parsons' paper.

In Table I are shown some efficiencies obtained with and without the use of electric current to aid in heating the platinum gauze. They show clearly that the heat of reaction alone did not raise the gauze to the re-

¹ Parsons, *Loc. cit.*

² *This Journal*, 10 (1918), 457; 11 (1919), 27 and 544.

³ Waidner and Burgess, "Optical Pyrometry," Bureau of Standards, Bulletin 1, 247.

⁴ *This Journal*, 9 (1917), 1106.

¹ *J. Chem. Soc.*, 46 (1884), 88.

² *Proc. Roy. Soc.*, 74 (1904), 110.

³ *J. Am. Chem. Soc.*, 27 (1907), 373.

⁴ U. S. Patent 855,904.

⁵ U. S. Patent 1,193,796.

⁶ U. S. Patent 987,375.

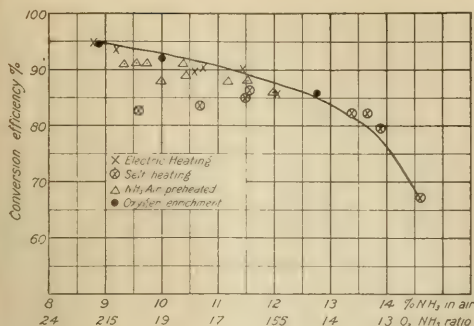


FIG. 2

quired temperature. In Table II are shown some efficiencies obtained by preheating the ammonia-air mixture. The fourth column of the table shows the temperature of the outside wall of the porcelain preheating tube and the fifth column the temperature of the ammonia-air mixture just after entering the oxidizer. The efficiencies of these tests compare very favorably with those of Table I at the same concentrations and gauze temperatures.

TABLE I—RESULTS OF TESTS WITH AND WITHOUT ELECTRICAL HEATING. NO PREHEATING OF AMMONIA-AIR MIXTURE

Test No.	Air Cu. Ft. per Hr.	Amperes	NH ₃ in Air Mixture Per cent	Temp. of Gauze Deg. C.	NH ₃ Escaping Oxidation Per cent	Conversion Efficiency
170	160	86	8.80	855	0.8	94.8
169	145	82	9.20	840	1.0	93.6
168	170	60	9.60	675	1.6	82.6
147	150	60	10.60	813	1.2	89.7
146	150	58	10.75	810	1.3	90.3
166	150	0	10.70	705	1.2	83.6
163	150	58	11.45	825	1.2	90.0
162	150	0	11.50	735	1.6	84.9
161	150	0	11.55	745	1.3	85.8
148	150	49	12.05	830	1.3	85.8
152	155	0	13.40	825	1.3	82.0
156	155	0	13.65	825	1.7	82.2
173	150	0	13.90	845	0.9	79.5
149	155	0	14.60	880	2.3	67.0
181	300	115	7.70	830	1.7	91.8
180	300	0	8.00	...	2.6	84.0
165	300	90	10.55	840	1.8	88.6
164	300	0	10.85	735	2.8	83.2
178	300	12	12.30	800	1.9	82.9
174	285	0	13.15	865	1.8	81.4

TABLE II—RESULTS OF TESTS PREHEATING THE AMMONIA-AIR MIXTURE

Test No.	Air Cu. Ft. per Hr.	NH ₃ in Air Mixture Per cent	Preheating Temperature Porcelain Tube Deg. C.	Oxidizer Temp. of Gauze Deg. C.	NH ₃ Escaping Oxidation Per cent	Conversion Efficiency
191	160	9.36	855	370	0.5	90.9
189	150	9.54	850	360	0.7	91.2
190	140	9.76	905	400	0.4	91.2
185	150	10.00	680	280	0.8	88.2
188	150	10.43	830	365	0.6	90.8
186	150	10.47	680	290	0.6	88.9
187	150	11.20	780	330	0.4	87.8
183	150	11.55	665	280	0.9	88.3
184	160	12.07	540	240	0.7	86.3

The curve of Fig. 2 represents the most probable values of conversion efficiencies of the gauze we were using at various ammonia concentrations, air velocity 150 cu. ft. per hr. and gauze temperature 800° to 900° C. All the points corresponding to the above velocity from Tables I and II are plotted in the figure. All the points except those representing ammonia concentrations below 11.5 per cent, where no energy was supplied except that furnished by the reaction itself, lie close to the curve. Fig. 2 shows clearly that there

is no intrinsic merit in electric heating. Any suitable method of maintaining gauze temperatures will result in satisfactory conversion efficiencies.

In order to determine whether ammonia suffered any decomposition by passage through the hot porcelain tube, a number of analyses of the air mixture were made before and after traversing the tube, with the results shown in Table III.

Temp. Outside Wall of Tube Deg. C.	NH ₃ Before Per cent	NH ₃ After Per cent
660	9.53	9.44
665	11.63	11.58
680	10.30	10.45
830	10.43	10.33
850	9.54	9.54
905	9.76	9.70

While the gas probably passed too rapidly to acquire anywhere near the temperatures of the tube, it is clear that ammonia may be easily preheated in a mixture with air in contact with a suitable surface without appreciable decomposition. Destruction of ammonia in the above table is seen to be less than 1 per cent, not much more than the error of analysis.

OXYGEN ENRICHMENT—In Table IV are presented some results obtained in June 1917 by using oxygen and air. Oxygen permitted the use of high enough ammonia concentrations to make the reaction self-sustaining. The results of Table IV plotted in Fig. 2 on the basis of oxygen-ammonia ratio by volume lie practically on the curve.

TABLE IV—RESULTS OF TESTS USING OXYGEN ENRICHMENT

Test No.	Air + Oxygen Cu. ft. per Hr.	Composition NH ₃ Mixture by Volume		Temp. Gauze Deg. C.	NH ₃ Escaping Oxidation Per cent	Conversion Efficiency Per cent
		Oxygen Per cent	Ammonia Per cent			
153	153	23.65	12.10	770	1.0	92.2
154	158	24.95	12.80	790	0.8	90.2
155	159	31.15	14.40	830	0.7	94.7
151	183	22.00	15.30	900	1.9	85.7
160	289	23.70	11.35	775	3.2	85.9
158	280	26.00	12.60	825	2.2	88.0

SUMMARY

I—A formula for calculating the heat of reaction of ammonia oxidation at any concentration and conversion efficiency has been developed.

II—The optimum temperature for conversion of ammonia to nitric acid by the catalytic oxidation method has been shown to lie above 800° C.

III—Both from calculation and experiment it has been shown that the heat of reaction developed at the optimum ammonia concentration is insufficient of itself to maintain catalysts at the optimum temperature.

IV—It is shown that electric heating, preheating the ammonia-air mixture, or utilizing oxygen, produce equally satisfactory results.

ACKNOWLEDGMENT

The work described in this paper was carried out under the immediate supervision of Dr. C. L. Parsons, to whom the writer is indebted for many helpful suggestions. A. S. Coolidge assisted in the heat of reaction calculations. Messrs. J. H. Capps, L. R. Lenhart, and R. C. Dabney assisted at various times in the laboratory.

OXIDATION IN THE MANUFACTURE OF TNT¹

By ALBERT S. EASTMAN

The nitration of cotton and the nitration of glycerin are carried out at such low temperatures that they are oxidized only very slightly by the mixture of nitric and sulfuric acids, and the spent acids contain only about 1 per cent of HNO_3 , as determined by titration with potassium permanganate. This substance represents the reduction products of the nitric acid, and is assumed to be formed by the union of nitrous acid or lower oxides of nitrogen with sulfuric acid in the absence of much water.

The nitration of toluene, however, is carried out at such a high temperature that there is considerable oxidation of the nitrotoluenes with a corresponding decrease in yield of TNT. The spent acid contains about 18 per cent of HNO_3 and an equivalent amount of oxygen must either have gone to oxidize some substance, or else it must have escaped in the free state. The nitrator contains a mixture of the various isomeric di- and trinitrotoluenes. In attempting to identify the products of the oxidation of these nitrotoluenes, we isolated 2,4-dinitrobenzoic acid. This is found in part of the charges, but most of them do not contain it in appreciable amounts. The total amount of organic acids formed by oxidation of the methyl group of the toluene has been determined in the spent acid the following way:

The nitric acid was removed from the spent acid by evaporation, and the sulfuric acid was removed by adding enough barium hydroxide to neutralize the solution, and filtering off the barium sulfate. The filtrate then contained the soluble barium salts of the organic acids, carboxylic acids formed by oxidation of the methyl group of the toluene, and sulfonic acids formed by the action of the strong sulfuric acid in the nitration.

The barium salts of the organic acids thus obtained were then analyzed by evaporating an aliquot part of the above filtrate to dryness, and weighing the dry barium salts. Then the residue was ignited in air to convert the barium salts of the carboxylic acids to barium carbonate and the barium salts of the sulfonic acids to barium sulfate. After weighing the mixture of carbonate and sulfate, the carbonate was removed by extraction with hydrochloric acid and the sulfate weighed. This furnished data from which the loss of toluene due to sulfonation and the loss due to oxidation to carboxylic acids, could be calculated. Assuming one acid group per molecule of toluene, there was 0.39 per cent loss of toluene by sulfonation and 1.24 per cent loss of toluene by oxidation to organic acid; total loss, 1.63 per cent.

The ignition loss from the dry barium organic salts may be regarded as representing the total loss of toluene, and this loss amounted to 1.86 per cent of the toluene used for nitration, which is an approximate check.

This loss of 1.24 per cent is so small as to account

for the formation of only a small part of the 18 per cent HNO_3 present in the spent acid, and it was therefore necessary to look for other oxidation products. The next experiments were designed to show whether any gases are formed during nitration. For this purpose the nitration was carried out in glass in an atmosphere of carbon dioxide, and the gas evolved was collected over sodium hydroxide solution, which absorbed the carbon dioxide. Separate nitrations were run in air to determine the amount of carbon dioxide liberated, the dioxide being absorbed in concentrated sodium hydroxide solution. In these experiments, dinitrotoluene or bi-oil, as it is called, was nitrated to trinitrotoluene. This is the third stage in the nitration of toluene to TNT.

It was found that carbon dioxide, carbon monoxide, nitrogen, and oxygen are evolved during nitration. One hundred parts of bi-oil, containing about 15 per cent TNT, liberate 7.39 parts carbon dioxide by weight, 0.495 part carbon monoxide, 0.409 part nitrogen, and 0.016 part free oxygen. The carbon dioxide and the carbon monoxide together represent the loss of sufficient TNT to lower the yield by about 5 per cent. As the yield obtained in the manufacture of TNT is about 86 per cent on the average, this loss amounts to more than one-third of the total loss sustained in the whole process of manufacturing TNT.

The composition of the gas liberated may vary considerably, even during a single nitration, as is shown by the varying inflammability of the mixture. The proportion of carbon monoxide may be so high under certain conditions that the gas mixture becomes explosive, and this may account for various explosions which have occurred in TNT nitrators, where the top of the nitrator has been blown off, without exploding the charge of TNT.

The experimental work described in this paper was carried out by Dr. W. J. Keith and Dr. J. E. Schott.

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STUDIES ON THE NITROTOLUENES. III—BINARY
SYSTEMS OF THE COMPONENTS *p*-NITRO-
TOLUENE, 1,2,4-DINITROTOLUENE,
1,2,4,6-TRINITROTOLUENE¹

By JAMES M. BELL and CHARLES H. HERTY, JR.

Received July 7, 1919

In the nitration of toluene by various methods, some of which are described by Hoffman,² the product is always composed of several nitrotoluenes. The chief compounds are: *p*-Nitrotoluene (MNT), *o*-nitrotoluene, 1,2,4-dinitrotoluene (DNT), and 1,2,4,6-trinitrotoluene (TNT). Present also, but in smaller quantity, are *m*-nitrotoluene and 1,2,6-dinitrotoluene. For an investigation of the conditions which would give maximum yields of any desired nitrotoluene, it is necessary first to have an accurate method of analysis of the product. Analyses by direct

¹ This paper is the third of a series dealing with the freezing points and thermal properties of the nitrotoluenes, the investigation having been undertaken at the request of the Division of Chemistry and Chemical Technology of the National Research Council.

² Bureau of Mines, *Technical Paper* 146 (1916).

¹ Read before the Division of Industrial Chemists and Chemical Engineers, 57th Meeting of the American Chemical Society, Buffalo, April 7 to 11, 1919.

methods are not possible, as the percentage of any constituent in DNT is the same as the percentage of that constituent in a mixture of equimolecular quantities of MNT and TNT, and as direct methods would not distinguish between isomers. For the analysis of such mixtures it is therefore necessary to resort to indirect means. Such methods depend on the construction of a chart or table from measurements of many synthetic mixtures of the components with respect to some physical property or properties. With any unknown mixture it is then possible to refer its measured physical values to the chart or table and to fix its composition. We have used the melting temperatures for this purpose for two-component systems and we shall later publish results upon the melting points of the three-component system of the three compounds MNT, DNT, and TNT.

PURIFICATION OF THE NITROTOLUENES—Commercial MNT and DNT were kindly furnished by Dr. C. G. Derick of the National Aniline and Chemical Company, and TNT was obtained from the du Pont Company. After many recrystallizations from alcohol and benzene and finally from pure alcohol, the three compounds were obtained pure, as was evidenced by the constant melting points.

MELTING POINT OF MNT—The melting point of MNT has been investigated recently by Rintoul,¹ who has also tabulated some of the earlier data. He finds that repeated crystallizations from absolute alcohol gave a product melting at 51.6° – 51.9° . In earlier work Mills,² using several solvents, obtained the constant melting temperature 51.3° . Auwers,³ who crystallized his material three times from alcohol, found the melting point to be 51.5° – 52.0° . Other investigators⁴ have used Kahlbaum's preparation with a melting point of 54° ; and Beilstein⁵ quotes Jaworski,⁶ Bartoli and earlier investigators as authority for the value 54° . This value has also been given by Hoffman⁷ in his description of the nitration of toluene. A recent handbook⁸ gives the value 52° , without reference to the authority.

It is evident from an examination of the literature that where several crystallizations were made, the melting point falls below 52° (51.3° to 51.9°), but where no descriptions are given for purification methods the value 54° is generally accepted. In the present work we have crystallized many times (3 times or more) and have found for successive crops of crystals the constant melting temperature 51.25° . It is probable that the true melting point is $51.5^{\circ} \pm 0.3^{\circ}$.

For the determination of this melting point, we have used the cooling-curve method. Five to 10 g. of the pure substance were melted in a test tube, in which was a thermometer reading to 0.1° . The tube was then

placed in a larger test tube, serving as an air-jacket. This was then placed in a large beaker of water, the temperature of which was held 4 or 5 degrees below the melting point of the compound. The molten mass was stirred constantly by means of a copper wire stirrer. The temperature fell rapidly until crystals appeared and then rose a little, the slight drop below the melting point being due to supercooling. The temperature then remained constant for from 10 to 20 min. This method gives much more accurate values than the small capillary tube method, but requires much larger samples of the substance.

MELTING POINT OF DNT—Various works of reference give the following temperatures of melting of DNT: 70° ,¹ 70.7° ,² and 71° .³ Bodewig⁴ gives 71° , Schiff⁵ gives 70.5° , and Guia⁶ gives 71° ; none of these authors offer evidence regarding the purity of their material. Beilstein and Kuhlberg⁷ give the melting point 70.5° after the substance had been crystallized once from CS_2 ; Mills⁸ finds 69.2° – 69.5° after the substance had been crystallized from several solvents. Taverne⁹ gives the melting point at 70° after the material had been crystallized several times from alcohol, and Rintoul¹⁰ finds 69.9 – 70.2° after numerous crystallizations from alcohol. We have found that successive crystallizations from alcohol yield a product of constant melting point, 69.5° – 69.6° . The most probable value is $69.6^{\circ} \pm 0.3^{\circ}$, using our determinations and those in which several crystallizations are recorded, *viz.*, those of Mills, Taverne and Rintoul.

MELTING POINT OF TNT—There is much more accord in the literature regarding TNT. Smith¹¹ adopts the mean of determinations by Comey¹² (80.5° to 80.6°), by Guia¹³ (80.65°), and by Rintoul¹⁴ (80.8° to 80.85°). Comey points out the importance of accurate information on this melting point, in the commercial testing of TNT. The handbooks have generally accepted the value 82° on the authority of Wilbrand.¹⁵ We have crystallized TNT repeatedly from alcohol and have obtained the constant melting temperature 80.35° . It seems probable that this value is correct to 0.3° .

MELTING POINTS OF BINARY MIXTURES—As there is no single temperature at which any given mixture changes entirely from liquid to solid, we shall take the usual meaning of the term "melting point." For mixtures this is the temperature where crystals first appear in the liquid. The accurate determination of such a temperature is frequently complicated by the phenomenon of supercooling, where the melt may cool several degrees below the normal freezing point be-

¹ Smith, "TNT and Other Nitrotoluenes," p. 102.

² Handbook of Chemistry and Physics, **1919**, 157.

³ Kempf, "Tabelle," p. 28; Bureau of Mines, *Technical Paper* **146**, p. 7.

⁴ Z. *Krysl.*, **3** (1879), 389, from *Jahresber.*, **1879**, 395.

⁵ *Ann.*, **223** (1884), 264.

⁶ *Ber.*, **47** (1914), 1718; *Gazz. chim. ital.*, [1] **45** (1915), 339.

⁷ *Ann.*, **155** (1870), 13.

⁸ *Phil. Mag.*, [4] **80** (1875), 17, from *Jahresber.*, **1875**, 377; *J. Chem. Soc.*, **41** (1882), 27, from *Jahresber.*, **1882**, 103.

⁹ *Rec. trav. chim.*, **17** (1898), 194.

¹⁰ *J. Soc. Chem. Ind.*, **34** (1915), 60.

¹¹ "TNT and Other Nitrotoluenes," p. 79.

¹² *This Journal*, **2** (1910), 107.

¹³ *Ber.*, **47** (1914), 1718; *Gazz. chim. ital.*, [1] **45** (1915), 339, 557.

¹⁴ *J. Soc. Chem. Ind.*, **34** (1915), 60.

¹⁵ *Ann.*, **128** (1863), 178, quoted by Comey.

¹ *J. Soc. Chem. Ind.*, **34** (1915), 60.

² *Phil. Mag.*, [4] **50** (1875), 17, from *Jahresber.*, **1875**, 377; *J. Chem. Soc.*, [3] **41** (1882), from *Jahresber.*, **1882**, 103.

³ *Z. physik. Chem.*, **30** (1899), 310.

⁴ Bartoli, *Gazz. chim. Ital.*, **15** (1885), 502; Neubeck, *Z. physik. Chem.*, **1** (1887), 657.

⁵ Beilstein, Vol. II, p. 92.

⁶ *Z. Chem.*, **1865**, 220, from *Jahresber.*, **1865**, 541.

⁷ Bureau of Mines, *Technical Paper* **146** (1916)

⁸ Handbook of Chemistry and Physics, 7th Ed., **1919**, 203.

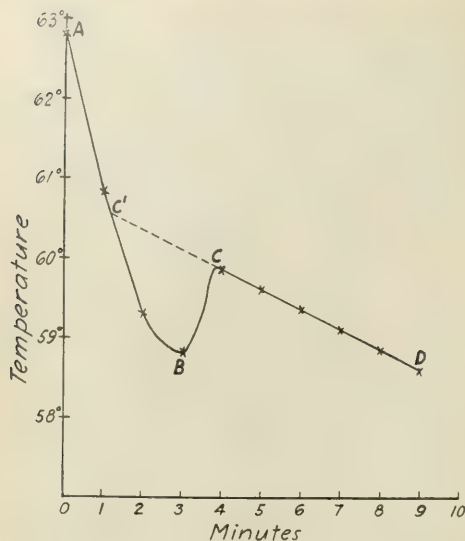


FIG. 1

fore crystals appear. Under such circumstances a considerable quantity of crystals appear and the composition of the remaining liquid is appreciably different from that of the original melt. The temperature observed in this way is not the same as would be found if the crystallization began regularly, for the composition of the liquid phase in equilibrium with crystals is different in the two cases. For aqueous solutions this error is somewhat adjusted by allowing the mixture to absorb heat slowly until the crystals just disappear, the last temperature being taken as the "freezing point of the solution." For such melts as we are here considering, however, the supercooling has sometimes been ignored with corresponding errors in the recorded temperatures of freezing. A common experimental method has been to study the melts by means of cooling curves. Let us examine a cooling curve in order to determine what point should be selected as the freezing point.

In Fig. 1 the (uncorrected) temperatures have been plotted during the cooling of a binary mixture of 20 per cent TNT and 80 per cent DNT. From A to B the mixture was molten and the cooling was rapid. At B, however, crystals appeared, thereby liberating the heat of fusion, and as a considerable quantity of crystals form quickly, the temperature rose to the point C. From C there is again a cooling which is slower than from A to B on account of the heat of fusion contributed as the crystals separate. The question now arises regarding the proper temperature to take as the freezing point. In numerous investigations the supercooling effects have been ignored and the freezing point has been assumed to be the point at which crystals first appear. This is the point B of the figure. It is apparent that the position of B is dependent on the degree of supercooling, which for

any given mixture may vary for duplicate trials. We have found as much as two degrees variation in the temperature of B, depending upon the extent of supercooling. We shall refer to this interpretation later, in explaining certain differences between our results and those of Giua.

A second interpretation of the plot is that the freezing point is the highest temperature attained after crystals have appeared, the point C of the figure. This interpretation is valid for finding the melting point of a pure compound, where there are no changes of composition in the liquid phase, but it is not valid where changes of composition occur. This second interpretation is frequently used in texts on physicochemical methods. The error involved is much less than by the first interpretation, but it is erroneous as the temperature found is the temperature of equilibrium between crystals and liquid, the liquid not having the same composition as the original liquid. In other words, the freezing point observed applies to a liquid of different composition from that for which it is recorded, and the extent of the error depends on the quantity of solid phase and this in turn depends on the degree of supercooling.

The third interpretation of the cooling curve makes the point C' the freezing point of the mixture, obtained graphically by extrapolating the branch DC back to the branch AB. The intersection of these curves gives the point at which the solid would appear in case no supercooling occurred, and this is of course the desired point.

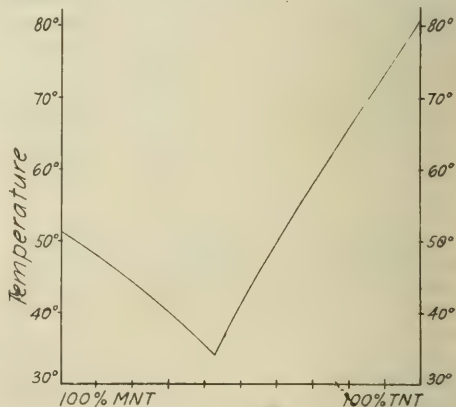


FIG. 2

The following table contains a comparison of results, using each of the three interpretations of the cooling curve for a mixture of DNT and TNT. In two tests the degree of supercooling was different, this difference being attributable in part to differences in temperature of the outside bath, which in one case was 46° and in the other 40°.

	Point B Degrees	Point C Degrees	Point C' Degrees
Bath at 46°.....	49.45	50.0	51.3
Bath at 40°.....	48.1	49.0	51.3

It will be observed that duplicate results are given

by taking C' as the freezing point, while duplicate results are not obtained by taking either B or C.

EXPERIMENTAL PROCEDURE

Five to 10 g. of the mixture accurately weighed were melted in a test tube provided with an accurate thermometer reading to 0.1° and with a copper stirrer. This tube was jacketed by a larger tube, which was placed in a 1500 cc. beaker of water, the temperature of which was held $4-5^\circ$ below the freezing point of the mixture. At first the temperature fell rapidly until crystals appeared, then rose a little and again fell, more slowly however than the original liquid. By the graphical method the temperature of freezing was found. Duplicate trials gave results agreeing within 0.2° .

After the primary freezing point had been determined, the mixture was further cooled until the eutectic temperature was reached. After slight supercooling the second solid phase appeared and the temperature remained constant for a period of time, depending upon the proportion of the liquid which remained to solidify. In each binary system the eutectic temperature was constant so far as certain experimental difficulties permitted. When the mixture was of high percentage in either component the quantity of solid was so great when the eutectic temperature was reached that the mixture could not be stirred. It is obvious that this may result in irregularities if in one portion of the paste the stable solid has appeared and in another portion it has not yet appeared. The lack of stirring may cause also a lack of uniformity of temperature in the mass. When the original mixture was nearer the eutectic mixture in composition these difficulties were not met and satisfactory concordant results were obtained for the eutectic point.

PER CENT BY WEIGHT MNT	PER CENT BY WEIGHT TNT	MOLECULAR PER CENT MNT	MOLECULAR PER CENT TNT	Freezing Point	Eutectic Point	Solid Phase
100	0	100	0	51.25°	
90	10	93.71	6.29	48.0	MNT
80	20	86.88	13.12	44.25	
70	30	79.44	20.56	40.1	33.85	
60	40	71.31	28.69	35.1	33.95	
55	45	66.93	33.07	36.35	34.0	TNT
50	50	62.35	37.65	41.35	34.2	
40	60	52.47	47.53	50.0	34.25	
30	70	41.52	58.48	57.9	33.7	
20	80	29.29	70.71	65.75	
10	90	15.54	84.46	73.1	
0	100	0	100	80.35	

PER CENT BY WEIGHT DNT	PER CENT BY WEIGHT TNT	MOLECULAR PER CENT DNT	MOLECULAR PER CENT TNT	Freezing Point	Eutectic Point	Solid Phase
100	0	100	0	69.54°	.....
90	10	91.82	8.18	65.7	.....	DNT
80	20	83.28	16.72	61.0	.....
70	30	74.42	25.58	55.65	45.4	
60	40	65.16	34.84	50.95	45.6	
45	55	50.51	49.49	50.4	45.55	TNT
40	60	45.39	54.61	54.3	45.55	
30	70	34.82	65.18	61.5	.....
20	80	23.76	76.24	68.5	.....
10	90	12.17	87.83	74.4	.....
0	100	0	100	80.35	.....

PER CENT BY WEIGHT MNT	PER CENT BY WEIGHT DNT	MOLECULAR PER CENT MNT	MOLECULAR PER CENT DNT	Freezing Point	Eutectic Point	Solid Phase
100	0	100	0	51.25°	.....
90	10	92.28	7.72	47.35	.....	MNT
80	20	84.16	15.84	42.5	.....
70	30	75.61	24.39	36.95	26.54	
60	40	66.59	33.41	31.1	26.48	
50	50	57.05	42.95	28.65	26.54	DNT
45	55	52.09	47.91	33.45	26.44	
40	60	46.97	53.03	37.8	26.48	
30	70	36.28	63.72	47.3	.....
20	80	24.93	75.07	55.41	.....
10	90	12.86	87.14	62.45	.....
0	100	0	100	69.54	.....

BINARY SYSTEM: MNT, TNT—Table I and Fig. 2 show the freezing points of a number of mixtures of these components. There are two branches to the curve, one where the solid phase is MNT and the other where the solid phase is TNT. These curves intersect at the eutectic point found for these components.

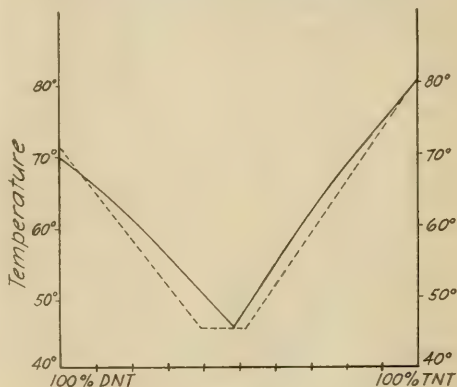


FIG. 3

DISCUSSION OF RESULTS

These binary systems have been studied also by Giua¹ who has given somewhat different data. Our results are in close accord with those of Giua for the melting points of the pure components, except for MNT where we find 51.25° and Giua gives 53° and 54° in the two publications cited. We also agree on the eutectic points. The position of the freezing-point curves is lower according to Giua than according to our measurements. This difference we attribute to Giua's interpretation of cooling curves, for he gives the freezing point as "Beginn der Krystallization" and "initio della cristallizzazione." It seems highly probable that Giua took the point B of Fig. 1 and therefore read temperatures lower than the true freezing points.

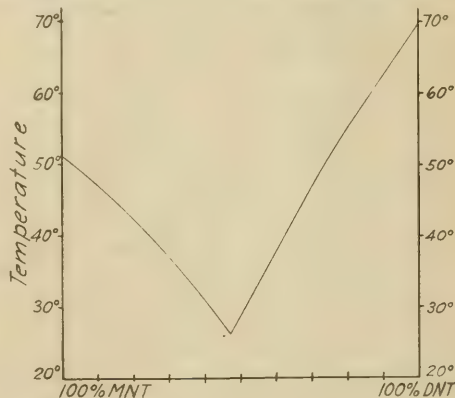


FIG. 4

¹ Ber., 47 (1914), 1718; Gazz. chim. ital., [1] 45 (1915), 339.

In many of our cooling curves we find that the temperature of point B, Fig. 1, at which crystals first appear, agrees with the values recorded by Giua. We have plotted his results on Fig. 3 for DNT-TNT. These freezing-point curves do not intersect at the eutectic point, a condition which is interpreted as indicating the existence of a compound of the components. Of course, if Giua's data are taken as correct, this must be the proper interpretation of the curves.

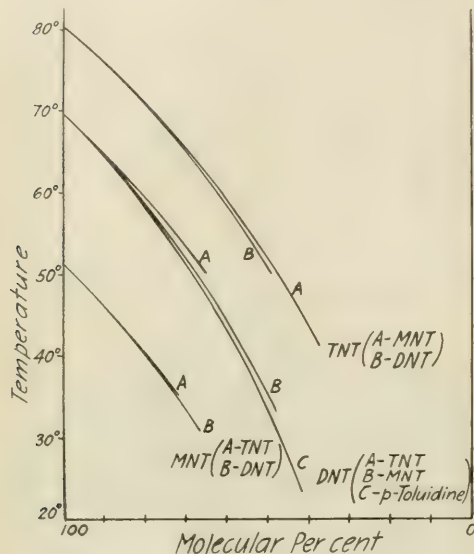


FIG. 5

Thus in all three of these binary systems Giua claims the existence of compounds over a narrow range of concentration. In none of the cases did we obtain a result other than the intersection of the freezing-point curves at the temperature found for the eutectic point. Giua's conclusions therefore regarding the existence of molecular compounds in these three cases seem to be erroneous.

In the first paper of this series,¹ the effect of various nitrotoluenes on the freezing point of trinitroxylenes was studied and the results were found to accord fairly well with a formula based on the assumption that these mixtures were "ideal solutions." It is possible to test the validity of the assumption of "ideal solutions" in another way. Thus the freezing point of such a mixture should depend on the molecular fraction of the freezing component and not on the nature of the other component or components, provided the components are of like chemical character. When, therefore, the freezing-point curves are drawn using molecular percentages, the curves should coincide. In Fig. 5 are shown the freezing points of the nitrotoluenes as influenced by other substances. The curves for MNT and the curves for TNT fall quite close together,

and it is concluded that the mixtures obey the ideal solution law. The curves for DNT do not lie so close together. The effect of *p*-toluidine on the freezing point of DNT is from the results of Kremann and Petritschek.¹ The cause or causes of the deviation may be found when another investigation now in progress has been completed. The formula based on "ideal solutions" involves the latent heat of fusion, regarding which no data could be found in the literature. The direct determination of the latent heat of fusion of all of these nitrotoluenes will form another paper of this series.

SUMMARY

In this paper we have given a discussion of the melting points of MNT, DNT and TNT, a discussion of the interpretation of cooling curves, and the data for the three binary systems of these nitrotoluenes.

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STUDIES ON THE NITROTOLUENES. IV—THE THREE-COMPONENT SYSTEM: *p*-NITROTOLUENE, 1,2,4-DINITROTOLUENE, 1,2,4,6-TRINITROTOLUENE²

By JAMES M. BELL AND CHARLES H. HERTY, JR.

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In the third paper of this series we have given the results of a study of the three binary systems of the nitrotoluenes: *p*-Nitrotoluene (MNT), 1,2,4-dinitrotoluene (DNT), and 1,2,4,6-trinitrotoluene (TNT). The present paper contains the results of a study of the ternary system of these components. We have again employed the cooling-curve method of finding the temperatures at which the various solid phases appear, using the extrapolation method of overcoming the difficulty introduced by the phenomenon of supercooling. This method was described in detail in the paper above referred to.³

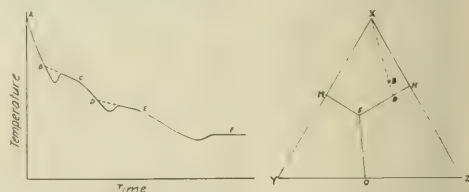


FIG. 1

For a binary mixture there are two freezing points: The primary freezing point at which the first solid appears, and the binary eutectic point where the two solids are in equilibrium with the melt. For a ternary mixture there are three freezing points: The primary freezing point at which the first solid appears, the secondary freezing point at which the second solid appears, and the ternary eutectic point where all three solids are in equilibrium with the melt or eutectic mixture. The last temperature was not difficult to determine

¹ Monatsh., **38** (1917), 385.

² This paper is the fourth of a series dealing with the freezing points and thermal properties of the nitrotoluenes, the investigation having been undertaken at the request of the Division of Chemistry and Chemical Technology of the National Research Council.

³ THIS JOURNAL, **11** (1919), 1025.

¹ THIS JOURNAL, **11** (1919), 1025

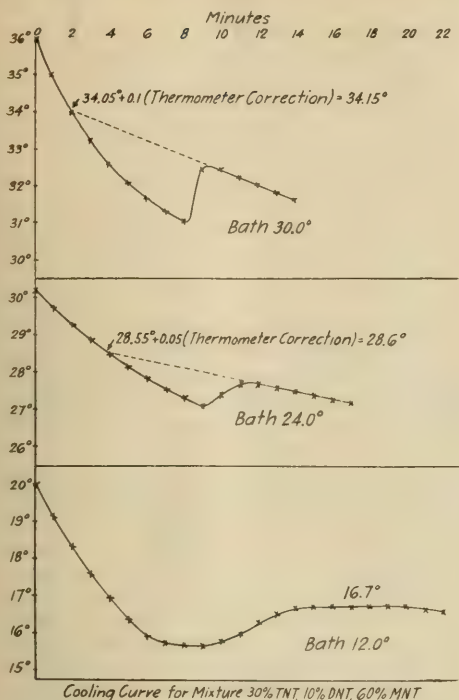


FIG. 2

in most cases, for the temperature remains constant for a considerable time. In the case of the primary and secondary freezing points, great supercooling frequently occurred where DNT was the solid which should separate out. In such cases it became necessary to "seed" the mixture with a few small crystals of DNT in order to start crystallization. Where successive freezing points are close together, it was necessary to maintain the bath at an intermediate temperature, so that no confusion would arise, due to the possible appearance of crystals out of turn. Suppose, for instance, that the liquid is supercooled with respect to two solids. There is no assurance that the one which normally appears at the higher temperature will appear first in the supercooled mixture.

The results for this ternary system have been plotted on the conventional triangular diagram. We have found that there are only three solid phases which separate, viz., the three components. No evidence whatever was discovered pointing to binary molecular compounds, as claimed by Giua,¹ or of ternary molecular compounds. The diagram therefore consists of three fields separated by three boundary curves which intersect in the ternary eutectic point.

In Fig. 1 we have shown the behavior of a typical mixture upon cooling. This mixture had the composition: 60 per cent MNT, 10 per cent DNT, and 30 per cent TNT, and is represented by the point B

of the triangular figure. A preliminary trial showed that the primary freezing point was near 34° and that the secondary freezing point was near 29°. In order to determine more accurately the first freezing point, the bath was held at 30° and the time-temperature curve plotted. This is the portion ABC of Fig. 1 and is given on larger scale in the first section of Fig. 2. It is seen that 34.15° is the primary temperature of freezing. At C the temperature of the bath was lowered to 24° and the cooling of course became more rapid. Section 2 of Fig. 2 shows that the secondary temperature of freezing is 28.6°. At E the bath was again cooled to 12° and Section 3 of Fig. 2 shows the eutectic temperature to be 16.7°. During these changes of temperature the composition of the melt has undergone changes which may be followed on the triangular diagram, Fig. 1. The melt passes first from composition B to D, a point on the boundary curve, and then follows the boundary curve to F, the eutectic mixture. Many such ternary mixtures have been studied in this way and the freezing points found are given in Table I.

The results in Table I also furnish the necessary data for finding points on the boundary curves. Fig. 3 shows the data for different mixtures, each containing 10 per cent DNT, the percentages of TNT being the abscissae. It is obvious that on the line for 10 per cent of DNT in the triangular diagram, the lowest primary freezing point and also the highest secondary freezing point are both where the 10 per cent line cuts the boundary curve. Moreover these points are co-

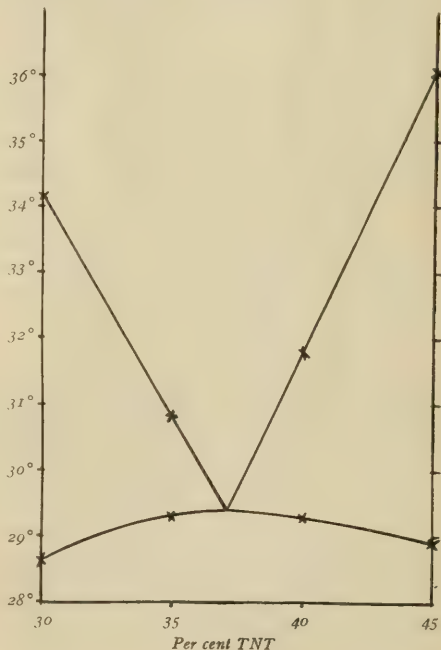


FIG. 3

¹ Ber., 47 (1914), 1718; Gass. chim. ital., [1] 45 (1915), 339.

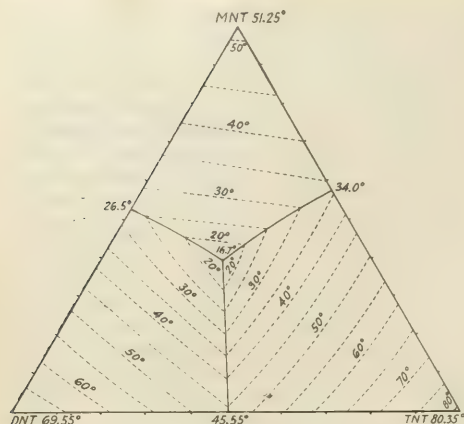


FIG. 4

incident. Thus by the interpolation method of Fig. 3 both the temperature and composition of points on the boundary curves may be found. By this method the points given in Table II have been located.

TABLE I—FREEZING POINTS OF TERNARY MIXTURES

COMPOSITION IN WEIGHT, PER CENTS			FREEZING POINTS, DEGREES	
MNT	DNT	TNT	Primary	Secondary
60	30	10	31.55	22.55
60	10	30	34.15	28.6
55	35	10	27.85	22.9
55	25	20	28.95	16.85
55	10	35	30.65	29.3
50	30	20	24.8	17.9
50	25	25	25.1	18.7
50	10	40	31.65	29.2
45	45	10	25.6	23.2
45	10	45	36.05	28.95
40	50	10	29.4	23.0
40	40	20	22.65	18.6
40	30	30	18.0	17.6
40	25	35	24.9	20.6
35	50	15	30.1	17.75
35	45	20	25.5	17.75
35	40	25	21.8	18.6
35	30	35	24.55	16.85
35	25	40	30.65	19.1
25	50	25	34.25	22.25
25	45	30	29.85	24.6
25	35	40	31.5	24.1
25	30	45	37.95	22.85
10	60	30	46.8	36.9
10	55	35	43.85	37.95
10	45	45	40.05	39.15
10	40	50	44.25	38.35

TABLE II—DATA FOR POINTS ON BOUNDARY CURVES

COMPOSITION IN WEIGHT, PER CENTS			FREEZING TEMPERATURE	
MNT	DNT	TNT	DEGREES	
48.5	41.5	10	23.4	
43.5	36.5	20	18.95	
52.5	10	37.5	29.35	
44	25	31	20.8	
41	30	29	17.8	
10	46.7	43.3	39.2	
25	39.8	35.2	25.4	
35	35.2	29.8	17.5	

These points fall exactly on smooth curves which approximate to straight lines, the boundary curves being drawn to scale in Figs. 4 and 5. From the data of Tables I and II, and from the data for the binary systems in the third paper of this series, Figs. 4 and 5 have been constructed. Fig. 4 shows the isothermals for the primary freezing points, and Fig. 5 shows the isothermals for the secondary freezing points, the latter isothermals being of course straight lines from the vertices of the triangle. The composition of the eutectic mixture is 39 per cent MNT, 33.5 per cent DNT, and 27.5 per cent TNT and the eutectic temperature is 16.7°.

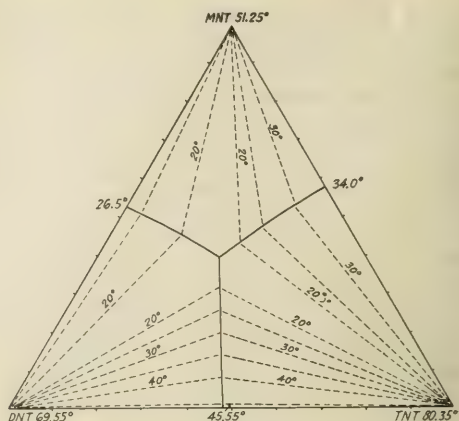


FIG. 5

With the above tabulated data it is possible to identify any unknown mixture of these three components. First, the primary and the secondary freezing points should be determined, and then the identity of the solid phases should be established. The methods of finding freezing points have already been given. For the identification of the solid phases an indirect method is proposed rather than the doubtful method of trying to isolate the freezing component free from the melt. The following consideration demonstrated how this indirect identification may be made. Take any mixture, say B of Fig. 1. The addition of component X to the mixture raises the primary freezing point, and the addition of either Y or Z to the mixture lowers the primary freezing point. The first phase to separate is therefore that one which, when added to the unknown mixture, raises the primary freezing point. Similarly it may also be shown that the second phase to separate is that one of Y or Z whose addition to the unknown mixture raises the secondary freezing point. We are thus able to locate the unknown in one of the six triangles of Fig. 1: XMF, XNF, YMF, YOF, ZOF, or ZNF. Reference to Figs. 4 and 5 locates the point from the temperatures of primary and of secondary freezing.

SUMMARY

In this paper we have shown how to identify any unknown mixture of the three nitrotoluenes, MNT, DNT, and TNT, from a study of the ternary system of these components.

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PARACYMENE. III—PREPARATION OF 2-CHLORO-5,6-DINITROCYMENE

By H. A. LUBS AND R. C. YOUNG

Received July 31, 1919

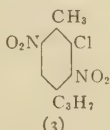
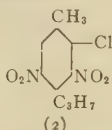
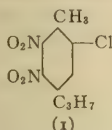
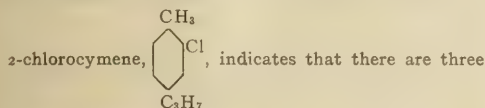
This compound was first prepared by von Gerichten¹ in 1878, who, however, simply described it as a dinitrochlorocymene melting from 108° to 109°, and

¹ Ber., 11 (1878), 1091.

made no attempt to determine the orientation of the various groups. Moreover, von Gerichten's description of its method of preparation is very meager, no mention being made of the amount of acids, time, or temperature necessary for nitration. Neither does he state the yield obtainable. Fileta and Crosa,¹ ten years later, prepared the same compound, but neither did they determine the positions of the various groups. They mention the fact that besides the solid dinitrochlor compound melting from 109° to 110°, there is also produced a liquid isomer. Their evidence in support of this statement is solely that an analysis of the liquid indicated it to be a dinitrochlor compound.

In addition to a solid compound melting from 108° to 109° we have isolated from the reaction product a substance which at first appeared to be an isomeric solid dinitrochlorocymene melting from 90° to 91°. Analyses showed that this supposedly dinitrochlorocymene was in reality a dinitrochlor compound but one containing a smaller amount of carbon and hydrogen than the corresponding cymene derivative.

A consideration of the constitutional formula of



By reducing the dinitrochlor compound and determining whether the substance formed is an *o*-, *m*-, or *p*-diamine, the position of the various substituents can be established. Since there are a number of general reactions for the differentiation and characterization of the various diamines, the solution of this problem is a relatively simple matter. Our work proves that the compound described by von Gerichten is identical with Formula 1.

In addition to the two crystalline compounds there is also obtained a heavy liquid which, upon analysis, gives a nitrogen content corresponding quite closely to that of dinitrochlorocymene. We did not investigate this oil very extensively, but obtained evidence that it is composed partially at least of a mixture of the two compounds previously described.

EXPERIMENTAL WORK

The starting material used is *p*-cymene prepared by the purification of crude spruce "turpentine." This is chlorinated, nitrated, and the resulting dinitrochlor compounds reduced.

PREPARATION OF 2-CHLOROCYME—Chlorine is passed into *p*-cymene containing iron filings until slightly more than the theoretical gain in weight is obtained. The temperature is not allowed to rise

above 35°. The resulting product is washed with water, then with sodium carbonate solution, dried over calcium chloride, and fractionated *in vacuo*. Most of the material boils between 85° and 90° at 5 mm. pressure. This portion gives upon analysis practically the theoretical amount of chlorine for monochlorocymene. At atmospheric pressure practically all of this fraction boils between 215° and 218°. This material is used in the nitrations.

NITRATION OF 2-CHLOROCYME—It was found that an ordinary tin can was far superior to a glass vessel for the nitration because of the much greater heat conductivity of the former. A mixture of 140 g. of concentrated sulfuric acid and 194 g. of 25 per cent fuming sulfuric acid is cooled to 0° and 84 g. of 2-chlorocymene added slowly so as to prevent any considerable rise in temperature. To the same amount of concentrated and fuming sulfuric acid mixture are added 72 g. of fuming nitric acid. This mixed acid is then dropped into the well-agitated sulfuric acid chlorocymene mixture at a rate such that the temperature does not rise above 0°. At the end of the reaction, a solid collecting at the top of the acid mixture interferes with the stirring and tends to stall the motor. This solid is then mechanically separated and mixed with cracked ice. It is then washed with cold water, and with sodium carbonate solution, and filtered. By the filtration a portion of the adhering oil is also removed which weighs about 15 g. About 17 g. more of partially oily and solid material are obtained by pouring the acid mixture on cracked ice and extracting with ether. The ethereal solution is washed with water and sodium carbonate solution and the ether evaporated. The solid material which is mechanically removed from the acid mixture, after washing with water, sodium carbonate solution, and filtering, is washed with about 100 cc. of alcohol to free it further from oil and it is then recrystallized twice from about 200 cc. of alcohol. In this way about 30 g. of a slightly yellow crystalline product are obtained which melt at from 108° to 109°. Evaporation of the alcoholic mother liquors yields approximately 26 g. of material, hence the total weight of material isolated from 84 g. of chlorocymene amounts to about 88 g.

In one case there was obtained a small amount of material practically insoluble in alcohol, ether, and water, and infusible in a sulfuric acid bath. Though not identified, this compound appeared to be very similar to a chloroterephthalic acid. Such a compound could easily be formed from the oxidation of the methyl and isopropyl groups by nitric acid.

The dinitrochlor compound melting from 108° to 109° was analyzed for chlorine.

Calculated for $C_{10}H_7N_2ClO_4$, 13.7 per cent Cl. Found: 13.9, 13.8 per cent.

Optical properties of 2-chloro-5,6-dinitrocymene, m. p. 108°–109°, were determined by the immersion method under the microscope, using potassium-mercuric iodide liquids of known indices, as follows:¹

CRYSTALLIZATION—Plates and rods, probably belonging to the monoclinic system.

¹ Thanks are due to Edgar T. Wherry for the crystallographic work.

¹ *Gazz. chim. ital.*, 18 (1888), 296.

IN ORDINARY LIGHT—Colorless; in rods and plates, with irregular fracture.

REFRACTIVE INDICES (D)— $\alpha = 1.550$, $\beta = 1.645$, $\gamma = 1.660$, $\delta - \alpha = 0.110$; all ± 0.005 . Intermediate values are usually shown.

IN PARALLEL POLARIZED LIGHT—Extinction is often inclined, attaining a maximum angle of 30° . The double refraction is extreme, fourth order colors being frequently shown. Sign of elongation usually +.

IN CONVERGENT POLARIZED LIGHT—Biaxial, and partial interference figures often seen, the axial plane running lengthwise of the rods. The axial angle is fairly large, about $2E = 70^\circ$, and the sign —. The dispersion is strong, with $2E_r < 2E_o$.

ISOLATION OF A SECOND DINITROCHLORO COMPOUND

When the liquid which was separated from the solid dinitrochlorocymene was allowed to stand in the ice box for several days, a small amount of crystals separated. Upon pouring off the supernatant oil, washing the crystals with cold alcohol and then recrystallizing from alcohol, yellowish needles with a melting point from 88° to 89° were obtained. In physical appearance they were very similar to the 2-Cl, 5,6-dinitrocymene. An ultimate analysis indicated its formula to be $C_7H_8N_2O_4Cl$ and not $C_{10}H_{12}N_2O_4Cl$ and hence there can be no doubt about these two compounds not being isomeric. It appears that during the nitration, a portion of the chlorocymene was oxidized to a compound poorer in carbon, and this compound subsequently nitrated. That such reaction can occur is indicated by the statement in Danish Patent No. 23,344, that *p*-nitrotoluene is produced by sulfonating *p*-cymene and then treating the product with nitric acid at a temperature from 40° to 60° .

This dinitrochloro compound can be reduced to a base melting from 115° to 116° , which from color reactions appears to have the amino groups in the meta position. Only a small amount of this base was isolated and hence it was not extensively investigated.

The following analyses¹ were obtained of the compound melting from 88° to 89° .

SAMPLE 1 PER CENT	SAMPLE 2 PER CENT	AVERAGE PER CENT	THEORETICAL PER CENT FOR $C_7H_8N_2O_4Cl$
C.....	38.7	39.5	39.1
H.....	2.7	2.5	2.6
N.....	12.6	12.5	12.6
Cl.....	15.7	15.6	15.7

Crystallographic properties of the compound melting from 88° to 89° are as follows:

CRYSTALLIZATION—Needles, probably monoclinic.

IN ORDINARY LIGHT—Colorless; in needles or rods, with irregular fracture.

REFRACTIVE INDICES (D)— $\alpha = 1.640$, $\beta = 1.660$, $\gamma = 1.720$, $\gamma - \alpha = 0.080$; all ± 0.005 . Intermediate values are usually shown.

IN PARALLEL POLARIZED LIGHT—Extinction is inclined and may reach 40° . The double refraction is extremely strong, the colors being usually third order. The sign of elongation varies, but is more often —.

IN CONVERGENT POLARIZED LIGHT—Biaxial, the axial plane running crosswise, one optic axis often emerging in sight. The axial angle is large, about $2E = 120^\circ$, and the sign is +. The dispersion is strong, with $2E_r > 2E_o$.

¹ The analyses for C, H, and N were made for us by L. J. Jenkins of the Nitrogen Laboratory of this Bureau, to whom we wish to acknowledge our thanks.

In an attempt to determine the ease with which the chlorine could be hydrolyzed from the nucleus an interesting color reaction was discovered, the nature of which we cannot explain. Upon heating about 20 mg. of the compound melting from 88° to 89° with several cc. of alcohol and adding a trace of solid sodium carbonate an intense blue color was developed in the alcoholic solution. This reaction was very useful to us in testing the various fractions for the presence of this compound since the blue coloration was not formed by the dinitrochlorocymene under identical conditions.

REDUCTION OF 2-CL, 5,6-DINITRO-*p*-CYMENE—After trying various reducing agents, the best procedure for the preparation of the diamino compound was found to be the following:

The dinitro compound is heated with water, and zinc dust and hydrochloric acid in small portions gradually added. A large excess of reagents is required. At the end of the reduction, especially if too large an excess of acid is avoided, the zinc chloride double compound with the diamino derivative precipitates out and can be filtered off. The double compound is then mixed with cracked ice and decomposed with strong ammonia water whereby practically all of the zinc goes into solution. The base is then separated from a small amount of zinc oxide by means of ether and the ethereal solution evaporated *in vacuo*. The product thus obtained can be recrystallized from ligroine in the form of rods or needles with a melting point from 67° to 68° . This compound was analyzed for nitrogen.

Calculated for $C_{10}H_{12}N_2Cl$, 14.1 per cent N. Found: 13.7, 13.5 per cent

These slightly low results are possibly due to traces of ligroine which could be removed only with difficulty.

DETERMINATION OF THE ORIENTATION OF THE AMINO GROUPS IN 1-CL, 5,6-DIAMINO-*p*-CYMENE—By showing whether this compound is an *o*-, *p*-, or *m*-diamine the position of the various substituents is established. That this diamine is an ortho compound is evident from the following reactions:¹

1—An ethereal solution of the free base gives an intense blue color upon being shaken with a few drops of dilute ferric chloride solution. Such a blue color is given by 1,2-diaminonaphthalene and *o*-phenylenediamine but not by *m*- or *p*-phenylenediamine.

2—Upon boiling the free base with glacial acetic acid, evaporating the acetic acid, diluting with water and neutralizing, a yellowish precipitate is obtained which is soluble in hydrochloric acid.

3—The free base gives the phenanthrazine reaction which is characteristic of *o*-diamines. Upon adding a saturated solution of phenanthraquinone to an alcoholic solution of the free base and boiling, a yellowish precipitate which increases in amount upon cooling is obtained.

4—Upon condensing the free base with ammonium sulfoeyanide and treating the product with alcoholic

¹ For a discussion of the reactions for the characterization of diamines and the literature pertaining thereto, see "Analyse und Konstitutionsermittlung organischer Verbindungen," Hans Meyer, Berlin (1909).

lead acetate, no lead sulfide is formed. This indicates that the diamine is not a meta or para compound.

5—The diamino compound does not give the Bismarck-Brown reaction characteristic of meta diamines.

6—This diamino compound does not give Lauth's reaction for *p*-diamines upon digesting in acid solution with hydrogen sulfide and ferric chloride.

SUMMARY

The nitration of 2-Cl-*p*-cymene does not proceed smoothly with the simple formation of dinitrochlorocymene. The principal product formed is 2-chloro-5,6-dinitro-*p*-cymene. Apparently an isomer is also formed which was not isolated.

Another dinitrochlor compound, with less carbon than that present in dinitrochlorocymene, is formed in small amount. The constitution has not been established.

A small amount of a compound of unknown constitution was also formed. This may be possibly a chloroterephthalic acid.

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THE CARBOHYDRATES OF FRESH AND DEHYDRATED VEGETABLES

By K. GEORGE FALK
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The changes in enzyme action produced by dehydrating vegetables were described in a previous paper.¹ In this paper the results of the study of the content and distribution of carbohydrates in fresh and dehydrated vegetables are communicated. Carrots, potatoes, cabbage, and white turnips, fresh and dehydrated by the air-blast and vacuum processes, were analyzed for reducing sugars, dextrins and soluble starch, and insoluble starch (by difference after hydrolysis).

ple sugars (alcohol extraction) before and after hydrolysis, and reduction by dextrins and soluble starch (water extraction) after hydrolysis. The results were calculated as grams of cuprous oxide per gram of moisture-free substance (dried at 100°), and as percentages of total reducing power as evidenced by the weights of cuprous oxide. Fehling's solution was used for the determinations of the reducing powers.¹

The results obtained indicated that no change in the carbohydrate distribution as determined (such as a breakdown of the more complex to the simpler constituents during dehydration) was observable. Certain precautions, however, had to be taken in the analyses. In the alcohol extractions, treatment of the fresh vegetable, 20 to 30 g. with 200 cc. alcohol, included the water present in the vegetable. In order to prevent change, the fresh vegetable was not dried before the analysis. To parallel the conditions, with 3 to 4 g. of the dehydrated vegetable, 20 to 25 g. of water were added in the alcohol extraction. If this were not done, the more dilute alcohol with the fresh vegetable extracted more material than the more concentrated with the dehydrated. This was then shown by the increased water-extracted materials (dextrins and soluble starch) from the dehydrated substance, indicating erroneously a conversion of insoluble starch into dextrins and soluble starch.

Two complete series of results with carrots and potatoes are given in the table. The results in parentheses were obtained without the addition of water to the dehydrated vegetables in the alcohol extractions.

The alcohol-soluble sugars of the vacuum-dehydrated carrots shown in the table are apparently somewhat low, due to some unknown factor in the determination. In view of the possible experimental errors of sampling and extracting, these results, as well as the results of a number of other experiments, indicate no change in carbohydrate distribution as deter-

CUPROUS OXIDE PER GRAM SUBSTANCE

	Moisture Per cent	Total Reduction	—Alcohol Extract— Before Hydrolysis	After Hydrolysis	Water Extract After Hydrolysis	—Reducing Sugars— Before Hydrolysis Per cent of total	After Hydrolysis Per cent of Total	Dextrins + Sol. Starch Per cent of Total	Insol. Starch (by Diff.) Per cent of Total
CARROTS:									
Fresh.....	88.4	1.197	0.684	1.104	0.032	57.1	92.2	2.7	5.1
Air dehydrated.....	12.8	1.151	0.619 (0.562)	0.986 (1.039)	0.043 (0.085)	53.8	85.7	3.7	10.6
Vacuum dehydrated.....	12.5	1.171	0.567 (0.540)	0.869 (1.065)	0.049 (0.059)	48.5	74.2	4.2	21.6
POTATOES:									
Fresh.....	73.8	1.842	0.046	0.091	0.011	2.5	4.9	0.5	94.6
Air dehydrated.....	11.2	2.024	0.056 (0.045)	0.134 (0.079)	0.011 (0.063)	2.7	6.6	0.5	92.9
Vacuum dehydrated.....	13.7	2.020	0.058 (0.056)	0.106 (0.067)	0.010 (0.030)	2.9	5.2	0.5	94.3

Samples from the same vegetable, as uniform as possible, were used for each process. The separation of the reducing sugars and of dextrins and soluble starch was based upon the method of Street and Bailey,² which consisted in successively treating the vegetable with boiling 95 per cent alcohol and with cold water. The determinations made included total reducing power (after hydrolysis), reduction by sim-

mined. Cabbage and white turnips gave results similar to these, except for somewhat different amounts of the various constituents.

Thanks are due to Miss E. Blount, Mr. I. Newirth, and Mr. J. Gross for carrying out the large number of analyses required in this investigation.

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¹ K. G. Falk, C. McGuire and E. Blount, *J. Biol. Chem.*, **38** (1919), 229.

² *This Journal*, **7** (1915), 853.

³ H. C. Sherman, "Methods of Organic Analysis," 2nd Ed., **1912**, 74.

POSSIBILITY OF COMMERCIAL UTILIZATION OF TOMATO SEED AND GRAPE SEED¹

By J. H. SHREADER

To all conversant with the canning industry, it is apparent that there is annually produced an appreciable tonnage of canning-house waste in the form of trimmings, skin, and seed. It is also generally recognized that this waste has some value as a stock food and as an oil-yielding material. Several attempts have been made to ascertain the commercial possibilities in its utilization for the above purposes, but without encouraging results.

In this investigation it was recognized that there is not produced at any given place enough waste to make its commercialization profitable, but it was felt that if all the waste in readily accessible localities could be assembled at some center, there would then, perhaps, be a great enough tonnage to make its fabrication profitable.

The industries producing the greatest tonnage are the tomato pulping stations and the grape juice plants. In making tomato catsup, pulp, paste, puree, and soup, the tomatoes are ground up in what are called cyclone machines. These are power applications of the housewife's colander. The soft red pulp and the juice are forced through perforations in a screen, while the skin, cores and seed are discarded. All of this is called cyclone waste. The proportion of this waste to the original tomatoes varies according to the character of the tomato and the operation of the given plant, ranging from 4 to 10 per cent by weight. I have used a value of 5 per cent. The dry seed usually comprise about 0.5 per cent of the tomato which is one-tenth of the above cyclone waste. In one exceptionally large plant they have produced and commercialized a variety of tomato in which the seed are only one-half of this.

In the grape juice industry the grapes are pressed in ordinary cider presses to obtain the juice. The skins, seed and pulp remain behind in the cloths. This waste is about 20 per cent of the original grapes, of which the seed constitute about one-quarter. Hence 100 lbs. of grapes yield about 10 lbs. of dry pomace, which in turn yields 5 lbs. of seed and 5 lbs. of dry residue.

Tomato cyclone waste consists of about 80 per cent water, and grape pomace about 50 per cent. A method has been worked out and operated on a factory scale whereby the wet seed of the tomato can be separated quantitatively (commercially speaking) from the rest of the undried material. A method has been worked out in the laboratory on a semi-commercial scale whereby grape seed can be separated from wet grape pomace without recourse to drying. This seed separation will enable the producer to separate his seed from the rest of the waste at each pulping and pressing station. This makes him independent of the necessity of shipping all of his waste to the central plant when freight rates make such shipment prohibitive. The

adopted methods of seed separation are continuous, cheap and foolproof. All of this equipment should be installed by the company operating the recovery plant and charged against the original investment.

Pumpkin seed are shipped as such for they are denuded of most of their pulp in the regular canning operations.

Cherry pits are available to the extent of several hundred tons, but the technology of their utilization has not been completely worked out.

In all cases above considered, I have obtained from the waste-producing stations in Maryland, Delaware, New Jersey, New York, Ohio, Indiana and Illinois the actual tonnage of raw material handled by them for each of the past five years. From these readily ascertained figures of raw materials I calculated the waste, using the above percentages of 5 per cent for tomatoes and 20 per cent for grapes. This was the only practical method for ascertaining with any degree of reliability the actual amounts of waste available. From freight rates covering transportation in car lots and less than car lots, I figured the assembling charges. For tomato cyclone waste as such, 12,500 tons cost about \$80,000 to assemble at Indianapolis and \$73,000 to assemble at Westfield, N. Y., the centers, respectively, of the middle western tomato pulping industry and the grape juice industry. To assemble the 2500 tons of wet seed alone, the charges were \$16,800 and \$15,100.

The available grape pomace was figured similarly. The total tonnage of grapes pressed for juice in the grape juice belts of New York, Ohio and Michigan was ascertained directly from the firms for each of the past five years in order to strike a fair average. From these figures, a pomace yield of 20 per cent was calculated which in turn yielded one-quarter seed, one-quarter dry skins, and one-half water. The costs of assembling the 4300 tons of grape pomace readily available at Indianapolis and Westfield, respectively, were \$20,400 and \$14,000, while the costs of assembling the 1,000 tons of seed alone were \$5,100 and \$3,500, respectively.

It is thus seen that the total cost of assembling all the material at Indianapolis is \$100,400 and \$87,000 at Westfield. If the seed alone are assembled the respective costs are \$21,900 and \$18,600. Therefore, it is manifestly cheaper to install the central utilization plant somewhere near Westfield.

If the seed alone are shipped to the central plant, they are then merely washed, pressed to remove excess water, and dried in rotary driers. If the whole waste is sent in, the seed must be separated and the two lots of seed and skins dried separately.

Because of the shortness of the tomato pulping season (August 1 to October 15) and that of grape juice pressing (September and October) it was decided to figure on a plant only large enough to dry the peak load and then press the seed in the winter months. There will be available about 2,200 tons of dry seed. Assuming an expeller day of 8 hrs. and a capacity of 500 lbs. per hr., it follows that one expeller will crush 2 tons per day. Since there remain only 200 working days,

¹ Read before the Division of Industrial Chemists and Chemical Engineers at the Buffalo Meeting of the American Chemical Society, April 7 to 11, 1919.

one expeller will handle 400 tons. Therefore, six expellers are necessary.

A charge of \$9 per ton of raw material is allowed for drying and handling from cars to storage bins preliminary to expelling, while \$15 per ton of dry seed is allowed for expelling the oil and handling from the seed storage to the oil in tanks. These include all overhead and management charges, except rent of property or interest on real estate investment.

The oils made by the above methods have been refined and deodorized and fabricated into edible products with splendid results. Experiments on animals have demonstrated the feeding value of the residues.

The Cobwell system of grease recovery from garbage was also investigated from this standpoint. Since it involves only one handling and yields the finished fertilizer and crude oil at once, it has the advantage of leaving the plant unencumbered for operating on other products during the remainder of the year. Based on large-scale operation of existing plants, a charge of \$4.75 per ton of raw material is allowed. No work to make oil in large enough amounts to study industrially has been done by this method.

The return from fabricated tomato cyclone waste is \$116,000 while the cost is \$118,000, which renders utilization of the whole waste impracticable. In the case of the Cobwell system, the loss is even greater. However, if the seed alone are shipped in, there is a profit in drying and expelling of about \$54,000, while in the Cobwell system it is about \$60,000. I have figured expeller oil at \$0.14 per lb., solvent oil at \$0.13, press cake at \$40 per ton and dry skins at \$10 per ton.

With grapes, there is only \$5,000 profit using the entire pomace, while in the Cobwell system there is a profit of \$26,000. With seed alone, by drying and pressing one clears \$15,000, while in extracting by the Cobwell system there is a profit of \$33,000. I allowed \$0.14 for expeller oil, \$0.13 per lb. for extracted oil, \$12 per ton for seed cake and \$17 per ton for dried skins.

Thus using the drying and pressing method on the waste of tomatoes and grapes there is a profit of \$69,000, while by using the Cobwell system of extraction it is \$93,000.

BUREAU OF PLANT INDUSTRY
U. S. DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

LABORATORY AND PLANT

THE APPLICATION OF ROTATING REDUCTORS IN THE DETERMINATION OF IRON

By WALTER SCOTT
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INTRODUCTION

In a former article¹ the efficiency and rapidity of rotating metallic cylinders in the reduction of vanadic acid have been described. It is the purpose of this paper to give an account of the results obtained in applying a similar method of reduction in the case of ferric sulfate.

REDUCTION OF FERRIC SULFATE BY THE ROTATING ZINC CYLINDER

In the first series of experiments, the results of which are shown in Table I, A and B, the reduction was brought about by a small hollow zinc cylinder into which was fitted a rubber stopper holding an iron spindle, this being attached to the shaft of a small motor which was run by the ordinary city current. The motor was fixed to a wooden stand in such a way that it could be raised and lowered, thus partly immersing the zinc cylinder in the solution to be reduced which was contained in a tall narrow beaker. A split glass cover, in which a hole had been made slightly larger than the iron spindle, was placed over the top of the beaker. The conditions of action were as follows: Total volume of solution reduced, 85 cc.; concentrated sulfuric acid, 5 cc.; surface of zinc in contact with solution, 25 sq. cm.; source of iron, ferrous ammonium sulfate, the iron content of which had been determined by titration with permanganate, standardized against sodium oxalate; the iron solution containing sulfuric

acid was oxidized previously to reduction by chlorine gas, the chlorine boiled off, and the iron solution reduced while hot.

A correction factor of 0.08 cc. of permanganate was obtained under the same conditions as in the experiment, and applied. Dilution was made with boiled water.

TABLE I
A—PRELIMINARY

Iron Taken Gram	Iron Found Gram	Error Gram	Time of Reduc- tion Min.	Temp. at End of Reduc- tion Deg. C.	Temp. at Titra- tion Deg. C.	Vol. at Titra- tion Cc.	No. of Rev. per Min.
0.0713	0.0364	-0.0349	1	83	35	300	1000
0.0713	0.0581	-0.0132	2	83	35	300	1000
0.0712	0.0649	-0.0063	3	82	37	300	1000
0.0713	0.0701	-0.0012	4	77	36	300	1000
0.0712	0.0710	-0.0002	5	76	35	300	1000
B—QUANTITATIVE DETERMINATIONS							
0.0713	0.0712	-0.0001	6	72	35	300	1000
0.0712	0.0713	+0.0001	6	75	37	300	1000
0.0713	0.0715	+0.0002	6	75	34	300	1000
0.0712	0.0713	+0.0001	6	75	37	300	1000

These results indicate that the reduction of the small amounts of iron taken is completed regularly under the given conditions within a period of 6 min.

INCREASE IN REDUCING SURFACE

For the experiments in Table II, A, B, and C, a larger cylinder was made and the iron spindle fixed directly in the zinc. This same type of zinc cylinder has been used in all the experiments which follow.

The conditions under which the results in Table II were obtained were the following: Total volume of solution reduced, 60 cc.; concentrated sulfuric acid, 5 cc.; surface of zinc in contact with solution, about 45 sq. cm.; source of iron, its content, reduction, and oxidation the same as in Table I. A correction factor of 0.10 cc. of permanganate was obtained

¹ Gooch and Scott, *Am. Jour. Sci.*, 46 (1918), 427.

and applied. Dilution was made with ordinary distilled water in A, and with boiled distilled water in B and C. The iron content was only approximate in the preliminary experiments of Table II, A and B, and all others which follow.

TABLE II
A—PRELIMINARY DETERMINATIONS
(Dilution made with distilled water)

Iron Taken Gram	Iron Found Gram	Error Gram	Time of Reduction Min.	Temp. at End of Reduction Deg. C.	Temp. at Titration Deg. C.	Vol. at Titration Cc.	Approx. No. of Rev. per Min.
0.0713	0.0595	-0.0118	1	67	32	300	800
0.0713	0.0700	-0.0013	2	78	33	300	800
0.0713	0.0675	-0.0038	2	73	31	300	800
0.0713	0.0705	-0.0008	2.5	76	30	300	800
0.0713	0.0704	-0.0009	2.5	72	32	300	800

B—PRELIMINARY DETERMINATIONS
(Dilution made with boiled distilled water)

0.0713	0.0716	+0.0003	2.5	71	31	300	800
0.0713	0.0710	-0.0003	2.5	75	33	300	800
0.0713	0.0708	-0.0005	2.5	74	28	300	800
0.0713	0.0710	-0.0003	2.5	73	31	300	800

C—QUANTITATIVE DETERMINATIONS
(Dilution made with boiled distilled water)

0.0705	0.0707	+0.0002	2.5	31	300	800
0.0706	0.0704	-0.0002	2.5	30	300	800
0.0705	0.0701	-0.0004	2.5	30	300	800
0.0705	0.0702	-0.0003	2.5	32	300	800
0.0706	0.0704	-0.0002	2.5	32	300	800
0.0706	0.0706	0.0000	2.5	30	300	800
0.0706	0.0704	-0.0002	2.5	28	300	800

The results of Table II indicate plainly the increased rapidity of the reduction when the surface of the reducing cylinder of zinc is increased.

REDUCTION BY ROTATING ZINC ANODE

In the experiments of Table III the reductions were made by using the zinc as the rotating anode and a piece of sheet platinum as the stationary cathode.

The time of reduction for these small amounts of iron was practically the same as when no electrolytic current was used.

The electrolytic current in these experiments, as well as in all others which follow, was furnished by eight storage cells, so arranged that the current was controlled by a rheostat.

The conditions were as follows: Zinc in contact with solution, 45 sq. cm.; platinum cathode, 5 cm. X 10 cm.; number of amperes used, 6; all other conditions—source and amount of iron; content, oxidation, reduction, volume, and temperature at beginning of reduction; amount of concentrated sulfuric acid used; dilution and volume titrated—were exactly the same as in Table II, B or C.

TABLE III
A—PRELIMINARY DETERMINATIONS
(Reduction at room temperature)

Iron Taken Gram	Iron Found Gram	Error Gram	Time of Reduction Min.	Temp. at Titration Deg. C.	Approx. No. of Rev. per Min.	Temp. at End of Reduction Deg. C.
0.0707	0.0425	-0.0282	1	20.5	800	21.2
0.0707	0.0677	-0.0030	3	19.5	800	24.0
0.0707	0.0708	+0.0001	5	20.0	800	26.0

B—PRELIMINARY DETERMINATIONS
(Reduction started at boiling temperature)

0.0707	0.0579	-0.0128	1	28	800	300
0.0707	0.0701	-0.0006	2	30	800	300
0.0707	0.0714	+0.0007	3	29	800	300

C—QUANTITATIVE DETERMINATIONS
(Reduction started at boiling temperature)

0.0705	0.0707	+0.0002	2.5	25	800	300
0.0706	0.0705	-0.0001	2.5	32	800	300
0.0705	0.0701	-0.0004	2.5	31	800	300
0.0706	0.0705	-0.0001	2.5	31	800	300
0.0705	0.0701	-0.0004	2.5	33	800	300

The results of these experiments show that there is no advantage in the use of the rotating anode as compared with that of the unelectrified zinc cylinder for small amounts of iron.

REDUCTION OF LARGE AMOUNTS OF IRON BY ROTATING ZINC CYLINDER

In the experiments of Tables IV and V, iron corresponding to 1 g. of ore (containing 70 per cent iron) has been determined quantitatively. In order to obviate a correction factor and the use of boiled water, the value of 1 cc. of a solution of potassium permanganate (approximately $N/10 \times 1.4$) in terms of iron was determined. In making this standardization about 5 g. (weighed to the fourth decimal place) of ferrous ammonium sulfate (the iron content of which had been previously determined) was dissolved in ordinary distilled water in a 1500-cc. evaporating dish. Then 7.5 cc. of concentrated sulfuric acid, and also the same amount of concentrated hydrochloric acid as would be introduced by the oxidation of iron with chlorine, were added. To the solution thus obtained was added a solution made by rotating the zinc cylinder for the same length of time in a boiling solution of water of the same volume and sulfuric acid content as was used in the reduction of iron. This mixture was diluted in the evaporating dish to 1 liter with ordinary distilled water and titrated with the permanganate to color. This method of determining the iron equivalent of 1 cc. of the permanganate assumes that no ferric iron is present, and such was found to be true.

TABLE IV
A—PRELIMINARY DETERMINATIONS
(Reduction started at room temperature)

Iron Taken Gram	Iron Found Gram	Error Gram	Time of Reduction Min.	Temp. at Titration Deg. C.	Approx. No. of Rev. per Min.	Vol. at Titration Cc.	Temperature Deg. C.	Be-fore Reduc-tion	After Reduc-tion
0.7065	0.3385	-0.3380	1	19.5	700	1000	19	22	..
0.7065	0.5494	-0.1571	2	19.5	700	1000	20	24.5	..
0.7065	0.6067	-0.0996	3	19.0	700	1000	20	27	..
0.7065	0.6456	-0.0609	4	20.5	700	1000	20	29.8	..
0.7065	0.6978	-0.0087	6	23.0	700	1000	20	33	..
0.7065	0.7072	+0.0007	8	25.0	700	1000	20	36	..

B—PRELIMINARY DETERMINATIONS
(Reduction started at boiling temperature)

0.7065	0.5511	-0.1554	1	23	700	1000	..	..	..
0.7065	0.5689	-0.0372	2	21	700	1000	..	..	..
0.7065	0.7009	-0.0066	3	23	700	1000	..	..	..
0.7065	0.7107	+0.0042	4	24	700	1000	..	..	..

C—QUANTITATIVE DETERMINATIONS
(Reduction started at boiling temperature)

0.7065	0.7058	-0.0007	4	24	700	1000	..	..	..
0.7065	0.7060	-0.0005	4	24	700	1000	..	..	..
0.7065	0.7056	-0.0009	4	24	700	1000	..	..	..
0.7065	0.7057	-0.0008	4	28	700	1000	..	..	..
0.7066	0.7062	-0.0004	4	28	700	1000	..	..	..
0.7066	0.7060	-0.0006	4	25	700	1000	..	..	..

To determine whether hydrochloric acid at the concentration and temperature of this experiment would vitiate the results (without using a manganous salt), experiments with and without the hydrochloric acid were carried out and no change could be detected.

Since the procedure of the preceding reductions was somewhat modified in obtaining the results of Table IV, the conditions are given as follows: An exact weight of ferrous ammonium sulfate was dissolved in 45 cc. of water, and 4 cc. of concentrated sulfuric acid added; this solution was heated to boiling and chlorine gas passed through it while still hot;

after oxidation the excess of chlorine was boiled off. While the solution was still at the boiling temperature the zinc cylinder was lowered into it and rotated for the periods indicated. The reduced solution was poured into a 1500-cc. evaporating dish, 7.5 cc. concentrated sulfuric acid added, the volume made up to a liter with ordinary distilled water, and titrated. The permanganate was made of such strength as to obtain complete oxidation with less than 100 cc. to avoid refilling the burette. The zinc cylinder was of such dimensions as to get a contact surface of about 75 sq. cm.

REDUCTION OF LARGE AMOUNTS OF IRON USING ROTATING ZINC ANODE

The equivalent value of 1 cc. of permanganate ($N/10 \times 1.4$ approximately) in terms of iron was determined in a similar way to that used in Table IV. The zinc was made the rotating anode and a piece of platinum foil, 5 cm. \times 10 cm., was the stationary cathode. The current used measured 6 amperes. Other conditions were the same as in the experiments of Table IV.

TABLE V

A—PRELIMINARY DETERMINATIONS (Reduction started at boiling temperature)

Iron Taken Gram	Iron Found Gram	Error Gram	Time of Reduction Min.	Temp. at Titration Deg. C.	Approx. No. of Rev. per Min.	Approx. Vol. at Titration Cc.
0.7065	0.6432	-0.0613	1	26	700	1000
0.7065	0.7046	-0.0019	2	26	700	1000
0.7065	0.7055	-0.0010	3	26	700	1000

B—QUANTITATIVE DETERMINATIONS (Reduction started at boiling temperature)

Iron Taken Gram	Iron Found Gram	Error Gram	Time of Reduction Min.	Temp. at Titration Deg. C.	Approx. No. of Rev. per Min.	Approx. Vol. at Titration Cc.
0.7065	0.7060	-0.0005	3	24	700	1000
0.7065	0.7066	+0.0001	3	22	700	1000
0.7066	0.7060	-0.0006	3	22	700	1000
0.7065	0.7058	-0.0008	3	20	700	1000
0.7065	0.7061	-0.0004	3	21	700	1000
0.7066	0.7067	+0.0001	3	22	700	1000

The results of Tables IV and V show that large amounts of iron as ferric sulfate in dilute sulfuric acid solution, and also containing small amounts of hydrochloric acid, are rapidly reduced both with and without the electrolytic current, the time of reduction being slightly less when the electrolytic current is used.

The correction factor and the use of boiled water were eliminated in this set of experiments by the method described above for the standardization of permanganate.

REDUCTION OF SMALL AND LARGE AMOUNTS OF FERRIC SULFATE BY ROTATING ALUMINUM TUBE AND BY ROTATING ALUMINUM ANODE

In the experiments of Table VI a good grade of aluminum pipe was substituted for the zinc cylinder. The hollow tube of aluminum was attached to the shaft of the motor by an iron spindle which was inserted into a rubber cork, and the cork into the tube. When the electrolytic current was used, connection between the spindle and tube was made by means of a small piece of sheet platinum. A correction factor of 0.20 cc. of permanganate was obtained and was used in the quantitative determinations.

The conditions of the experiments in A were the same as in the experiments of Table II, except that the amount of concentrated sulfuric acid added was 4 cc., the total volume reduced was 52 cc., and the surface of contact with the aluminum was 70 sq. cm.

The conditions of the experiments in B and C were the same as in the experiments in Table III, excepting that the amount of concentrated sulfuric acid was 4 cc., the total volume reduced 52 cc., and the surface of contact with the aluminum 70 sq. cm.

The conditions of the experiments in D were exactly the same as in A except that large amounts of ferric sulfate were used.

TABLE VI
A—PRELIMINARY

(Reduction started at boiling temperature without the electrolytic current)

Iron Taken Gram	Iron Found Gram	Error Gram	Time of Reduction Min.	Temp. at Titration Deg. C.	No. of Rev. per Min.	Vol. at Titration Cc.	Amperes Used
0.0716	0.0145	-0.0301	1	29	700	300	0
0.0716	0.0657	-0.0059	3	29	700	300	0
0.0716	0.0706	-0.0010	4	30	700	300	0
0.0716	0.0716	0.0000	5	26	700	300	0

B—PRELIMINARY

(Reduction started at boiling temperature with the electrolytic current)

Iron Taken Gram	Iron Found Gram	Error Gram	Time of Reduction Min.	Temp. at Titration Deg. C.	No. of Rev. per Min.	Vol. at Titration Cc.	Amperes Used
0.0716	0.0659	-0.0157	1	31	700	300	6
0.0716	0.0715	-0.0001	2	28	700	300	6

C—QUANTITATIVE

(Reduction started at boiling temperature with the electrolytic current)

Iron Taken Gram	Iron Found Gram	Error Gram	Time of Reduction Min.	Temp. at Titration Deg. C.	No. of Rev. per Min.	Vol. at Titration Cc.	Amperes Used
0.0716	0.0716	0.0000	2.5	30	800	300	6
0.0716	0.0716	0.0000	2.5	28	800	300	6
0.0716	0.0716	0.0000	2.5	30	800	300	6
0.0715	0.0716	+0.0001	2.5	27	800	300	6
0.0716	0.0715	-0.0001	2.5	32	800	300	6

D—PRELIMINARY FOR LARGE AMOUNTS

(Reduction started at boiling temperature without the electrolytic current)

Iron Taken Gram	Iron Found Gram	Error Gram	Time of Reduction Min.	Temp. at Titration Deg. C.	No. of Rev. per Min.	Vol. at Titration Cc.	Amperes Used
0.7150	0.6570	-0.0580	1	24	800	1000	0
0.7150	0.6995	-0.0155	2	23	800	1000	0
0.7150	0.7091	-0.0069	3	26	800	1000	0

The experiments made with aluminum seemed to indicate that the reduction brought about by this metal is somewhat more rapid than that by zinc, either with or without the aid of the electrolytic current. The difficulty in obtaining aluminum of the necessary degree of purity has, however, prevented, for the time at least, the quantitative study of the use of aluminum in the reduction of larger amounts of ferric sulfate.

CONCLUSION

The results show that ferric sulfate, in either small or large amounts, may be rapidly and efficiently reduced by rapidly rotating reducers of zinc or aluminum, either without or with the aid of the electrolytic current; and that quantitative results may be obtained by titration of the reduced ferrous salts with potassium permanganate.

The reducing action of the rotating zinc cylinder exposing a considerable area of action (75 sq. cm.) to solutions of ferric salts of suitable volume (50 cc.) affords a rapid and exact alternative to reduction by the amalgamated zinc column of the Jones reductor, the rapidity of reduction depending largely upon the area of the reducing surface of the zinc, the temperature, and the volume of the solution. By this method it should be possible to determine with rapidity, convenience and exactness the total content of iron in sulfate or chloride solutions of ferric salts obtained by any of the usual processes from the metal or an ore.

ACKNOWLEDGMENT

This work was done at the Kent Chemical Laboratory of Yale University in 1918, and the writer wishes to thank Prof. F. A. Gooch, who suggested the problem, and whose advice at all times has been most helpful.

AKRON, OHIO

THE PERMANGANATE METHOD FOR COPPER

By LOUIS F. CLARK

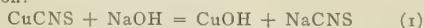
Received July 2, 1919

Almost every works laboratory employs some method of control analysis which although known to be theoretically inexact yet yields results sufficiently correct for all practical purposes. Usually, in such cases, expediency is placed before theory and discrepancies accounted for by arbitrary adjustment. If, however, by a slight change in procedure, such an expedient method can be brought more nearly into theoretical line, the change would seem to be justified.

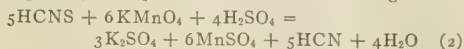
In the copper laboratory, such an expedient method is that known as the "permanganate," and although known to be theoretically inexact, yet it may be so adjusted by factor or graph correction that it is accepted as a useful control determination. When so employed, the usual procedure involves the precipitation of the copper as cuprous thiocyanate from an acid solution, followed by such treatment of the precipitate that a solution of the thiocyanate ion is obtained and a residue containing the cuprous ion left on the filter paper. The thiocyanate solution is acidified and oxidized by permanganate. The details of the procedure can be found in the text of Lord and Demorest, page 210. The alkaline titration suggested by these authors is not usually practicable, and when acid solution is used a correction factor is necessary.

The reactions involved in the usual procedure, assuming proper precipitation of cuprous thiocyanate, are:

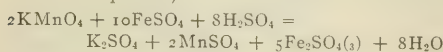
1—Decomposition of the cuprous thiocyanate precipitate by hot solution of caustic soda, thereby leaving the cuprous ion on the filter paper as insoluble cuprous hydroxide. The thiocyanate ion passes into solution as sodium thiocyanate, according to the equation:



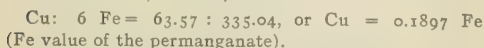
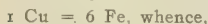
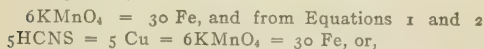
2—The solution is acidified and titrated with permanganate, the equation for the reaction being



From the equation,



we may write,



However, the oxidation does not actually proceed as indicated by the above equation, but only approximates the theoretical relation. Further, the approximation does not seem to be close enough to a linear function so that a definite coefficient can be determined for a wide range of copper values. Thus graphs are sometimes used to more closely approximate the truth. Others simply increase the theoretical factor 0.1897

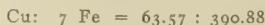
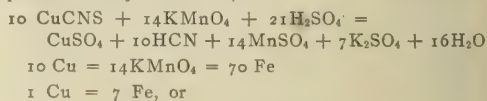
to values ranging from 0.1950 up to 0.2100, depending upon individual experience.

One authority¹ states that the oxidation of thiocyanic acid by potassium permanganate proceeds according to the aforementioned equation when the thiocyanic acid solution is added to an excess of potassium permanganate and this excess is measured by another reagent. He also gives an alternative procedure for the determination of copper in which the cuprous hydroxide, obtained by the decomposition of cuprous thiocyanate, is treated with a ferric salt and the reduced iron so formed titrated with permanganate as a measure of the copper. Obviously, this last procedure wherein $1\text{ Cu} = 1\text{ Fe}$ would be less accurate in actual results, even though theoretically correct, than the oxidation of the thiocyanate ion where $1\text{ Cu} = 6\text{ Fe}$, even though the latter reaction is not strictly in accord with the theory. However, the combination of these two principles seems to give a method which partly overcomes the defects of both.

This combination of principles may be effected as follows: Place the filter paper containing the cuprous thiocyanate in the beaker in which the precipitation was made, add 25 cc. of hot 4 per cent sodium hydroxide solution, and agitate with a rod until the paper is shredded and the precipitate decomposed. Then add 25 cc. of cold 15 per cent sulfuric acid, 1 per cent ferric sulfate (anhydrous) solution. The result of this procedure with the volumes indicated gives a red mixture of ferric thiocyanate, ferrous sulfate, cupric sulfate, and a large proportion of cuprous thiocyanate reforms when the mixture is acidified.

The principle of introducing thiocyanic acid into an excess of potassium permanganate is now somewhat approached in so far as only that portion of the cuprous thiocyanate soluble in the acid ferric sulfate is presented for oxidation. The principle of the oxidation of a ferrous ion for each cuprous ion is incorporated in the reaction. The titration proceeds readily. As the end is approached the ferric thiocyanate color gives way and the mixture becomes whiter; 5 cc. of concentrated hydrochloric acid should now be added to aid in the solution of the residual cuprous thiocyanate. Finally, the solution is titrated slowly to a stable permanganate pink. The end color lasts about 3 min. Loss of color is probably caused by the reducing action of the filter fibers or of the hydrochloric acid.

The equation for the reaction in this combination procedure may be written,



whence, $\text{Cu} = 0.1626\text{ Fe}$ (Fe value of the permanganate). Thus the theoretical value is reduced from 0.1897 to 0.1626. The actual factor much more nearly approaches a linear coefficient and is very much closer to its theoretical value. Some data to

¹ Sutton, "Volumetric Analysis."

illustrate these points are herewith given. Indefinite amounts of iron were used with each sample of copper. The solution of KMnO_4 (7 g. per l.) on determination gave Fe value of 1 cc. = 0.01207.

No.	Copper Gram	KMnO_4 Cc.	KMnO_4 Gram Cu per Cc.	Actual Ratio, K Cu, Fe	Copper Found Using Av. Actual Value of K Gram
1	0.0138	7.9	0.001972	0.1634	0.0139
2	0.0276	13.9	0.001985	0.1645	0.0276
3	0.0326	16.4	0.001987	0.1647	0.0326
4	0.0527	26.5	0.001988	0.1647	0.0526
5	0.0670	33.9	0.001977	0.1638	0.0674
6	0.0834	42.1	0.001982	0.1642	0.0836
7	0.0917	46.1	0.001988	0.1647	0.0916
8	0.1214	61.0	0.001990	0.1649	0.1212
9	0.1432	71.9	0.001992	0.1651	0.1428
10	0.1625	81.4	0.001996	0.1654	0.1617
11	0.1912	96.2	0.001988	0.1647	0.1911
12	0.2000	100.3	0.001992	0.1650	0.1994
Average =			0.001986	0.1646	

Hence, the actual copper value of the permanganate = $0.01207 \times 0.1646 = 0.001986$, thus the actual factor is 0.1646 and the theoretical 0.1626; the difference is probably due to the slight solubility of cuprous thiocyanate.

SOME OBSERVATIONS ON THE PROCEDURE

1—The strength of permanganate solution, 7 g. per l., as used above, was selected because 10 cc. closely equals 1 per cent copper on a 2-g. sample of ore. This is a very strong solution, about three times that usually used for the titration of iron, yet 1 cc. equals only 0.1 per cent copper; hence it is very easy to check to 0.02 per cent copper (on low-grade ores). Slight irregularities due to filter papers, etc., do not appreciably affect the results. However, the 5 cc. concentrated hydrochloric acid should not be added to the liquid being titrated until the end is nearly reached in order that enough manganese sulfate may be present to act as acceptor between the ferrous iron and the permanganate.

2—The precipitation of the cuprous thiocyanate from about a 2 per cent sulfuric acid solution (other acids having been removed by evaporation to sulfur trioxide fumes) has been found satisfactory. A solution containing 4 per cent sodium thiocyanate and 10 per cent sodium sulfite is used as precipitating agent (10 cc. of this usually suffices for most samples).

3—Unless the insoluble residue is very white it is advisable to remove it by filtration before precipitating the cuprous thiocyanate.

4—The solution containing the cuprous thiocyanate should be boiled to coagulate the precipitate. It may then be readily filtered on a coarse paper that has received two or three small washes of a "filler." This filler is made by agitating 1 g. of corn starch (cooking starch) with 1 l. of water. This is a mechanical filler and does not relieve one of the necessity of using a few drops of sulfuric acid in the hot water used to wash the precipitate to prevent formation of a hydrosol.

5—This starch filler has been found to insure very clear filtrates even when using coarse filter paper. The amount used has not been observed to consume any appreciable quantity of permanganate either by itself or by possible products of its hydrolysis under the conditions of the procedure.

6—The titration seems to be effected most accurately

in the solution volumes previously indicated. If larger amounts of copper are being titrated it would be better to use stronger permanganate.

SUMMARY

A modification of the usual permanganate method for copper is presented whereby (a) the theoretical ratio of copper to iron is reduced from 0.1897 to 0.1626; (b) the actual ratio factor is found to more closely approach the character of a linear coefficient; (c) the procedure seems in many cases to be more rapid and to give more accurate results.

POTRERILLOS LABORATORIES
POTRERILLOS, CHILE

THE USE OF NICKEL CRUCIBLES FOR THE J. LAWRENCE SMITH FUSION IN DETERMINING SOIL POTASSIUM

By SETH S. WALKER

Received July 7, 1919

The scarcity and high price of platinum during the war led the writer to investigate the feasibility of substituting nickel crucibles for platinum ones in fusing soils by the J. Lawrence Smith method for total potassium. There would seem to be no theoretical reasons against the use of nickel for this purpose. Still, it is noticeable that wherever the Smith fusion method is described in the literature platinum crucibles are specified, and in view of this the writer did not feel justified in making the substitution without experimental proof of its adequacy.

Accordingly duplicate fusions were made on a number of soils, using a platinum crucible for one duplicate and a nickel crucible for the other. In all cases 0.5 g. of dry soil was taken and thoroughly mixed with 0.5 g. of ammonium chloride and 4 g. of calcium carbonate by grinding in an agate mortar. The mixtures were fused (after the usual preliminary heating to expel ammonia) for 45 min. at the highest heat obtainable with a good Bunsen burner. The subsequent operations were essentially as described by Ames and Gaither¹ and were carried out alike for all determinations. Porcelain dishes were used for the final evaporation with platinum solution. The potassium precipitates were collected on Gooch crucibles and dried in a water oven. The following table shows the weights of potassium chlorplatinate found by the two methods.

WEIGHTS OF K_2PtCl_6 FOUND BY FUSING SOILS IN PLATINUM AND IN NICKEL CRUCIBLES

Soil No.	KIND OF CRUCIBLE	
	Platinum Gram	Nickel Gram
S-223	0.0142	0.0145
S-254	0.0080	0.0082
S-255	0.0158	0.0178
S-258	0.0177	0.0175
S-259	0.0096	0.0098
S-260	0.0118	0.0118
S-262	0.0034	0.0032
	0.0037	0.0038

DISCUSSION OF RESULTS

In only one case, viz., Soil S-255, was there an appreciable difference in the weights found; and when the comparison was repeated on that soil, results were obtained which not only agreed between themselves, but also with the result previously obtained with the

¹ Ohio Agr. Expt. Station, Bulletin 261, 507.

nickel crucible. This indicates that the discrepancy at first observed was due to some undetected error in manipulation with the platinum crucible fusion, rather than to inadequacy of the nickel crucible.

Although, as shown, correct results are obtained by using a nickel crucible, it cannot be claimed that nickel is as satisfactory as platinum. The nickel crucibles are decidedly attacked by the fusion mixture, so that the life of a crucible is rather short. The inner surface of the crucible soon becomes rough and pitted, making it somewhat difficult to remove the mass cleanly. The fused mass is always colored green by dissolved nickel, and it does not slake and disintegrate as well as those from platinum crucibles. But,

as also mentioned by Ames and Gaither,¹ poor slaking does not affect the final result.

SUMMARY

It is found that the same result for soil potassium is obtained whether the soil is fused in a platinum or a nickel crucible.

Nickel crucibles are attacked by the J. Lawrence Smith fusion mixture and are therefore not as satisfactory as platinum crucibles.

SOIL LABORATORY
LOUISIANA AGRICULTURAL EXPERIMENT STATION
BATON ROUGE, LOUISIANA

¹ *Loc. cit.*

ADDRESSES AND CONTRIBUTED ARTICLES

CHEMICALS RECEIVED BY THE BUREAU OF CHEMISTRY DURING THE WAR¹

By H. E. Buc

For a good many years the Bureau of Chemistry has been regularly examining all the stock chemicals purchased. Without going into a detailed account of this work, initiated by Dr. L. F. Kebler and carried on under his charge, it may be said that during the period of half a dozen years preceding the war the chemical reagents on the market, mostly of American make, were quite generally of excellent quality. During the first year of the war, according to our records, there was no marked change. Since that time, however, the Bureau has had considerable difficulty in procuring good chemicals belonging to certain classes, and we have been occasionally disappointed with chemicals belonging to types that generally come quite pure.

The writer's experience covers a period of four years, 1915-1919. During that time about 1300 samples were examined. Of these about 150 shipments were found to be more or less unsatisfactory. During a similar preceding period of four years, 1911-1915, during which a like number of chemicals were tested, only about 50 were unsatisfactory. Too much importance should not be attached to the proportion of 150 to 50 as the kinds of chemicals tested were not exactly parallel. On the other hand, in the latter period, in addition to the above 150, a number of tests were made of samples submitted by dealers. When these were found unsatisfactory, the agents or manufacturers were so informed, thus diminishing the number of shipments of unsatisfactory chemicals. It should also be added that the shortcomings of the chemicals tested in the war period were more serious than those recorded in the pre-war period.

A more detailed comparison between the two periods is hardly necessary. The main purpose of this paper is to point out the present situation in regard to ordinary reagents, as shown by the examinations made in the Bureau of Chemistry. For the purpose of this discussion the chemicals may be divided into several classes which differ widely in quality.

LIQUID INORGANIC CHEMICALS—Hydrochloric, sulfuric, nitric, and phosphoric acids, and ammonia, generally have met our requirements.

LIQUID ORGANIC CHEMICALS—The ordinary alcohol, ether, acetone chloroform, carbon tetrachloride, carbon disulfide, and glycerin have been found satisfactory for practically all chemical purposes. On evaporating large quantities of ether the penetrating odor of formaldehyde is often perceived in the last portions. However, attempts to identify formaldehyde

by means of morphine were futile. All samples of carbon tetrachloride examined contained carbon disulfides.

Other liquid organic reagents have been of less excellent quality.

Good methyl alcohol is obtainable, but not without at least traces of acetone. Amyl alcohol of good quality is not to be had. Not only does it contain appreciable amounts of pyridine but the boiling range is very wide. This is also true of amyl acetate. Pure benzene seems to be non-existent. Thiophene and carbon disulfide are always present, and quite often the boiling range points to the presence of homologs.

"Absolute" organic chemicals (free from water, etc.) are generally unobtainable. This is true of acetic acid, methyl alcohol and ethyl acetate, which are occasionally desired in absolute or nearly absolute condition. We prepare our own absolute ethyl alcohol (not less than 99.8 per cent), having started to make it ourselves long before the war, owing to the fact that we were unable to procure a dependable grade.

In the case of absolute ether, for the most part the products sent to us are good. Occasionally we are obliged to reject samples which show turbidity when treated with sodium. Our experience with the preparation of this product, which at one time we did ourselves, indicates the necessity of thoroughly washing out the alcohol in the preliminary stage. A heavy test for aldehyde seems always to accompany the turbidity obtained with sodium.

Acetic acid (99.9 per cent) complying with the dichromate test requirement is now unobtainable; but even before the war this grade was not easy to get. The best grade which we can obtain at present, and that from only one firm, is labeled 99.5 per cent, but is actually a little higher. Samples that have reached us from other firms rarely go above 99.0 per cent.

ALKALI SALTS—This embraces a number of common and important reagents. For the most part they are of good quality, but certainly not dependably so. We have on record sodium chloride with quite a little magnesium present, and ammonium chloride leaving a high residue on ignition.

"Anhydrous" alkali carbonates seldom have less than 8 to 12 per cent of water. Sodium and potassium hydroxides, particularly the latter, at one time gave us considerable trouble. The quality coming in now is fair, except for too strong a test for chlorides. Incidentally, it should be said that the strength of these chemicals is higher than is commonly supposed. Sodium hydroxide comes about 97 per cent potassium hydroxide, hardly ever falls below 86 per cent and occasionally goes above 90 per cent. Potassium permanganate, long a source of worry to our purchasing office, now comes in good quality, in spite of a rather novel appearance and color. Occasionally, however, it bears more than traces of chloride.

¹ Presented before the Division of Industrial and Engineering Chemistry at the Philadelphia Meeting of the American Chemical Society, September 2 to 6, 1919.

OTHER SOLUBLE SALTS—While seldom very bad, these are often contaminated with foreign metals, especially with alkali salts, reaching to tenths of one per cent. The mercury salts almost always leave an appreciable residue on ignition, mostly, if not entirely, iron. Zinc salts frequently contain 0.1 to 0.2 per cent of lead.

Hydroxylamine and phenylhydrazine salts are grossly impure, bearing a large proportion of inorganic salts, reaching as high as 24 per cent.

The following are a few instances of poor chemicals in the above class:

Barium acetate, 0.26 per cent calcium, etc.
Cobalt nitrate, 0.80 per cent chlorine
Hydroxylamine, hydrochloride, 21.0 per cent residue on ignition
Mercuric acetate, 9.0 per cent residue on ignition
Nickel sulfate, 1.00 per cent alkali salts
Zinc oxide, 0.22 per cent lead
Zinc sulfate, 0.3 per cent alkali salts

INSOLUBLE PRODUCTS—This heading is meant to include all difficultly soluble products. It is in this class that we have made the largest proportion of rejections. Here an acceptable chemical is the exception; a poor chemical is the rule. A number of instances follow:

Animal charcoal, 25.0 per cent residue on ignition
Barium carbonate, 3.8 per cent soluble matter
Calcium oxide, 22.8 per cent loss on ignition; iron sulfate present
Calcium, 2.8 per cent foreign metals
Copper carbonate, 4.4 per cent soluble matter
Cupric oxide, chlorine present
Lead carbonate, 7.0 per cent soluble matter
Lead chromate, 7.0 per cent soluble matter, largely acetate
Lead chromate, 9.0 per cent soluble matter
Lead peroxide, 30.0 per cent soluble matter

"ANALYZED" CHEMICALS—At no time has it been our purpose to verify the label "analysis." Our object was merely to pass on the suitability of the chemicals for our work. It is only incidentally that we have noted discrepancies numerous enough and large enough to warrant our distrust of all label analyses, except those of one firm, from which, however, we have received only a comparatively small number of samples.

SUMMARY

1—During the last four years about 1300 shipments of chemicals from a large number of dealers and manufacturers have been tested in the Bureau of Chemistry. The greater part of the reagents bore an analysis on the label.

2—Most of the chemicals examined are satisfactory. Occasionally impurities are found often enough in chemicals from practically all manufacturers to make it necessary to test all shipments.

3—The standard acids, ammonia, alkali salts and alkali, and most of the organic solvents are generally satisfactory.

4—The soluble salts other than alkali salts are generally acceptable but are seldom of a high degree of purity.

5—Certain organic solvents and solids are either unobtainable or unsatisfactory.

6—The insoluble products are generally unfit for use in analytical work.

BUREAU OF CHEMISTRY
U. S. DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

REPORT ON THE PRODUCTION OF SYNTHETIC ORGANIC CHEMICALS IN THE RESEARCH LABORATORY OF THE EASTMAN KODAK COMPANY FOR THE YEAR 1918-1919¹

By C. E. K. MEES

The preparation of synthetic organic chemicals was commenced by the research laboratory of the Eastman Kodak Company in

¹ Presented before the Division of Industrial and Engineering Chemistry, American Chemical Society, Philadelphia, Pa., September 4, 1919.

September 1918 in order to supply the demand for these chemicals by research workers in the United States. Proposals for the work were submitted at the Cleveland Meeting of the AMERICAN CHEMICAL SOCIETY in September 1918, and there approved by the Divisions of Organic and Industrial Chemistry. A report was presented by Dr. Clarke at the Buffalo Meeting of the AMERICAN CHEMICAL SOCIETY in April 1919; the present report represents experience in the working of the department for a period of eleven months.

Much assistance in the undertaking has been received from the American chemical manufacturers, who have willingly supplied not only materials which they had on the market, but in many cases intermediates which they prepared for their own use. Much assistance has also been received from university laboratories. The University of Illinois has supplied a considerable number of the chemicals prepared under the direction of Dr. Adams. Professor Turner, of the University of Missouri, and Prof. H. I. Jones, of the University of Oklahoma, have also supplied a number of substances. Recently, Professor Acree, of the New York State College of Forestry, in Syracuse, has undertaken to prepare pure sugars and indicators.

A wider extension of this collaboration is to be desired. If investigators who in the course of their researches make new or interesting organic compounds would prepare and sell small quantities in excess of their needs, samples for experimental or comparison purposes could then be supplied to other workers.

Most substances sold have, however, been prepared in the laboratories of the Eastman Kodak Company and all materials listed under the name of Eastman Organic Chemicals have been tested there. The first list of chemicals was issued in January 1919, a second in March, and the most recent list in August 1919—this containing the names of 550 substances, of which 268 were prepared in the laboratory. Up to September 1, 1919, a total of 348 preparations had been undertaken.

Substances are listed in three degrees of purity: The "Eastman chemicals" are those of the highest purity which can be obtained. The "practical chemicals" are those which are of sufficient purity for ordinary synthetic work, and in most cases these can be substituted in preparations for the Eastman chemicals, especially as information can always be given as to the impurities which these "practical chemicals" contain. The "technical chemicals" are those which are available on the market in bulk only but are retailed in small quantities for the convenience of both manufacturer and consumer.

The financial situation of the work up to date is not very satisfactory. The total loss in the twelve months during which the department has been running is \$14,822, this figure not containing any charges for rent or overhead of any kind, and representing only the apparatus, supplies and labor used in the department. This loss covers the whole of the working period and thus includes the first months, during which production was very low. It also includes depreciation in the value of materials bought, which is mainly due to the lowering of prices during the last twelve months. Many materials can now be purchased for much less than they cost during the war, and it has been necessary to write off the value of the stock to cover this depreciation.

The investment in the stock is very considerable. The large number of chemicals held in stock and the considerable average value which they represent makes a very heavy investment necessary. At the present time the sales of materials are rising rapidly; but it is not anticipated that the department will meet its expenses during the next year, even with some increase in the prices, which will be necessary.

The main cost is in the labor used for the preparations and is due primarily to the small scale on which the material can be prepared as well as to the new experimental work which is necessary in order to add new preparations. About twenty

new preparations are added per month, and in most cases these cost from three to ten times the value of the material made.

We believe that with the support of the American chemists we can finally make a success of this undertaking, and we are prepared to continue it in that belief. It is of no use to ignore the fact, however, that the next year will be a critical one for the undertaking, and if the American universities decide to purchase German chemicals, which may be sold at a lower price than we can supply them, we shall be forced to discontinue this work. If chemists continue to purchase the chemicals from us we hope that finally we shall be able to prepare and supply them at prices comparable with those at which they can be purchased from abroad, and with that object we are prepared to continue our work.

EASTMAN KODAK COMPANY
ROCHESTER, NEW YORK

THE EXAMINATION OF THE COLLEGE TRAINED CHEMIST FOR GOVERNMENT SERVICE

By WILLIAM J. COTTON

Received August 11, 1919

There are over one thousand institutions in the continental United States that style themselves as colleges or universities. Previous to the entrance of this country into the World War, the United States Civil Service Commission had recognized a large majority of these institutions as coming under the heading "college or university of recognized standing."

In the pre-war days the examinations of the Commission were for the most part "assembled;" that is, competitors were required to report at designated places throughout the country and submit to a competitive written examination. With the advent of war this slow method of maintaining registers of qualified eligibles was no longer practical. A more rapid method, requiring a minimum of work on the part of the Commission, had to be devised.

The assembled type of examination had almost invariably been used to fill positions paying salaries up to \$1800. To fill the relatively few positions paying more than this amount the "non-assembled" type of examination had frequently been used. This latter type of examination consisted of a rating on the sworn statement of education and experience of the applicant as set forth in the application he had filed with the Commission, subject to such corroborative evidence as the Commission desired to secure. To meet the war demand for qualified technical and scientific workers, the Commission decided to use the non-assembled type of examination to fill all such positions except where the government department concerned might request otherwise.

Owing to the rather stiff qualifying requirements, the non-assembled types of examination had, previous to the war, produced usually but few applicants. The difficulty of arranging the applicants in the order of merit was not great. The applications could all be compared and rated at one sitting. The extension of the non-assembled types of examination to the lower grade technical positions, and at a time, too, when for patriotic and other motives, thousands of technical men were answering the call of the Government, meant that on any one of many examinations hundreds of applications might be expected. Because of the lower salaries offered in the low-grade positions, a large amount of practical experience along technical lines could not be required as a prerequisite for consideration. The problem, therefore, essentially resolved itself into that of a just rating of the general and technical education of the applicant.

From January 1917 to January 1919, the writer served as chemical examiner for the Civil Service Commission. During the first year of this time he was privileged to be associated with Mr. Anton Prasil, now with the National Aniline and Chemical Company. Since the leaving of Mr. Prasil, the writer has

handled the chemical end of the Civil Service work. Chemists and more especially the faculties of the chemistry departments of our colleges and universities, might be interested to know something of the "education" rating given on the chemistry examinations of the Commission.

When the Commission made the decision above noted, three problems immediately presented themselves for solution: First, the vague expression, "college or university of recognized standing," which had theretofore been used in announcing examinations, must be replaced by an equivalent expression, the meaning of which would be definite and easily understood by the applicant. Second, for each examination announced, such prerequisites must be established as would insure that the previous training and experience of those passing the examination would qualify them to fill the position for which the examination was held. Third, it was necessary to determine, as accurately as possible, the relative value of the chemical training given at each college or university from whose students and graduates applications might be received. These problems are stated in the order of increasing complexity.

The first problem presented but little difficulty. Conferences with the Bureau of Education, together with the inspection of numerous college catalogues, resulted in recommending to the Commission that by "college or university of recognized standing" should be meant an institution requiring for entrance at least 14 units of high-school work, and for graduation an additional 118 semester credits of college work. It was further suggested that the substance of this recommendation be substituted in the printed announcements of examinations in lieu of the vague phrase theretofore used. The recommendation and suggestion were adopted by the Commission. For instance, the announcement of the junior chemist examination contained this statement: "Applicants must have graduated from a college or university which requires for entrance at least 14 units of high-school work, and for graduation an additional 118 credit hours. By credit hour is meant * * *." It is of interest to note at this point, that of the institutions coming to the attention of the examiners, five hundred and thirty-one of them met this requirement. Whether or not there are more that could qualify, the writer is not in a position to state. Probably about five hundred and fifty could qualify.

The practical operation of this clause soon suggested a further modification. It was found that certain institutions enjoyed an enviable reputation, and yet did not absolutely require more than 8 or 10 units of high-school work for entrance. Many students entering these colleges, however, presented a full 14 units of work. In justice to these, the statement was reworded to read: "Applicants must have graduated from a full four-year high-school course or have completed 14 units of high-school work accepted for college entrance. In addition applicants must have graduated with a degree from a college or university with the completion of at least 118 credit hours of which * * *. By credit hour is meant one lecture or recitation or two hours of laboratory work per week per semester." This wording put the burden of qualifying on the individual applicant and not on the institution. Such a statement stood the test of almost two years of practical usage with uniformly pleasing results. It constituted the solution to the first of the problems above enumerated.

Because this article is written primarily for those interested in the college training of chemists, the writer will describe how the second and third problems above noted were solved in the case of one particular type of position, that of junior chemist. The selection of the junior chemist is made because the particular type of chemist sought through examinations of this title is the college graduate, who has majored in chemistry, and who need necessarily have had no practical experience. Chemists not meeting these requirements are provided for through other

structional staffs from among their own graduates. Many of the smaller colleges cannot afford to pay the salary required to get a graduate of another institution. It is necessary for them to capitalize the loyalty and inertia of their own graduates. This practice, however, is not confined to the smaller colleges. The assignable reason for its practice by the larger institutions would seem to be the high esteem with which they regard their graduates. An interesting example of this is a certain well-known institution on the eastern seaboard. Its chemistry faculty consists of eight members, one of whom is emeritus. Of the remaining seven, all received at least a substantial portion of their education at that institution. Such a practice, if continued, can but lead to a narrowing of the mental vision of its instructional staff.

The war brought women chemists to the front. Heretofore, women have studied chemistry much as they studied astronomy, for the pure pleasure of the study itself. With their entrance into the industrial world an additional viewpoint must be acquired, namely, that of making themselves valuable as chemists to their employers. Industrially and in governmental service women appear to be particularly adaptable as analytical chemists. Yet it is a fact that the majority of women's colleges emphasize quantitative analysis to a lesser degree in their curriculum than any other branch of chemistry.

The high cost of print paper has not been without its advantages. It has tended to eliminate an undesirable custom practiced by a number of our institutions. The evil referred to is that of padding the catalogues. Certain institutions seem to vie with one another in the bulk, offerings, and gorgeousness of their catalogues. The chemistry sections of these catalogues are not free from this vice. Courses are announced and described in the catalogues of certain institutions which require special and extended physical and chemical equipment and instructors trained along these special branches of chemistry. The size of the institution, its assets and income indicate that it has no such equipment. Its catalogue shows no instructor qualified to handle the course. And yet it is announced as being offered. This practice should be stopped. Such a catalogue fools no one but its authors, the student victims, and the parents of the latter.

Most educators have devoted thought to the problem of the relative time to be allotted in a curriculum to each of the various courses of chemistry. No argument is needed to sustain the assertion that all branches do not require the same amount of time. Yet in probably 40 per cent of our institutions the mechanical arrangement of the institution's semester schedule will determine the time to be allotted to the study of a particular branch of chemistry. Some instructors are partial to three-hour courses, some to four, and some to five. For instance, one institution coming under survey gives six credits of general and inorganic, six of qualitative, six of quantitative, six of organic, and six of physical. The writer is advocating no special scheme of time allotment. This must depend on the judgment of the individual instructors, on the purpose for which the course is offered, and on the equipment and library facilities available. But such a course as that outlined above shows the entire lack of appreciation of the time element in outlining a curriculum. Mechanical convenience of the schedule should be among the less important factors taken into consideration.

During the course of the investigation, the above interesting facts regarding the chemistry departments of our institutions came to light. The writer is not in a critical mood and the above suggestions are made because it is felt that they will be welcomed as an aid in the solution of the reconstruction problems now before the chemistry departments of colleges and universities.

BIBLIOGRAPHY ON THE USE OF "CUPFERRON" AS A QUANTITATIVE REAGENT

By S. A. BRALEY

Received June 9, 1919

From a survey of the standard texts on analytical chemistry it seems that "cupferron," the ammonium salt of nitrosophenylhydroxylamine, has not been given due consideration as a quantitative reagent. From the results obtained by various investigators, it should be a reagent of exceptional value as a selective precipitant. It is my purpose here to call attention only to the many uses for which it may be employed and give a complete bibliography of the work that has been carried out on the subject.

O. Baudisch¹ first suggested the use of "cupferron" for the separation of copper and iron. He shows that iron is quantitatively precipitated by "cupferron" from strongly acid solutions, while copper is not precipitated under the same conditions. On the other hand, copper and iron are both precipitated from slightly acid solutions while nickel is not, thus affording a separation of copper from iron when present together and of iron and copper from nickel when all three are present. Again the copper salt is soluble in concentrated ammonia solution, thereby making an easy separation of copper from iron when both are precipitated together. Baudisch and King² state that the precipitate of iron thus obtained settles rapidly and is easy to handle. It is soluble in ether, chloroform, and acetone, and thus can be dissolved away from lead, silver, mercury, and tin if they should in any manner contaminate the precipitate.

Biltz and Hódke,³ Hanus and Soukup,⁴ and R. Fresenius⁵ have carried out more extensive investigations showing that not only is this separation very clean-cut in the case of copper and iron from nickel but they may also be separated from solutions containing aluminum, chromium, cobalt, zinc, alkaline earths, and manganese. The iron may also be separated from lead and bismuth in addition to those metals already mentioned. With the present increasing number of alloys having as their chief constituents the elements just named it seems that this reagent should greatly facilitate the ease and rapidity of their analysis.

Bellucci and Grassi,⁶ and Thornton⁷ find that from solutions acid with hydrochloric or sulfuric acids titanium is precipitated as well as iron, thus giving a method for the separation of titanium and aluminum and at the same time making a determination of the titanium, as its salt can be directly ignited to the oxide (TiO_2). Thornton⁸ has also extensively investigated the use of "cupferron" for the separation of zirconium and thorium from iron and has apparently obtained satisfactory results.

James Brown⁹ by using the data of previous workers together with that of his own on zirconium has made an excellent separation of iron, titanium, and zirconium from manganese and aluminum. His data show that great accuracy is possible in a determination of this kind. He precipitates the iron, titanium, and zirconium from cold solutions containing 25 cc. of sulfuric acid (1 : 1) in 150 cc. of solution. He analyzed the filtrate containing the manganese and aluminum by the ordinary methods and treated the precipitate in the following manner: It was ignited to give the combined oxides, these were taken into solution, and the iron precipitated with hydrogen sulfide in the

¹ *Chem.-Ztg.*, **33** (1909), 1298-1300; *J. Chem. Soc.*, [Aii] **1910**, 76-77.

² *THIS JOURNAL*, **3** (1911), 629; *Chem. Abs.*, **5** (1911), 3780.

³ *Z. anorg. Chem.*, **66** (1910), 426-31; *J. Chem. Soc.*, [Aii] **1910**, 550.

⁴ *Z. anorg. Chem.*, **68** (1910), 52-56; *J. Chem. Soc.*, [Aii] **1910**, 899.

⁵ *Z. anal. Chem.*, **50** (1911), 35-43; *J. Chem. Soc.*, [Aii] **1911**, 336.

⁶ *Atti accad. Lincei*, [5] **22** (1913), 30-34; *J. Chem. Soc.*, [Aii] **1913**, 250; *Chem. Abs.*, **7** (1913), 1688.

⁷ *Am. J. Sci.*, [4] **37** (1914), 173-8; *J. Chem. Soc.*, [Aii] **1914**, 299; *Chem. News*, **114** (1916), 13.

⁸ *Am. J. Sci.*, **37** (1914), 407; **38** (1914), 137.

⁹ *J. Am. Chem. Soc.*, **39** (1917), 2358-66; *Chem. Abs.*, **11** (1917), 3190.

presence of tartaric acid. The titanium and zirconium were then separated by ordinary methods. Excellent results were obtained in solutions containing varying amounts of the elements between the following limits: Fe_2O_3 , 0.0859–0.1789 g.; ZrO_2 , 0.1130–0.2159 g.; TiO_2 , 0.0542–0.0050 g.; Al_2O_3 , 0.1043–0.1135 g.; MnO_2 , 0.1254–0.0051 g. From the results obtained it would seem that this procedure could easily be applied to the R_2O_3 precipitate in a clay analysis.

Turner¹ and Rodeja² have determined vanadium in a similar manner and obtained successful separations of it from AsO_4^{3-} .

¹ *Am. J. Sci.*, [4] **41** (1916), 339–43; **42** (1916), 109–10; *J. Chem. Soc.* [Aii] **1916**, 347, 540; *Chem. News*, **114** (1916), 261.

² *Anal. soc. espan. fis. quim.*, **12** (1914), 379–82; *Chem. Abs.*, **9** (1915), 2202; *Anal. soc. espan. fis. quim.*, **12** (1914), 305–9.

and PO_4^{3-} as well as from uranium in strongly acid solutions. However, Turner seems to take exception to Rodeja's method of procedure.

Wissenson¹ has successfully used this reagent to determine the iron in potassium ferrocyanide and Schroeder² gives some additional data for the separation of iron from cobalt and nickel. However, these two papers seem rather unimportant, but the references are given to complete the bibliography.

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¹ *Z. anorg. Chem.*, **23** (1911), 969; *Chem. Abs.*, **5** (1911), 3024.

² *Z. anorg. Chem.*, **72** (1911), 94.

SYMPOSIUM ON REFRACTORIES

Papers presented at the 58th Meeting of the AMERICAN CHEMICAL SOCIETY, Philadelphia, Pa., September 4, 1919

THE WORK OF THE TECHNICAL DIVISION OF THE REFRACTORIES MANUFACTURERS' ASSOCIATION

By R. M. HOWE

In May 1917, the Refractories Manufacturers' Association entered into an agreement with the Mellon Institute of Industrial Research of the University of Pittsburgh, whereby research work was to be conducted at that institution for the benefit of the refractories industry. The incumbent of this multiple industrial fellowship was not, however, available for other than urgent work, and consequently a plan was formulated in accordance with which company members that maintained no laboratories, and a few that did, could have constant access to this central laboratory devoted to the refractories industry for obtaining analyses on and advice respecting ceramic materials. This was equipped with the necessary apparatus for making physical and chemical tests and for the experimental manufacture of fire brick.

The problems of the refractories industry are numerous indeed, and hence the personnel of the research staff increased from one to five in a very short time. Experimental work was done for over fifty companies during the first year, and, as a result, little time was available for general research on account of the demands for individual service. These requirements were undoubtedly due to the fact that the laboratory was made self-supporting, yet was not operated for profit. The only restrictions made were to prevent the possible monopoly of the staff by any one company.

The problems which are most frequently encountered can be best illustrated by following the raw material from the mine to the kiln. Since many excellent articles on the manufacture of silica and magnesite brick have been published, this paper will be limited to refractories made from fire clay.

The characteristics of this material vary considerably, not only in different districts but in different deposits of the same district, and in different sections of the same deposit. This variation concerns the chemical composition, refractoriness, hardness, color, plasticity, and other general characteristics of fire clay. In addition to this, it is sometimes discovered that flint clay deposits, which are believed to be extensive, are exhausted quickly, and that land supposed to cover flint clay covers none.

It is the former condition that makes it essential for a miner to know each piece of clay as it is encountered, and to be able to accept or reject it according to that knowledge. It is the latter condition which explains why plants are sometimes located at what is now known to be a disadvantage. Both conditions explain how necessary it is to have complete data available as to the extensiveness and quality of a deposit. Accordingly, the practice of securing drill cores is growing and these are

tested thoroughly. Such tests give the requisite information, and make it possible to recognize the good and bad material by visual methods.

It is remarkable that most of these systematic studies reveal the fact that good clay is being rejected or left in the mine because of a difference in color, hardness, or structure. Less often undesirable clay is used.

The clay, after being mined and sorted, is taken to a crusher, where it is again sorted and reduced to a workable size. It is later mixed, ground, and tempered with water prior to being shaped. Since different plants follow different practices in preparing the clay for shaping, it is necessary to consider blending, grinding, and tempering separately, although these three operations are often conducted simultaneously.

While many clays are used alone in the manufacture of fire brick, in most cases mixtures or blends are employed because these have more desirable properties than are generally found in any one clay. Hence crushed fire-brick bats and plastic clays are blended for manufacturing a strong, refractory product of low shrinkage. Raw or calcined flint clay often displaces the bats; silica is sometimes added to open the structure and hence increase the resistance to spalling; while bauxite raises the softening point. In other cases, clays are blended so as to secure a greater capacity from the available materials.

After these materials have been mixed, they are ground together and in this process many of the final properties of the fire brick are imparted. The coarser grinds are generally used in producing open, porous roof brick, etc., while finer grinds are used in making dense slag and abrasion-resisting products.

Naturally, fusion, slag penetration, spalling, abrasion, and reheating tests are all of value in judging how well certain grinds and mixes will meet the requirements of usage.

Tempering also exerts a very important influence in determining the final characteristics of a fire brick. This term, which is broad, covers the addition of large or small amounts of water, working for different periods of time, and the application of slight or heavy pressure during working.

Water Per cent	Porosity Per cent	Modulus of Rupture	Same after 20 Immers- ions from 1300°C. into Cold Water	Relative Strength of Briquettes after Immersions Per cent	Working Consistency
7.5	24.0	2491	804	32.1	Very stiff mud
9.0	20.3	6019	2776	46.2	Stiff mud
10.0	20.6	4020	3298	82.1	Soft mud

The figures of Table I illustrate very clearly how different amounts of water affect the structure of fire brick. In securing these data, a large batch of clays was made up with different amounts of water and then pressed into briquettes. These were burned and tested (Fig. 1).

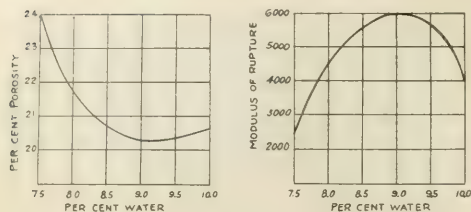


FIG. 1

It is thought that these test results are typical and that the following rules apply when sufficient pressure is used in shaping fire brick:

- 1—Increasing the water content increases the strength of a fire brick until a limit is reached, after which further addition of water lowers the strength.
- 2—Increasing the water content decreases the porosity of a fire brick until a limit is reached, after which further addition of water increases the porosity.
- 3—An excess of water does not affect the density of a fire brick as much as an insufficient amount.

Time of pugging, too, plays an important rôle in controlling the properties of fire-clay brick, and a few figures are available which show how long and short pugging affects strength. For example, one batch of brick which was made from rapidly pugged clay had an average end-crushing strength of 31,667 lbs. Another batch made from the same clays, when pugged longer, had an end-crushing strength of 42,767 lbs. Another batch showed strengths of 36,366 and 46,000 lbs. for short and long time of pugging.

From the data which have been presented as examples of the influence of water and pugging, one can appreciate how bricks made by different processes must vary. The soft-mud process involves long-time tempering with a large amount of water; the dry-press involves a shorter period of working and less water; and the stiff-mud process might be considered as intermediate between these two. Furthermore, it must be borne in mind that no two clays are alike and that results secured by a certain process with one mix would not apply to a second. Therefore, the writer will avoid any statements concerning the methods employed in the shaping of fire brick. Each method has its advantage and produces excellent bricks for certain uses, but one cannot state that any particular process is the best for all clays.

After shaping, the ware is dried on hot floors, in the open, or in tunnel driers, but this very important step concerns only the manufacturer. In the case of large shapes, weeks are required for drying, although by controlling the humidity of the modern dryer this time may be greatly decreased. It does, however, prepare the green brick for introduction into the kiln and hence for subsequent burning.

It is then that the contraction is removed from the clays and "creeping" of arches and "opening" of joints are prevented. A firm bond is developed and resistance to abrasion is increased. Sometimes a lightly burned product gives the best results, although such cases are less common. It is at this period in manufacture that a pinkish cast is sometimes developed if damp bricks are subjected to the combined action of sulfur and water. This discoloration may therefore indicate either an excess of impurities or the full development of the coloring effect of the usual amount.

However, the laboratory problem in this connection deals with the determination of the proper burning temperature for different clays. Some clays contract rapidly at low temperatures, and, after reaching a certain limit, remain constant in volume. Others continue to contract over a very wide range of temperature. A third class contracts but very little at any

temperature and hence is termed open-burning. Studies of such clays, when made and plotted as in the curves, give very useful information from two standpoints. They tell the manufacturer what treatment is necessary to remove shrinkage and obtain a well-burned product. They also inform the consumer how the different clays are going to behave in service, whether they will remain open or become dense at working temperatures. In that connection, such curves will undoubtedly throw some light on the problem of spalling, which is apparently due to the vitrification of the bond clay during service and the subsequent lower resistance to heat changes. A few volume-temperature curves which indicate the variations in burning behavior of different clays are given in Fig. 2 to illustrate this point.

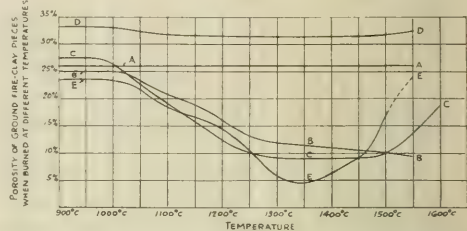


FIG. 2

A—Open-Burning Flint Clay; B—Dense-Burning Flint Clay; C—High-Grade Dense-Burning Plastic Clay; D—High-Grade Open-Burning Plastic Clay; E—Low-Grade, Dense-Burning Plastic Clay

While this paper is very elementary in nature, it is hoped that it will show how every step of the many which are involved in fire-brick manufacture is important; that this industry is not so crude as is often supposed; and that most manufacturers are working to improve their products. While the naturally occurring materials are limited in application and can hardly be subjected to chemical treatment, they can be used in the most efficient manner and it is the purpose of modern manufacturers to do this.

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THE SELECTION OF REFRACTORIES FOR INDUSTRIAL FURNACES

By W. F. ROCHOW

Economy in the use of refractories is largely governed by the selection of the class of material best suited for the purpose intended, the quality of the brick, and the design of the furnace. The importance of such factors as good brick laying, care in storing and handling the brick, and proper manipulation and control of the furnace, while clearly evident, cannot be emphasized too strongly. Each class of the commercial refractories possesses some properties which make it especially adapted for certain conditions encountered in the process. Careful study of the properties and of the actual working conditions, together with practical trials, will determine the proper material to use. A superficial consideration of these factors is not sufficient, for in some cases economies have resulted from the use of refractories whose chemical composition and physical properties would indicate that they were entirely unsuited.

For a long time, because of the acid character of silica brick, it was not considered good practice ever to use them where a basic material would come in contact with the brick. In some processes, however, the temperature necessarily employed is not high enough to induce chemical reaction between the refractory and the charge. Thus silica brick have been used for

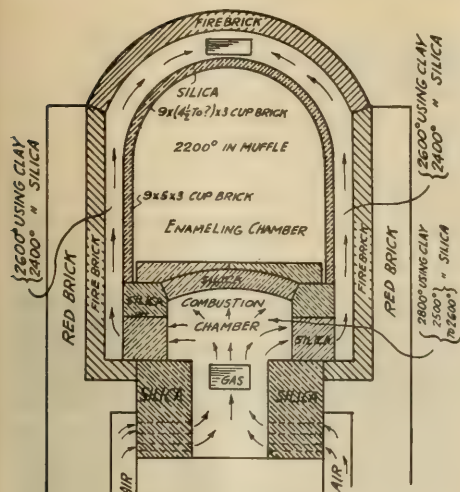


FIG. 1—SECTION OF MUFFLE FURNACE

many years in kiln linings for burning such basic materials as lime, dolomite, and magnesite. Care must be taken with kilns of this kind to avoid spalling caused by rapid temperature changes and to keep the temperature within the proper limits. Moreover it is sometimes economical to use a refractory of chemical character opposite to that of the products of the furnace, notwithstanding chemical action occurring between them, as, for example, in the glass industry silica brick are used practically to the exclusion of every other refractory in the roofs of tanks and pot furnaces although they are subjected to the alkaline vapors from the glass batch. Other refractories which may here better resist the chemical action have not the same combination of other desirable properties which make silica superior.

In this paper it is proposed to consider principally the silica and magnesia refractories.

SILICA REFRACTORIES

In general terms the properties of silica brick to be considered in their use are their high thermal conductivity, mechanical strength and resistance to abrasion at furnace temperatures, thermal expansion, spalling tendency, and high softening and fusion point. The thermal conductivity of silica as compared with that of first quality fire-clay brick is illustrated by the following figures which are the results of determinations by Dudley.¹

The coefficient K expresses calories per second flowing through 1 sq. cm. area, 1 cm. thick, per 1° C. difference.

	Mean K between 0° and 100° C.	Mean K between 1° and 1000° C.
Flint Clay Brick.....	0.0016	0.0025
Silica Brick.....	0.0021	0.0031

Along with other of its properties, the good conductivity of silica renders it the best suited material for the construction of the major portion of by-product coke ovens and other furnaces in which heat must be transferred through the refractory. Advantage also is taken of its conductivity in enameling furnace muffles. As shown in Fig. 1 the use of silica is not confined entirely to the muffle but also is used in the combustion chamber.

In this type of furnace any danger from spalling is avoided by the proper control of the temperatures on heating and cooling when starting up or shutting down. As bearing on the spalling tendency of silica it is interesting at this point to consider briefly

its thermal expansion. From the curve¹ of Fig. 2 it is apparent that most of the expansion occurs over a narrow range and at comparatively low temperatures. By heating and cooling slowly over this critical range up to about 500° C. any difficulty due to spalling is eliminated.

Notwithstanding the high thermal conductivity, the good mechanical strength of silica brick at high temperatures makes it possible to insulate them under very difficult conditions. Unlike fire-clay and magnesia refractories there is only a narrow temperature range between the softening and fusion points of silica, and hence no deformation occurs up to the melting point. Silica brick used in arches and subjected to high heats are being insulated with such material as kieselguhr with appreciable saving. Under similar conditions the best fire-clay brick would soften gradually and eventually collapse. Where clay brick are necessarily used it is frequently impracticable to insulate them. Often it is possible to effect an economy by cooling rather than by insulating and under some conditions it is necessary to provide radiation or conduction of heat from the refractory.

For a high-grade silica brick, Nesbitt and Bell² secured an average crushing strength of 1831 lbs. per sq. in. at 1350° C. The best clay brick which they tested had a crushing strength of 1289 lbs. per sq. in. at the same temperature. As shown by results from the load test of the American Society for Testing Material most fire-clay brick settle somewhat under a pressure of 25 lbs. per sq. in. at 1350° C., while good silica brick remain rigid under the same load at 1500° C. This test is of considerable value in selecting refractories, although in most industrial applications the conditions are rarely as severe as those employed in the load test, in that only a small fraction of the brick is exposed to the intense heat of the furnace while the remainder of the brick actually supporting any load is comparatively cold. Proper consideration, moreover, should also be given other properties, for some brick having a high ultimate fusion point often show greater contraction than others of much lower refractoriness, but of higher silica content. The siliceous clays expand up to certain temperatures in accordance with the relative proportions of their free silica content.

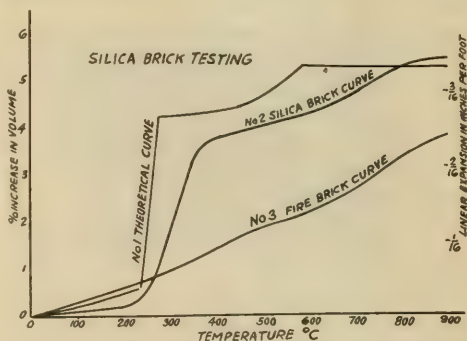


FIG. 2

In addition to chemical analysis and the load, fusion, and spalling tests used for determining the quality of silica brick, it has been pointed out that the specific gravity may be used as a criterion of the extent to which the permanent expansion should be carried in the first firing. D. W. Ross³ recently has made a

¹ Montgomery and Office, *J. Am. Ceram. Soc.*, 1918.

² "The Necessity of Inspection and Testing of Refractory Brick," A. S. T. M., June 1918.

³ "Silica Refractories," U. S. Bureau of Standards, *Technologic Paper* 116.

¹ *Trans. Am. Electrochem. Soc.*, April 1915.

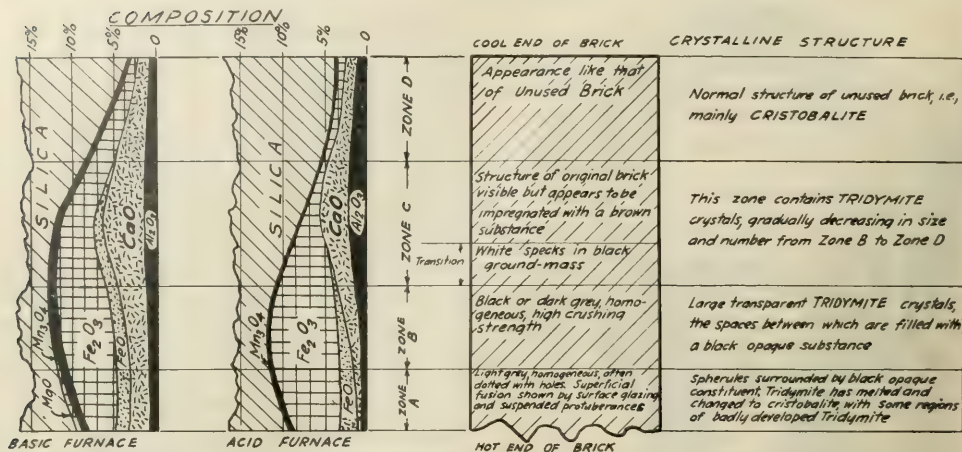


FIG. 3 SKETCH ILLUSTRATING TEXTURE, COMPOSITION, ETC., OF SILICA BRICK AFTER USE IN OPEN-HEARTH FURNACE ROOFS

very thorough investigation of silica refractories and suggests that a specific gravity of 2.38 may be accepted as the upper limit for well-burned brick. For most American brick, that is, those made from Medina quartzite of Pennsylvania, this is undoubtedly an accurate figure, but for others a slightly higher specific gravity is sometimes found in properly burned brick. A fine grained quartzite of high purity and 2 per cent of lime are the sole constituents of unburned silica brick. Upon burning, the quartzite undergoes partial inversions to other crystalline forms, *i. e.*, cristobalite and tridymite. These changes are accompanied by permanent volume increases and it is desirable that this permanent expansion be attained to the maximum degree so that there may be no excessive after-expansion when the brick are used in the furnaces. The specific gravity of the crystalline forms of silica are as follows: quartz 2.65, tridymite 2.270, cristobalite 2.333, and quartz glass 2.21.

Some quartzites invert to cristobalite and tridymite more slowly than others, giving a slightly higher specific gravity to the brick made therefrom. Such brick, however, are practically identical with those having a lower specific gravity and when properly made do not show an appreciably greater expansion. The following microscopic analyses¹ of two silica brick, both burned in the regular commercial manner, one made of Baraboo and one of Medina quartzite, illustrate the difference in the rate of inversion of these two quartzites.

Brick	Quartz and Silicates Per cent	Cristobalite Per cent	Tridymite Per cent
Made from Baraboo quartzite	44	52	4
Made from Medina quartzite	13	72	15

Brick made from rock having inversion characteristics similar to the Baraboo may be properly burned when inversion has occurred to such an extent that its specific gravity is slightly, if any, lower than 2.42.

Often very much of practical value can be learned by studying the remaining portion of brick after long use. An interesting example of the manner in which silica brick deteriorate in the roofs of open-hearth furnaces may be had from the results of the investigations by E. Rengade.² Four distinct zones have been distinguished in silica brick taken from the roof of open-hearth furnaces after having been in service for the normal period of time. A number of analyses made to determine the

composition of these various zones are averaged and are plotted in Fig. 3.

MAGNESIA OR MAGNESITE REFRACTORIES

Since late in the year 1914, when the supply of Austrian magnesite was cut off as a result of the war, there has been more thorough study of the properties of basic refractories than ever before. Unlike the Austrian magnesite, the domestic material does not naturally contain a sufficient amount of iron oxide. The presence of iron in any proportion lowers the fusion point, but in quantities of from 4.5 to 8 per cent of ferric oxide, it widens the range of vitrification and develops good bonding properties at furnace temperatures. In the use of the domestic product in manufacturing refractories it has become the practice to add a percentage of iron oxide and in this manner the properties are made very similar to those of the Austrian magnesite.

While magnesia brick give excellent service and are almost indispensable in many metallurgical operations, unsatisfactory results may be secured unless they are used with due regard to their properties. At high temperatures magnesia brick are not mechanically strong nor resistant to abrasion. As is illustrated in the curve of Fig. 4, they expand considerably, with the maximum expansion occurring at about 1350° C. On account of this high thermal expansion the brick have a tendency to spall when heated or cooled too rapidly.

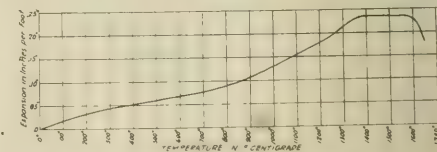


FIG. 4—THERMAL EXPANSION OF MAGNESIA BRICK

In several applications an economy has been effected by the use of metal-encased magnesia brick in place of the regular magnesia and silica brick in parts of the furnaces. In the manufacture of this product, rectangular or circular soft steel casings of definite gauge, open at both ends, are rammed full with a high grade of dead burned magnesite. When properly dried, the brick are ready for use without having been burned. These brick are always laid as headers with either open end next to the heat. No cement is used in laying the rectangular brick but the spaces between those of circular cross section are filled

¹ Insley and A. A. Klein, U. S. Bureau of Standards, *Technical Paper* 124.

² Academy of Science, Paris, May 1918.

with moistened furnace magnesite. At the temperature of the furnace in which they are used, the steel container melts back for a distance of one or two inches from the exposed surface and impregnates the dead burned magnesite which it encloses. The surface thus becomes practically jointless. Because of this monolithic surface and the somewhat more open texture of this construction, the spalling tendency is considerably less than that of magnesia or silica brick. The stiffening effect of that part of the metal case which does not fuse also helps reduce spalling to a minimum. This brick is used in the back walls, bulk heads, and gas ports of basic open-hearth furnaces and in the side walls of electric steel-melting furnaces. An installation of these brick in a 6-ton Heroult furnace is shown in Fig. 5.



FIG. 5—VIEW OF SIX-TON HEROULT ELECTRIC FURNACE SHOWING PATENT METAKASE MAGNESITE BRICK SIDE WALL LINING

In addition to the physical and chemical properties of refractories the design of the shape used also is worthy of careful attention. Difficult and intricate shapes should be avoided as much as possible. They cannot be repressed, are more liable to defects in workmanship, and cost more. With few exceptions they cannot be used to advantage over the standard sizes and shapes. Standard sizes are carried in stock by the refractories manufacturers and ordinarily are available to the user promptly when needed. Because of the time required for manufacture, a number of weeks must necessarily elapse before special shapes can be secured.

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INTERESTING FACTS CONCERNING REFRACTORIES IN THE IRON AND STEEL INDUSTRY

By C. E. NESBITT AND M. L. BELL

In the manufacture of iron and steel the part played by refractories is a most important one and up to the present time has not had proper consideration. Owing to increased production, larger and more complicated furnaces, and economy of

operation, the necessity for greater efficiency from refractories is forced upon us. This improvement in refractories can only be accomplished by the coöperation of the consumer and the producer. The consumer should be familiar with the conditions prevailing in his furnaces, such as temperature, slag, gases, dust, mechanical wear, abrasion, expansion and contraction, etc., so that he is in position to know what the brick must stand.

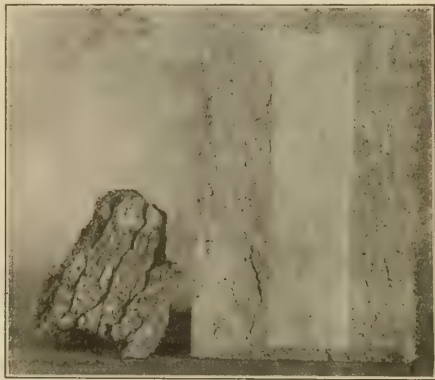


FIG. 1—SMALL PORTION OF DISINTEGRATED REFRACTORY BRICK AFTER 5 YEARS' SERVICE IN BLAST-FURNACE LINING. NOTE SIMILARITY OF CRACKS IN SMALL PORTION AND IN UNUSED BRICK

On the other hand, the manufacturer of refractories should know the limitations and possibilities of his product. He should know the effect on quality in service produced by variation in moisture, fineness of grind, proportionate sizing of particles, method of molding, drying, and burning. Such information enables him to advise the consumer as to the kind of brick best suited for his particular needs.

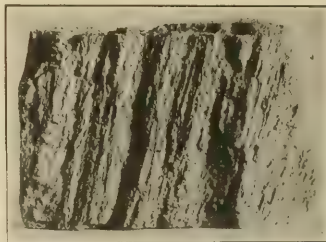


FIG. 2—CLAY BRICK FROM COLD-BLAST MAIN OF BLAST FURNACE SHOWING EROSION PRODUCED BY DUST CARRIED IN BLAST

In the iron and steel industry the temperature range is wide. Temperatures in the interior of a blast furnace vary from 260° C. at the top to 1800° C. at the tuyères. Refining temperatures are high in open-hearth, Bessemer converters, and electric furnaces, while temperatures in quenching and annealing furnaces are moderate. Besides this wide range of temperature, refractories must meet a wide variation on physical requirements, such as corrosive action of acid, basic or neutral slags, sudden thermal changes, load, abrasion, impact, and expansion.

Early in our investigation we found need for simple tests which would give us some data on the important qualities necessary in refractory brick. These tests should be easily and rapidly ex-

ected to be able to be run in quantity and should show a close relation to actual service conditions. This means that the tests employed must be shorter and more severe than actual working conditions and must show variation in working quality.

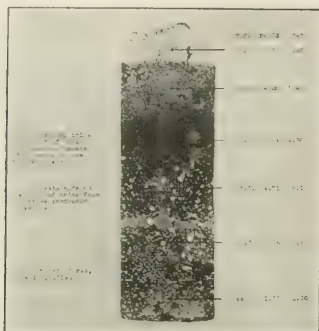


FIG. 3—CHANGE OF COMPOSITION DUE TO ABSORPTION OF IMPURITIES BY SILICA BRICK USED IN ROOF OF BASIC OPEN-HEARTH FURNACE

A series of tests was developed for both clay and silica brick. Data obtained from these tests, after use over an extended period, showed that the most important working qualities could be determined by two or three tests, namely, the spalling and hot crushing tests for silica brick, and the spalling, hot load, and slagging tests for clay brick. We do not deem it necessary at this time to give these methods in detail as they have been published in some of our former papers.¹

By the use of these tests we are trying to solve some of the refractory problems in our industry, a few of which are the following: Why does the life of blast-furnace linings vary from 2 to 7 years, basic open-hearth roofs from 25 to 400 heats, soaking pits from 6 to 18 months, converter bottoms from 4 to 16 heats, and ladle linings from 4 to 25 heats? How can we explain the fact that one solid brick is found in a blast-furnace lining surrounded by a number of disintegrated bricks and in another place on the same level one disintegrated brick will be surrounded

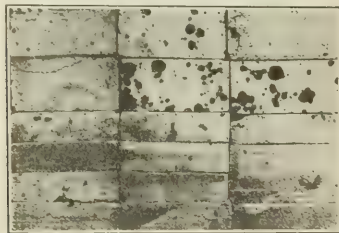


FIG. 4—SILICA BRICKS DEFECTIVE FROM FIRE CRACKS, POOR SLICKING, AND FOREIGN MATERIALS

by a number of sound bricks? These and many other problems present themselves which are difficult to solve. Variations in quality of the refractories are due to method used in grinding, moulding, setting, drying, burning, and cooling. It is a well-known fact that silica bricks show a falling off of approximately 50 to 60 per cent in crushing strength when heated from room temperature to 1350° C., hence defects which lower the mechanical strength of a product which has already been weakened

by heat are serious factors. In the table below are shown results of tests on good commercial silica brick crushed at room temperature and at 1350° C., together with bricks defective because of fire cracks, poor moulding, poor slicking, etc.

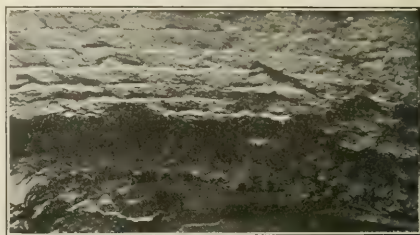


FIG. 5—ROOF OF BASIC OPEN-HEARTH FURNACE SHOWING FAILURE DUE TO UNEQUAL WEAR AS A RESULT OF SLAGGING AND SPALLING

CRUSHING STRENGTH—OLSEN MACHINE		
Results in pounds per square inch		
Commercial Silica Brick	At 1350° C.	Defective Brick At 1350° C.
At 30° C.		
1317	989	437
1755	1123	466
2323	1152	466
2685	1282	498
3062	1300	657
AVERAGE	2271	505

Fire cracks also cause a decided shortening of the life of a silica brick structure such as an open-hearth roof where there are severe thermal changes. This is well illustrated when commercial silica brick with and without fire cracks are subjected to our spalling test at 540° C. The results are expressed in percentage loss in weight.

Free from Fire Cracks	With Fire Cracks
21.9	39.4
22.4	44.0
25.0	44.5
29.1	44.8
33.1	59.4
AVERAGE	26.3
	46.4

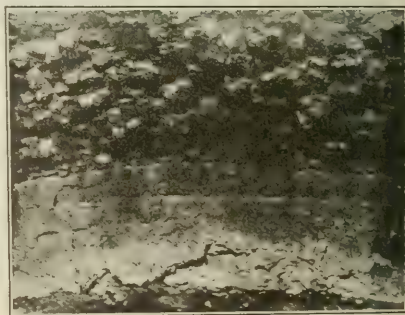


FIG. 6—SPALLING OF CLAY BRICK IN ROOF OF AIR FURNACE

Roofs of 90-ton open-hearth furnaces working under normal conditions with producer gas should last for an average of 200 heats. Bricks taken from a furnace roof after 261 heats showed an average spalling loss of 20 per cent. Another roof which made 221 heats showed a loss of 23 per cent. In a similar roof in which the life was only 80 heats the average spalling loss was 47 per cent.

The degree of fineness or size of particles especially in silica brick has a very pronounced effect on the spalling loss. The

¹ *Trans. Am. Soc. for Testing Materials*, 1916, 1917, 1918, 1919.

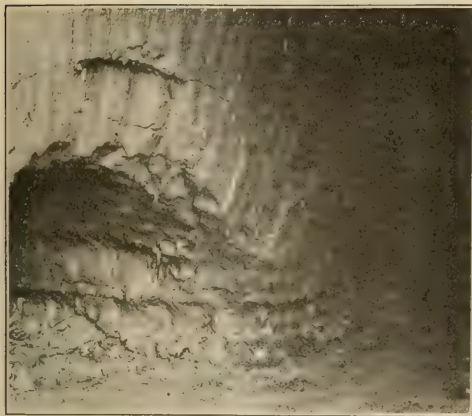


FIG. 7—WEAR IN AIR FURNACE PRODUCED LARGELY BY SLAG ACTION AND TEMPERATURE CHANGES

finer the grind the higher the loss, which in turn means a decided shortening of the life of the structure when subjected to severe thermal changes as illustrated in this table.

FINENESS OF GRINDING	SPALLING LOSS
Mesh	Per cent
4	30.4
8	47.6
12	63.2

The interesting facts stated above in regard to silica brick are generally true with clay brick, except that they are not so marked, owing to the fact that the raw materials have entirely different properties. However, the method of manufacture has a pronounced effect on the qualities of clay brick. This is illustrated by the average spalling value of six different brands of brick,

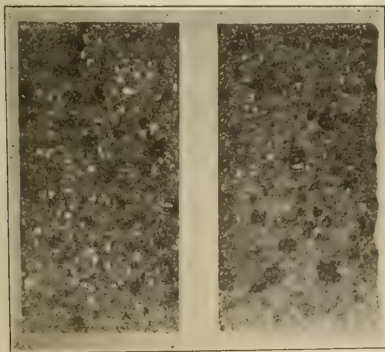


FIG. 8—BLOCKS CUT FROM TWO SIMILAR SILICA SHAPES SHOWING VARIATION IN FINENESS OF GRIND

three of which are machine-made, but by different processes, while three are hand-made brick.

AVERAGE PERCENTAGE LOSS BY SPALLING AT 1350° C.					
Machine-Made			Hand-Made		
26.9	11.7	9.4	7.3	3.4	16.7

Again this variation in quality of refractories is shown by the results obtained from the load test in which a steel ball is pressed

into a fire-clay brick heated to 1350° C. by applying a load of 1600 lbs. Results are depth of penetration expressed in inches.

Machine-Made			Hand-Made		
0.27	0.46	0.29	0.55	0.72	0.44

The degree of fineness to which the raw material is ground in clay brick produces results similar to those of silica brick, namely, the finer the grind, the greater the spalling loss. The results given here are the averages obtained from two brands of clay brick, one of coarse grind and the other of fine grind.

	Loss by Spalling
	Per cent
Coarse Grind.....	8.47
Fine Grind.....	49.95

Reduction in strength by heating is shown by the impact test. A steel ball approximately 2 1/2 lbs. in weight was dropped by a suitably designed machine from successive increasing heights of 2 in. upon the heated brick. The brick tested was a well-known ladle brick made largely of plastic clay.

HEIGHT OF FALL OF BALL TO BREAK BRICK			
Temperature.....	30° C.	340° C.	480° C.
Average height, inches.....	51.2	40.3	33.6

The effect of extreme variation in degree of burn is well illustrated in a recent shipment of clay checker brick. The average spalling loss was 14 per cent for the average burn and 60 per cent for the hard-burned bricks.

From all the comparative data it is evident that refractories require more than general consideration. They demand a most thorough study by both producer and consumer. Investigators should try to adopt simple practical tests which can be run in quantity and which give data showing variations in quality, which reflect in the life of the structure.

The consumer judges his refractories by the life obtained and demands a product giving a more uniform life. Variations in uniformity are largely due to methods of manufacture. It is believed that a much more uniform product can be secured if a careful study is made of the variations in manufacture which affect the important qualities.

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SUPERIOR REFRACTORIES

By ROSS C. PURDY

There is a demand for better quality in refractories, the real urgency and volume of which are growing apace with the rapid development in more efficient manufacturing equipment. The most vital limiting factor in the development and adaptation of electric furnaces is adequate refractories, the present furnaces having many compromises in design and operation, and serious limitation in use because of failure of the refractories to withstand the service conditions that otherwise would be placed upon them. New inventions of processes to lessen cost, improve quality, recover by-products, eliminate material losses, etc., etc., are not war babies, but the natural result of actual necessity for new and greater refinement in materials and economies in processes. The increase in mechanical and dielectric strains on high tension insulators resulting from extensive development of electric power, the increased strain on spark plugs and the increase in hazards due to failure of spark plugs in air craft are but two of many examples of the increasing urgencies that can be met only by materials that necessitate more intense heat treatment. Examples of increases in demand for improved quality and refinement are more numerous and perhaps more urgent for metals than for ceramic ware.

New alloys that require higher temperatures for tempering, new glasses that necessitate more intense heat treatment to melt and refine, new labor-saving devices that entail more severe temperature changes, new by-products that must be

reclaimed to make the essential process commercially feasible; all of these and many more create an actual, not fanciful, demand for a refractory that will be superior to that which hitherto has been considered adequate. These new requirements and these changes in requirements call for a distinct applied chemical engineering, a specialty in ceramic engineering, which must be employed jointly by the producer and users of refractories.

What is meant by a superior refractory? Simply one that will better meet the requirements in each case. No doubt the superior refractory in most cases will be found by proper selection of the refractories already available, but there are cases, and they are multiplying rapidly, where new refractory products will have to be developed. There are known requirements for refractories made of pure silicon carbide, fused alumina, sintered magnesia, fused spinels, crystallized sillimanite, calcined zirconia, etc., refractories that are not now much beyond the laboratory stage in development.

It will be only such as these last-named refractories that will meet the excessively high temperature requirements and have at the same time the many other desired heat, strength, and di-electric properties. There is no denying of the demand for such special refractory materials, but the plain truth is that most of the new requirements will be met either by intelligent adaptation of the materials in general use to-day or by readily made modifications of them.

To make proper selection of a suitable refractory requires an understanding of the several properties that are requisite in each case and a knowledge of their relative importance. This may sound pedantic and unnecessary repetition of that which has often been said and written, but when one hears chemists, metallurgists, and engineers of recognized ability discussing refractories altogether in terms of the temperature of fusion and of chemical analysis, it is made plain that all of our present refractory difficulties are not chargeable to the producer.

How do refractories fail? To answer this question intelligently and in language that will need no interpretation, it is necessary to deal with the simple fundamentals, and, to prevent confusion of ideas, let us take the better known fire-clay refractories for illustration of these fundamentals.

The most refractory fire clays may be either nearly 100 per cent pure kaolinite or a relatively complex mixture of refractory minerals, such as kaolinite, quartz, diaspore, bauxite, etc. Such a variety of mineral mixtures, so far as they concern us at this time, may be equally as refractory although representing comparatively wide variation in chemical composition and mineral constitution. The fundamental concepts of what is essential in refractories would, however, apply alike to each.

FUSION

At no time in the history of the clay refractory, either during fabrication or use, is the process of fusion of the several mineral components carried to completion. A well-made clay refractory article will have had the fusion of the minerals carried only to that point at which maximum strength and greatest constancy in volume are attained without distortion of the fabricated refractory article. Retaining of shape of the fabricated article is the result only of stopping the progress of fusion very much short of attainment of ultimate possible strength and constancy in volume of the refractory constituents. Chemists would speak of this partial fusion as arrested reaction. It is a very important consideration how far these reactions should progress in the manufacturing of the refractories and to what further extent they will be carried in use.

Now the interesting fact in this partial fusion or arrested reaction consideration is that the degree of fusion is affected by such factors as compactness of the mass, homogeneity of the mixture, size of the mineral particles, and other physical factors. These physical factors result from plasticity and fineness of the clays, the degree to which the clays are pulverized, mixed, and

tempered; and also to the method of manufacture of the refractory article. These physical factors have a very decided and strong influence on the rate of fusion and it is this rate of fusion that is of more importance than the possible ultimate fusibility.

SOFTENING POINT

The melting point or temperature of melting of a pure mineral can be determined, but it is impossible to find a melting point in a mixture of minerals or even in such relatively simple mineral mixtures as refractory fire clays. This is due not alone to the viscosity of the melt but also to the range between the melting points of the components or compounds present. Rather than a melting point, we have a melting range or period. You cannot intelligently speak of fusion of clays in terms of degree of temperature. A clay, which when molded into the standard cone shape will squat at 1600° C., most likely will have had its fusion well progressed at 1000° C. This melting range, of course, has some relation to the rate of fusion, but neither can be stated in definite temperature terms, and neither can be closely correlated with the chemical analysis of the mixture.

To judge clay refractories solely on basis of temperature of fusion or on chemical analysis, or both, as valuable as such evidence certainly is when considered with data on other properties, will always lead one astray.

THE ESSENTIAL REQUIREMENTS

Many refractory installations must sustain a heavy load at relatively high temperatures; others must be impregnable to gases; others must offer the least opportunity for collection on their surface of fusible solids such as coal ash; others must resist corrosion of molten glass, slag, or metal. In nearly all cases it is desirable, and in most cases essential, that the refractories maintain a constancy in permanent volume, and in most installations the refractory must be resistant to abrasion and withstand sudden temperature changes.

Now what will give the essential combination of these properties in a given case? High ultimate fusibility, structural strength, suitable density, and low permanent volume change are essential in all cases of superior refractory installation. Notice, please, that neither chemical characteristics, heat conductivity, nor electrical resistance are mentioned here, although in a few special cases these are essential considerations.

The frequently used classification of refractories as acid, basic, or neutral has a value in but very few cases, such as basic and acid processes for steel, and even in these there is evidence that too much stress has been placed on having the chemical nature of the refractory the same as that of the slag. One need but make a few slag tests on bricks to learn that the effects of basic and acid slags have practically the same corrosive fusion effect through a very long range in composition of either the slag or the refractory. The emphasis that is now placed on basic and acid refractories will be found as much a bugaboo in the vast majority of refractory installations as the old notion that it is essential to have a course of neutral brick between the acid silica crown and the basic magnesite linings. The refractory most suitable for a stoker furnace cannot be determined by consideration of balance between the chemical nature of the coal ash and that of the refractory.

Bear in mind, please, that special cases are not being considered here; it is only the general, but very much the largest number of cases, requiring superior refractories that we should consider when attempting to determine the best superior refractory. It is recognized that there are exceptional cases where the chemical characteristic of the refractory is a very essential consideration, but why, I am arguing, should we "pick on" the 99.9 per cent of the cases and apply to them the chemical considerations that hold only for the other 0.1 per cent of the refractory cases.

SUPERIOR REFRACTORIES OF THE FUTURE

For all installations where the cost will justify the expense, the superior refractory of the future will be made of fused alumina, silicon carbide, crystallized sillimanite, fused spinels, sintered magnesia, or other very refractory mineral substances that have been so fused or sintered as to have attained completed chemical change and have come to a constancy in volume. Which of these refractory substances will be most suitable in a given case will be much more dependent on physical than on chemical conditions, and the desired physical properties can be obtained with much more certainty with such refractories than with such materials as clay, bauxite, or calcined magnesite in which the physical and chemical reactions and alteration have not been carried to stability, *i. e.*, the physical-chemical reactions are only partially completed in the fabricated refractory ware.

In the case of the superior refractories under discussion, there need be either no bonding material used, or, to produce the maximum strength, there need be but a small per cent of very fusible material such as silicate of soda, very fusible clay, or stoneware glaze. A strong, highly refractory article can be thus made of any of these materials, and have any structural characteristic desired.

The present-day demands for special superior refractories will be met by very refractory materials which have been fused or sintered to a physical and chemical constancy; and so fabricated, as here described, as to have the essential physical and mechanical properties.

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WORCESTER, MASSACHUSETTS

REFRACTORY PROBLEMS OF THE GAS INDUSTRY

By W. H. FULWEILER AND J. H. TAUSSIG

There are two general processes in use for the manufacture of illuminating gas. The one, which is known as the coal-gas process, involves the distillation of coal in refractory vessels called retorts at a comparatively high temperature, *i. e.*, 1000° to 1200° C., and the other, known as the water-gas process, consists in decomposing steam by passing it through a highly heated quantity of carboniferous material, *i. e.*, generally, anthracite coal or coke and in carburizing this gas with petroleum oil, which is injected into heated vessels along with the water gas.

COAL GAS

We may take as a typical example of a modern coal-gas installation, a system now coming into general use, which is known as the vertical retort system.

Fig. 1 gives a sectional elevation of such an installation. It will be noted that there are a number of retorts located in the combustion chamber. These are heated by means of producer gas generated in the producer and burned with a preheated supply which is technically known as secondary air.

The products of combustion pass downward through recuperators or heat interchangers, in which the incoming supply of secondary air is preheated to the desired temperature.

Probably a more efficient type of apparatus, and the one being used in the most recent installations, is one in which the producer gas is made in external producers.

The coal gas as it passes out at the tops of the retorts is conducted through appropriate piping to the condensing, scrubbing, and other purifying apparatus.

The temperature in the combustion chamber is 1450° to 1550° C., in the lower portion of the retorts, 1350° to 1500° C. This temperature gradually decreases throughout the retort chamber and at the top, where the gases enter the recuperators, is about 850° C. It gradually decreases through the recuperators and the gas leaves them at a temperature between 480° and 530° C.

The incoming secondary air enters the recuperators at atmospheric temperature and leaves them at a temperature of about 760° C.

The retorts themselves are charged or filled with coal at from 10- to 12-hr. intervals. This means that the internal surfaces of the retort are subjected to a very considerable variation in temperature, due to their filling with a large quantity of cold material.

The retorts are about 23 ft. long and have at the top a heavy iron casting forming the upper mouthpiece. This involves a rather considerable load per square inch of cross section at their lower portions, where they are subjected to the highest temperatures, so that, in addition to their refractory qualities, their resistance to deformation under load must also be considered.

In order to secure the most economical materials under the rather diverse conditions that exist in a modern retort bench, it has been necessary to use both silica and fire-clay materials. This gives rise to an extremely complicated problem in the design and construction of these benches, on account of the different coefficients of expansion of the two classes of material.

The average silica material will expand about $\frac{9}{16}$ in. per ft., while the average fire-clay material, under the same temperature, will probably expand about $\frac{1}{16}$ in.

Another consideration, especially in heating up the setting for the first time, is the fact that silica develops the greater part of its expansion at 300° to 350° C. while fire clay expands gradually up to about 1100° C.

The bench structure may be looked upon roughly as a rectangular column of silica material, floating on a cast-iron base, which at the existing temperature has about the same expansion as the fire clay, surrounded by a retaining wall of fire-clay material and enclosed in a heavy steel framework.

These requirements may be more clearly illustrated by a series of slides showing a modern vertical setting.

Fig. 2 shows the steel framework and lower cast-iron plates which support the retorts and the upper structure of the bench.

Fig. 3 shows the combustion chamber where the initial combustion of the producer gas and secondary air takes place. These arches are double and are of the highest grade silica material in order to resist the extremely high temperature, and also to support a load which may amount to 25 lbs. per sq. in.

Fig. 4 shows the retorts which are of silica and also the recuperators which are of fire-clay material.

In the operation of these recuperators, the heating waste gases pass back and front in their downward travel through the large horizontal flues, while the secondary air, which is being heated, rises around these flues through the rather small spaces to be seen alongside the blocks forming the horizontal flues.

Fig. 5 shows the upper portion of a bench nearing completion and illustrates how the upper sections of the retorts are connected with the iron castings, forming the upper mouthpiece.

Fig. 6 illustrates the large mass of iron work with the many joints which connect the upper portion of the retorts to the gas-collecting system.

It will be apparent that the question of expansion, and particularly the differential expansion, is one that requires a very considerable amount of thought in both the design and actual work of construction, since provision must be made for the iron plates to move as they expand on the lower framework, and to follow the expansion of the fire-clay walls so as to keep the retorts in line with the iron mouthpiece and to prevent the remainder of the silica structure being displaced relative to the fire-brick construction. This is especially important in view of the large number of joints that must be kept tight.

It may be said that in the usual type of construction, the benches are built in stacks of about 90 ft. in length. Expansion springs are provided on the longitudinal tie members, so that an

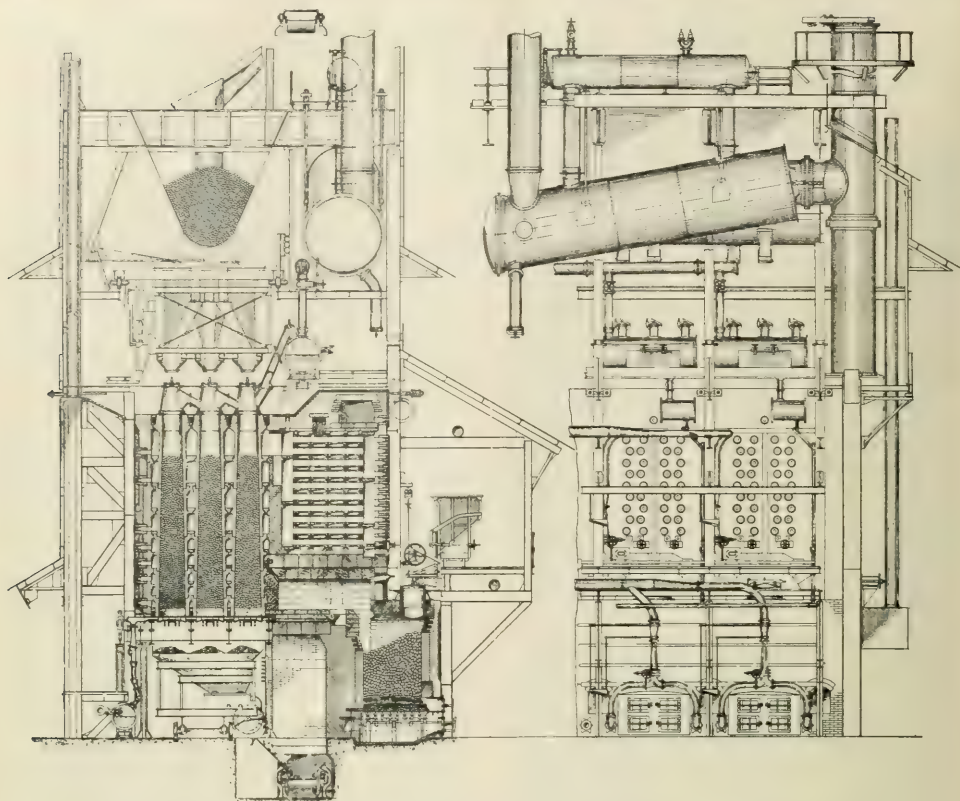


FIG. 1

expansion of 2 in. or a total of 4 in. can take place in a length of 90 ft.

Regarding the expansion, vertically, the construction is arranged so that the silica members, which include the retorts and combustion chamber lining, can expand freely from the outer fire-clay brick work, and the connections to the iron work, forming the gas take-offs, are so arranged that this expansion is taken care of by slip joints.

CHARACTER OF MATERIAL USED—In the combustion chamber, retorts, and connecting blocks, which are exposed to a temperature of 1550°C ., high-grade silica material is used. This will contain over 96 per cent SiO_2 with about 1.5 per cent CaO which acts as a bond.

In the recuperators, where the temperatures vary from atmospheric to 850° , normal conditions, and 1100° , maximum, fire-clay material is used, containing 55 per cent SiO_2 , the remainder being Al_2O_3 plus small quantities of CaO , Fe_2O_3 , etc.

On account of the rapid changes in temperature, due to the high conductivity and radiation of the iron work, that occur at the top and bottom of the retorts, fire clay is used in these sections because of its smaller coefficient of expansion and its ability to resist spalling under these conditions.

The outside walls are made of a lower grade fire brick, since they are exposed to moderate temperatures only.

The whole bench structure is insulated with a covering of brick made from infusorial earth.

One bench of nine retorts will require approximately 76 tons of silica material and 108 tons of fire-clay material.

In spite of the care used in the selection of materials, failures of refractory materials sometimes occur from carelessness in operation, if extensive temperatures are generated.

Fig. 7 shows the character of the failure of material in the combustion chamber of a vertical bench.

Fig. 8 shows failure in the retort chamber of a horizontal bench.

In the above examples the material was of fire clay which has now been replaced with silica material. It will be noted that the material has been softened by the excessive temperature.

WATER GAS

Fig. 9 is a photograph of a model of standard form water-gas apparatus. This consists generally of three steel shells, lined with fire brick and insulating material.

The shell to the left is called the generator, and is provided with grate and suitable connections for the introduction of air under pressure and for steam both below the grate and above it, also with a set of connections and reversing valves, so that the products of combustion may be taken either from the top of the generator or from the bottom of the generator.

These connections connect with the top of the carburetor which is the second vessel. This is also steel, lined with fire brick and with checker brick.

The bottom of the carburetor is connected to the bottom of

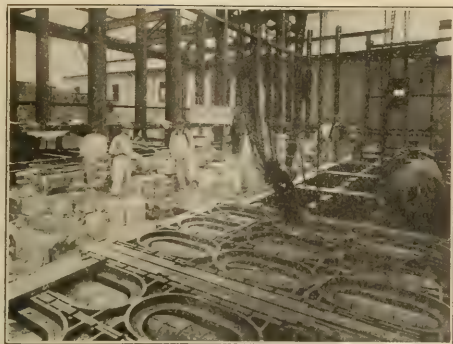


FIG. 2

the superheater, which is similar to the carburetor in construction, and is provided with a stack valve at the top for the escape of the waste gases and with a connection leading to the cooling and purifying system for the water gas that is produced.

In operating, the fuel contained in the generator is brought up to a high temperature by means of an air blast introduced beneath the grate.

Any combustible gases in the producer gas thus formed are burned by means of an auxiliary supply of air at the top of the carburetor and at the bottom of the superheater, thus enabling the temperature of these vessels to be controlled.

When the fuel has reached the proper temperature, the air blast is shut off, the stack valve lowered and the steam is passed through the fuel in the generator, either from the top or the bottom, the hot gas thus produced passing down the carburetor.

At the top of the carburetor it meets a stream of oil which is vaporized upon contact with the hot checker brick and on further contact in the carburetor and superheater is cracked, and transformed into a fixed gas, light hydrocarbon vapors, and a small amount of tar.

In the water-gas apparatus, we have the effect of high temperatures, abrasion, slagging action, and spalling action.

In the generator, the linings are subjected at the top to the effect of abrasion due to the introduction of the fuel, to the abrasive action of the small particles whirled about by the blast, and also to the effect of tools used in removing the clinker.



FIG. 3



FIG. 4

In the combustion zone we have very high temperature due to the preliminary combustion of the fuel, slagging action due to the ash of the fuel, a certain amount of abrasion due to the fuel itself, and, depending upon the character of the fuel used, we may have serious abrasion caused by the removal of clinker.

In the lower portion of the generator the temperatures are lower, but we have the effects of steam on the up run, the hot gases on the down run, and the effect of tools in removing the clinker, which gradually collects on the grate from which it is removed at intervals.

In the connections between the generator and the carburetor we have high temperatures, erosion due to particles of fuel passing through at high velocity, and a certain amount of slagging action from the ash.

In the carburetor the lining brick have only moderate temperature, but the checker brick and the crown are exposed to a tem-



FIG. 5



FIG. 6

perature as high as 1200° during the blasting period and are then deluged with a spray of cold oil during the gas-making period. This results in an accelerated spalling action on the checker brick, and has required the development of a special test to determine what are suitable brick for this work.

CHARACTER OF MATERIALS USED—In the selection of materials, the two important points, then, are the generator lining and the checker brick.



FIG. 7

In the selection of material for the generator lining, we have not only to consider the relatively high temperature, due to the combustion of fuel, but also the action of the clinker as a slag.

Table I shows the analyses of ash of a number of generator fuels, having various melting points. It will be noted that there is a very great variation in the relative occurrence of silica, alumina, iron, etc.

TABLE I—COMPOSITION OF ASH AND FUSION POINT

Fusing point Deg. C.	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	SO ₃	Undet.
1092	28.0	8.3	49.7	5.3	1.2	6.6	0.9
1133	29.7	14.2	49.9	2.1	0.7	2.2	1.2
1195	34.0	21.0	23.2	7.4	5.8	8.5	0.1
1213	35.8	34.1	12.4	10.4	tr.	6.5	0.8
1290	46.5	35.7	7.8	5.0	1.0	3.8	0.2
1413	42.0	38.0	15.8	2.2	1.1	0.8	0.1
1450	54.1	33.3	7.8	1.5	1.5	0.7	1.1
1510	50.8	33.9	10.2	1.7	tr.	2.0	1.4
1660	49.0	42.0	5.0	1.8	tr.	1.9	0.3

This results in the development of three distinct classes of clinker. The high fusing ashes tend to build out on the sides of the generator, thus seriously reducing the working area. This must be removed by barring down from the top. While this type of clinker does not seriously deteriorate the lining from the chemical standpoint, the result of the mechanical abrasion in the barring down is a very destructive factor.

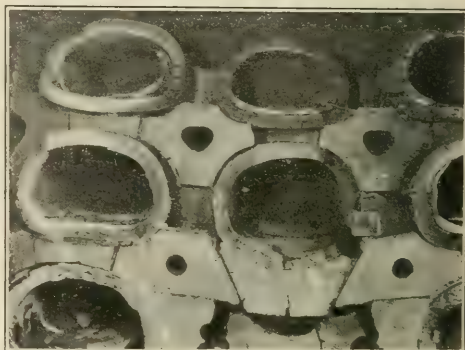


FIG. 8

The ashes with the moderate fusing temperature fuse to a certain extent on the sides of the linings but to the greater part they come down on the grate forming a compact mass which can be removed without much difficulty.

The ashes with a low fusing temperature, and it will be noted these are generally high in iron and rather low in alumina, seriously attack the linings and in addition come down and form on the grate bars a very hard, compact mass of material that is exceedingly difficult to remove when cold. In extreme cases, they may even melt and run through the grate bars, forming stalactites of material in the ash pit.

A very considerable amount of experimental work has been done with a view toward utilization of different grades of refractory material for generator linings.

The usual lining block is, of course, of fire clay. Silica materials have not been generally successful, due to the extreme and very frequent changes in temperature to which the blocks are subjected.

Experiments with magnesite brick have not been very successful, due to the difficulty of spalling.

Recently, magnesite blocks enclosed in a thin iron casing seem to have been somewhat more successful.

Chrome brick, owing to their extremely neutral character, have been tried. We have not sufficient data as yet to determine their value.

Zircon brick suffer from the disadvantage of high cost, but their extremely neutral character may prove sufficiently advantageous to warrant more extensive trials.

Two classes of carborundum materials have been worked with—the solid brick and the veneered brick. The solid brick is much stronger mechanically and its extra cost will probably be compensated for by a longer life. In the consideration of these materials it must be remembered that they will cost about 30 times as much as the fire-clay materials.

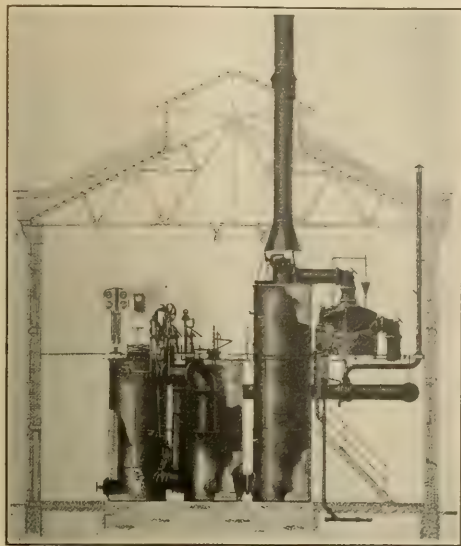


FIG. 9

With all of these neutral materials, the adhesion of the slags to the sides is eliminated, along with any corrosive action which might take place, and this also results in a decrease in the time required for cleaning the sets, as the barring down with high fusing ashes is eliminated.

The use of water-cooled iron surfaces, which have been very successfully adopted in producer work, is being seriously considered for at least a small portion of the zone, where the greatest corrosive effect is observed.

In connection with the checker brick it has been found by the use of the so-called "dipping test" that certain classes of brick are very much more efficient in resisting the spalling action, due to the alternate heating and cooling, than others. These may be described generally as bricks of the flint-clay type with rather coarse grog and a minimum amount of plastic clay. A dense brick that would not absorb the oil should apparently be more

satisfactory, but in general such bricks do not resist the spalling action.

Another feature that requires some consideration is the question of abrasive action in the fire-clay linings of the connections between the different shells. These linings are often almost entirely cut away by the abrasive action of the coke particles in the gas steam, and by the slagging action of the ash.

CEMENTS

In connection with the general use of refractories, it has been found that great care must be used in the choice of cements, and is believed that frequently failures have been attributed to the refractory material, when, in fact, they may have been due to the use of improper cements.

A great deal of experimental work has been done on this subject, and it is believed that we are now being directed to the use of more suitable materials for this purpose.

One of the difficulties involved is that the average mason wishes cement which works easily under the trowel. With the more refractory cements, which should be used, there is a tendency to add plastic clay or a similar material to give it this smooth working and it is the use of such material that seriously deteriorates the refractory qualities of cement with the result that the jointing material fuses and this deterioration may even extend to the brick itself.

In general, better results are obtained on construction work by using a cement composed principally of ground material similar in quality to the grog in the brick and a minimum amount of material of lower fusibility.

In using silica shapes where the expansion is high, no cementing material is used in many cases, the brick or shapes being laid up separate from one another by means of corrugated cardboard, whose thickness is so chosen that when the brick are brought up to the proper temperature it will allow sufficient room for the expansion to take place and thus form a sufficiently tight joint.

LABORATORY TESTS

The complexity of requirements has led to the use of a number of laboratory tests, to insure that material as received will be of suitable character for the use intended.

These tests are generally those which have been adopted by the American Society for Testing Materials and need not be described here. They include tests for the resistance to deformation under the load at high temperature, for slagging action, fusibility, and spalling action.

In connection with the resistance to deformation under load an automatic device is used which determines the expansion of the specimen at various temperatures and under different loads. This is a very important matter, as the expansion should be accurately known in order that the proper allowances for it may be made in the design and construction of bench work.

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FOREIGN INDUSTRIAL NEWS

By A. McMILLAN, 24 Westend Park St., Glasgow, Scotland

THERMALENE

Thermalene, discovered by Karl Wolf, of Zurich, is an intimate mixture of acetylene and vaporized oils and is claimed to have important advantages over other gases for producing high temperatures. The generating mixture is supplied in tin cans, the largest of the four commercial sizes now prepared yielding 200 cu. ft. of gas. Each tin can is packed with alternate layers of calcium carbide and crude oil mixed with sawdust. The addition of water, slaking the carbide, sets up the

generative action, vaporizing the oil. The acetylene and oil gas thus generated, cooled and purified, combine in the pipes. Thermalene is somewhat heavier than air and has a specific heat a little over $\frac{1}{8}$ that of acetylene, and at room temperature is liquefied by a pressure of from 1500 to 1600 lbs. per sq. in. A notable peculiarity is a soft, sweet, inoffensive odor. In welding, sparks are thrown off. It can be used at relatively low pressure, produces no corrosive or poisonous effects, and is not liable to cause explosions.

PLATINUM

The *Nieuwe Rotterdamse Courant* writes that shortly before the war it was discovered that there were large quantities of platinum in the districts of Olpe and Siegen in Westphalia and in the Westerland. At the outbreak of war the capital necessary for exploitation had not been raised. Capitalists have now been found, however, who are prepared to finance the exploitation of the platinum in the districts mentioned. Should the venture prove successful a new industry will be established which will be a compensation for the loss of the potash mines in Alsace.

ELECTRICAL PRECIPITATION OF TAR FOG

The removal of tar fog from coal gas is a troublesome operation but is very essential in the direct ammonia process. According to a communication to the Canadian Mining Institute, the Cottrell process of electric precipitation is quite able to deal with the crude gases produced in the distillation of coal, wood, and petroleum, even at the high temperatures used in modern industrial processes, while the usual methods of tar removal in extractors require cooling of the gases. The author of the paper states that he obtained cleaner distillates with electrical precipitation than formerly. The treator chamber he used consisted of an iron pipe 75 ft. high and 12 in. in diameter, provided with fused quartz insulators. He passed about a million cubic feet of gas through the heater per day. The heater requires about 2 h. p. or 3 h. p.

MAGNETIC METHOD FOR TESTING FERROUS METALS

The possibilities of the magnetic method of testing ferrous metals, says *Engineer*, 128 (1919), 255, are summarized in a paper by Mr. L. A. Wild, which was recently read before the Faraday Society. The author states that varieties of heat treatment on any particular steel show effects of the same degree whether tested by the scleroscope or by the magnetic method. The scleroscope, however, shows the effect on selected spots only, which have to be averaged, while the magnetic method sums up the whole state of the material. When it comes to comparing steels of different composition, the magnetic method classes material in the same order as the scleroscope as far as ordinary carbon steels are concerned, having only a comparatively low magnetic content. The addition of manganese reduces the scleroscope hardness of water-quenched steel, and leaves the magnetic hardness unaltered. Manganese increases the magnetic hardness of annealed steel without producing a corresponding increase in the scleroscope. Tungsten increases the magnetic hardness of water-quenched steel but it reduces the scleroscope hardness. While, therefore, possessing limitations the method is of great utility for the investigation of heat-treatment problems and should find a place in works laboratories where it may be used for such purposes as deciding between the merits of different oils for quenching, the degree of care required for tempering and kindred problems as they arise.

TANNING MATERIAL DEPOSITS

A writer in *La Halke aux Cuirs* draws attention to the property of some tanning materials in giving a heavy deposit when used in pits. It is evident that of two different tanning materials containing the same tanning content, that which will deposit the least quantity of sediment will be the more economical to use, as it is clear that such a deposit formed is a dead loss to the tanner. He then quotes some experiments made by Paessler which show the loss of tanning taking place when solutions of different tanning materials are left exposed for some time. This loss varies from zero per cent in the case of quebracho to 29 per cent in that of divi-divi.

LACTIC ACID

A British Patent 128,687 (1918) by A. P. H. Desborough, J. Reilly and H. C. Thaysen, gives the following method for the preparation of lactic acid. Sugar, such as maltose which may be obtained by the action of malt or molds on cereals, chestnuts, acorns, etc., dextrose, saccharose, mannite, raffinose, and arabinose are fermented with a new type of lactic acid producing organism—*bacterium volutans*—found in sour mash, maize, or other cereal meal, soil, carrots and parsnips, and identified by the size and by the production of volutine which can be detected microscopically by staining with polychrome methylene blue solution. The acidity developed by the fermentation is reduced by repeated addition of sterilized alkali, or alkaline earth compounds, such as calcium carbonate or oxide. The lactates may be separated by evaporation and crystallization or by the formation of other lactates. These crude lactates are washed with small quantities of water and the wash liquors are worked up for the volatile acids such as acetic acid and butyric acid. The lactates are afterwards decomposed by sulfuric acid or other acid and the lactic acid extracted with butyl or isobutyl alcohol. The volatile fatty acids are separated by distillation. The lactic acid obtained is purified by forming the lactide and afterwards reconvert the crystallized lactide into the acid. Solutions for fermentation may be obtained by treating brewers', distillers' or other washes which have been spoiled by entry of foreign organisms by saccharifying with malt if necessary and boiling.

MAKING CONCRETE BLOCKS

In a machine for molding concrete blocks or slabs for building purposes designed by Messrs. Winget, Victoria St., London, the pressure is applied through machine-cut reduction gear by means of a hand wheel, the continued rotation of which brings the ram-plate down upon the concrete in the mold and then returns it to its starting position. The moulding box is locked by two simple handles which automatically square it up when closed, and arrangements are provided to ensure that it cannot fail to return to its proper position under the press every time. The machine, which, mounted on rollers, weighs 8 cwt., is intended for hand labor—two girls, it is stated, can work it efficiently, though power can be used if desired. Its output is given as at least 50 blocks an hour, each measuring 18 in. by 9 in. by 4 1/2 in. or 16 in. by 9 in. by 4 1/2 in., and as each block of former size is practically equivalent to 6 bricks and is laid at one operation, economy is effected in both mortar and speed of erection. The machine also makes partition slabs of the same dimensions as already mentioned and of three thicknesses—2 in., 2 1/2 in. and 3 in.—or it can turn out closer or bonding blocks of half-size, two at a time.

AUTOMATIC STOKERS

The Erith-Riley automatic underfeed stoker, described in a pamphlet issued by the Erith Engineering Co., Grace Church St., London, consists of any number of uniform standardized inclined retort units. A single ram or plunger feeds the coal to each retort, all the rams being actuated by a slow moving crank-shaft driven by a turbine or motor. Cross-heads on the rams reciprocate the entire fuel-bearing surfaces, the movement being adjustable to suit the fuel. Each reciprocating unit, two of which, with a fixed bottom plate and base plate, constitute the retort unit, consists of the side plate of the retort, to which the tuyères admitting air are bolted, and the shoe on which the side plate slides. Hinged to the sliding shoe is a rocker bar, the combined horizontal and vertical movement of which crushes and discharges the ash continuously, preventing the accumulation of large clinker.

THE HÖCHST DYEWORKS

A recent number of the *Frankfurter Zeitung* announced that, in consequence of the coal shortage, a large part of the Höchst dyeworks would be shut down, presumably only for a short time. The pharmaceutical and a few other important departments will remain working. The 1918 report of the Höchst dyeworks states that so far it has not been possible to restore the production of peace goods to any extent. In the course of the work of renovating the peace plant it became evident that they had suffered so severely—partly from long inactivity, partly from war uses—that the amounts hitherto reserved would not suffice for the depreciation effected and that additional funds must be provided. Apart from new plant, the restoration of the business to a peace footing would require considerable expenditure.

TIME LIMIT FUSES

An improvement which has rendered it possible to extend the range of time limit fuses and to make them in small sizes with reliable fusing points is described in a leaflet issued by the British Thomson-Houston Co., of Rugby, England. The purpose of a fuse of this kind is to obtain in a simple manner a delayed action in an oil switch so that the circuit is not disturbed by momentary faults or temporary overloads. The device is connected in parallel with the trip coil of the switch, the trip coil being connected directly across the series transformer which operates it. Normally, owing to the relatively high impedance of the trip coil, practically the whole of the current from the transformer passes through the fuse, but should a sufficiently large overload occur on the circuit the current melts the fuse link and passes through the trip coil, at once tripping the switch. The time required for the fuse link to melt is proportioned to the heating effect of the current passing through it so that a delaying action is obtained which rapidly decreases with increase of the current flowing in the circuit. It has been found, however, that in small fuses below four amperes materials able to give a substantial time limit, of which pure tin is the best, are liable to oxidation if loaded too near to the fusing point, and that a thin skin of oxide is able to support the molten metal to an extent that seriously alters the minimum fusing point. As a remedy the metal is now coated with a material which prevents oxidation and is not damaged by the minimum fusing current, but which softens at the fusing temperature. This treatment enables fuse links to be made in sizes down to an ampere or less and is now applied to fuses of all sizes as a safeguard against oxidation.

ELECTRICALLY HEATED BOILERS

A somewhat unusual problem, says *Electrician* 83 (1919), 133, is discussed in a recent issue of the *Schweiz. Elekt. Zeitschrift*, viz., the use of electric heating for steam-raising boilers. The method would only apply in exceptional circumstances, for example, in cases where coal is scarce and water power cheap. It seems that some such conditions prevail in some wood-pulp factories of the far north. Narrow tubes of insulating material containing water are vertically arranged so as to communicate with the interior of the boiler at the upper and lower ends of the tubes. Current is passed through the water columns inclosed in the tubes. The resistance is relatively high and accordingly high voltage, alternating P. D. is desirable, three phases being used. The current is regulated by moving the electrodes in the tubes. The efficiency of the boilers is said to exceed 95 per cent. One unit produces 1.25 kg. of steam at 6 to 8 atmospheres. Electric boilers, up to a capacity of 1,500 kw. with voltages of supply up to 10,000 volts, have so far been designed.

CASE-HARDENING

Some figures relating to the gas consumption of one of their Revergen furnaces when employed on a case-hardening job were recently published by the Davis Furnace Co., of Luton, England. This furnace is provided with a special type of regenerator, and is fired with town gas at ordinary pressure, the air being introduced at a pressure of 3 in. or 4 in. water gauge. The work consisted in case-hardening 713 lbs. of motor-car gear wheels, packed in six boxes, and the material had to be charged into a cold furnace, raised to 900° C. and maintained at that temperature for 8 hrs. The furnace was heated up from cold to the required temperature in 70 min., with a total consumption of 925 cu. ft. of gas or 1.29 cu. ft. per lb. of material. In the succeeding 8 hrs. the consumption varied from 275 to 350 cu. ft. per hour or from 0.38 to 0.49 cu. ft. per lb., the overall consumption for the whole run of 9 hrs. 10 min. being 3.425 cu. ft. or 4.8 cu. ft. per lb. of load.

OZOKERITE

It is reported, says *Petroleum World*, by those who ought to know, that in the eastern counties of England, a new bore made recently into the oil-shale field has met with an extremely rich formation which practically amounts to ozokerite or mineral wax. This is one of the more solid and, indeed, most valuable forms in which petroleum occurs. It is comparatively rare and the principal place where it is mined is at Boryslaw in Galicia. There are also ozokerite mines at one or two other points in that country. If reports are true, it probably means that the formation is of considerable volume. Further than that it is impossible to go, but facts are gradually accumulating which go to show that there lies beneath the surface of England a wealth of mineral oil and kindred deposits which has hitherto been unsuspected.

DETERMINATION OF LIGHT HYDROCARBONS IN FAT

The following method is given in *Chem. Umschau*, 26 (1919), 19. About 200 or 300 cc. of the oil are heated in a current of steam, not superheated, and the distillate collected in a cylinder. The light hydrocarbons and petroleum, boiling up to 240° C., are removed in from 15 min. to 1½ hrs. These may be quantitatively estimated to within 0.5 per cent. The specific gravity of the distillate is next determined and the results expressed as a gravimetric percentage, a mean of 0.7 being taken as the specific gravity, if the distillate is not sufficient, for a determination. Samples of linseed oil cake were examined by this method and gave 0.2 to 3.5 per cent volatile hydrocarbons; rape seed oil 0.1 to 4 per cent; maize oil 2.5 per cent, and a maize germ extract 11.5 per cent. The hydrocarbons could, however, in some cases be traced to residual solvent left in the oil cake.

IMPORT PROHIBITION

Presidential decrees have now been issued in France giving force to the proposed relaxation of the import prohibition régime and also to the proposed surtax to be placed on certain goods when imported into France. Among the items on which the surtax of 20 per cent is imposed are salts of soda, not mentioned in the tariff except sodium phosphate, chlorates of potassium, sodium, barium, and other chlorates; nitrates of thorium and cerium and other rare earths; prussiate of potash, yellow and red; artificial flowers and wreaths and similar articles of vitrification or porcelain; cartons ornamented with paintings, reliefs, etc.; wares of cardboard or wood pulp with painted or inlaid decorations. The relaxation of the import prohibition régime does not apply to news print paper among other goods.

ALUMINATES OF LIME AS CEMENT MATERIAL

According to an article in the *Chemical Trade Journal*, the aluminates of lime, even when they contain such amounts of impurities as 10 per cent silica and 3 per cent oxide of iron, constitute a material which is claimed to be a very valuable cementing material when gauged with water. This particular value lies in the high early strengths which they develop, which property varies directly as the amount of alumina present as aluminate of lime. Under certain conditions of curing there is a marked increase of strength with age but it does not extend over a very long period of time. It also appears that if the concrete is subjected to an excess of water during curing, there will be a decrease of strength. Such amounts of moisture as are usually present in the air do not materially affect the strength. It seems, therefore, that these cements might be of considerable value for certain special uses where the principal requisite would be quick hardening.

NEW INDIRECT UNIT FOR INDUSTRIAL LIGHTING

According to *Engineering*, the British Thomson-Houston Company are introducing a type of indirect fitting specifically for industrial use. This unit (known as Icumla) utilizes a lamp with the lower half of the bulb silvered so as to reflect rays on a large steel reflector above it, which in turn redirects and diffuses the up-thrown light. The silvering completely conceals the lamp-filament, and the fitting is suitable for factories where it has hitherto been impracticable to use indirect methods owing to the darkness of the ceilings or to the presence of skylights, etc. These fittings are made in two sizes, the 24 in. for 150 to 200 watt, and the 30 in. for 300 to 1000 watt lamps of the half-watt type.

PAPER THREAD

The British Consul at Granada, Spain, states that a local manufacturer has erected a factory to manufacture thread from paper, and to weave cloth for the packing of their products. The raw material or paper paste is obtained from eucalyptus wood of which tree the company has a plantation covering many acres, which is being largely extended. The process is as follows: Paper is first fabricated with the wood paste destined for the weaving machine. This is then cut in long and narrow strips like ribbon similar to that used in telegraph offices. It is then rolled in small reels. Each reel is placed on a spinning wheel which is held in position by a needle which revolves with a velocity of 5,000 to 6,000 rev. per min. By this means the strip of paper is twisted and forms a kind of tube which so far is neither very firm nor very strong. To make it of greater resistance it is soaked in a special kind of glue which at once becomes indissoluble, being exposed to thermal vapors. In this way the thread can again undergo another stretching or straining and remains fine but stronger. The materials which are obtained from paper thread are still far too coarse to substitute for linen or cotton cloth.

LUMINOUS PAINTS

According to British Patent 130,885 (1919), a luminous paint is manufactured by heating together sublimed sulfur with carbonates of strontium, calcium, and magnesium. The strontium carbonate is preferably the predominant constituent of the carbonates. The proportions in one example were: 26 parts sulfur, 19 parts strontium carbonate, 6 parts calcium carbonate and 1 part magnesium carbonate. The mixture is heated in a crucible at a temperature of about 1500° F., then ground and made up into a liquid paint by mixing with a colorless varnish prepared from mastic and other gums with turpentine spirit or drying oils.

COAL FROM SULFITE LYE

At the Greaaer cellulose mill, near Fredriksstad, Norway, a new method for producing fuel from sulfite lye has recently been tried and the result is exceedingly satisfactory. It will, in this way, says *Paper Trade Journal* for August 1919, be possible to extract surprisingly large quantities of fuel from this lye which before was run into the sea. The mill will thus obtain much more fuel than it needs for its own use. For Norway, Sweden, and Finland the new invention will be of considerable importance as in this way a large part of the coal fuel which otherwise has to be imported may be replaced by this artificial fuel. The factory is so far only built up to one-half of its intended size but will soon be extended. The fuel is produced as a brown powder which is burnt in a special kind of oven. The factory and its new method have been the subject of much attention among specialists, and there has been an influx of foreign engineers to look at it. The mill mentioned above will have, besides sufficient for its own use, considerable quantities of fuel for sale.

IRON-NICKEL ALLOYS

According to an English patent, two classes of alloys are prepared by the addition of nickel to molten cast iron (2 to 5 per cent). In one class the nickel content may be from 5 to 20 per cent and the alloy may be made by the addition of nickel or ferromanganese to molten foundry metal. A second series of alloys containing 20 to 38 per cent nickel, or particularly 32 to 38 per cent nickel, is more difficult to prepare and a high grade of nickel must be used. Other alloying metals may be used to vary the properties of the alloy with nickel as the preponderant addition. The alloys vary from cast iron in having a lower ball hardness but are able to withstand a higher transverse load. The fluidity of the molten metal is increased and the resistance to corrosion is considerable.

ALUMINUM SHEET AND SECTIONS

Discussing the use of aluminum in the construction of motor vehicles and aircraft, a pamphlet issued by the British Aluminum Company points out that while sheet aluminum, owing to the ease with which it can be finished and painted, has long been used for paneling and body work, only of recent years have beading, doorplate, tie and a variety of other sections been used in conjunction with it. The main advantage of aluminum lies in its light weight, a sheet of 20 s. w. g. thickness and 1 ft. sq. weighing only 1 1/2 lb., whereas steel weighs three times as much and this property largely accounts for the extensive use made of the metal for parts of aeroplanes and airships. The pamphlet gives some directions for the working of aluminum sheets, together with illustrations of some of the 800 to 900 drawn and extended sections now produced by the company. There are also tables giving the physical and mechanical properties of aluminum, brass and steel, and comparing the weights of various thicknesses of aluminum sheets with those of other metals.

GERMAN CHEMICALS

The prices of chemicals in Germany, and more especially those used in the manufacture of leather, have risen enormously. This, says *Leather World*, is partly due to the fault of the zentralen or central offices, which have increased the purchase prices by 50 to 60 per cent, or, later, even by 100 per cent. In the matter of certain chemicals it is now impossible to fix any prices as they vary within very wide limits according to buyers and sellers in different districts. In other states matters are similar, although prices are perhaps not being so shamelessly forced up by middlemen. In Germany, 1 kilo soda is five marks as against eight to ten pfennigs in pre-war days. There seems little prospect so far of any improvement.

SCIENTIFIC SOCIETIES

STANDARD METHODS FOR THE SAMPLING AND ANALYSIS OF COMMERCIAL FATS AND OILS¹

The following report of the *Committee on Analysis of Commercial Fats and Oils* of the *Division of Industrial Chemists and Chemical Engineers* of the *AMERICAN CHEMICAL SOCIETY* was adopted April 14, 1919, by unanimous vote:

W. D. RICHARDSON, *Chairman*,
Swift and Co., Chicago, Ill.

R. W. BAILLY,
Stillwell and Gladding, New York City.

W. J. GASCOYNE,
W. J. Gascoyne and Co., Baltimore, Md.

I. KATZ,*
Wilson and Co., Chicago, Ill.

A. LOWENSTEIN,*
Morris and Co., Chicago, Ill.

H. J. MORRISON,
Proctor and Gamble Co., Ivorydale, Ohio.

* Resigned.

J. R. POWELL,
Armour Soap Works, Chicago, Ill.

R. J. QUINN,*
Midland Chemical Co., Argo, Ill.

PAUL RUDNICK,
Armour and Co., Chicago, Ill.

L. M. TOLMAN,
Wilson and Co., Chicago, Ill.

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Emery Candle Co., Cincinnati, Ohio.

J. J. VOLLERTSEN,
Morris and Co., Chicago, Ill.

SCOPE, APPLICABILITY AND LIMITATIONS OF THE METHODS

SCOPE

These methods are intended to aid in determining the commercial valuation of fats and fatty oils in their purchase and sale, based on the fundamental assumption commonly recognized in the trade, namely, that the product is true to name and is not adulterated. For methods for determining the identity of oils and fats, the absence of adulterants therein and for specific tests used in particular industries, the chemist is referred to standard works on the analysis of fats and oils.

APPLICABILITY

The methods are applicable in commercial transactions involving fats and fatty oils used in the soap, candle and tanning industries, to edible fats and oils and to fats and fatty oils intended for lubricating and burning purposes. The methods are applicable to the raw oils used in the varnish and paint industry with the exceptions noted under limitations, but special methods have not been included.

LIMITATIONS

The methods have not been developed with special reference to waxes (beeswax, carnauba wax, wool wax, etc.) although some of them may be found applicable to these substances. The Committee considers the Wijs method superior to the Hanus method for the determination of iodine number of linseed oil as well as other oils, although the Hanus method has been considered standard for this work for some time and has been adopted by the American Society for Testing Materials and in various specifications. It has been customary to use the Hübl method for the determination of iodine value of tung oil (China wood oil) but the Committee's work indicates that the Wijs method is satisfactory for this determination.

SAMPLING

TANK CARS

1. **SAMPLING WHILE LOADING**—Sample shall be taken at discharge of pipe where it enters tank car dome. The total sample taken shall be not less than 50 lbs. and shall be a composite of small samples of about 1 pound each, taken at regular intervals during the entire period of loading.

The sample thus obtained is thoroughly mixed and uniform 3-lb. portions placed in air-tight 3-lb. metal containers. At least three such samples shall be put up, one for the buyer,

¹ Approved by the Supervisory Committee on Standard Methods of Analysis of the American Chemical Society.

one for the seller, and the third to be sent to a referee chemist in case of dispute. All samples are to be promptly and correctly labeled and sealed.

2. **SAMPLING FROM CAR ON TRACK**—(a) *When contents are solid.*² In this case the sample is taken by means of a large tryer measuring about 2 in. across and about 1½ times the depth of the car in length. Several tryerfuls are taken vertically and obliquely toward the ends of the car until 50 lbs. are accumulated, when the sample is softened, mixed and handled as under (1). In case the contents of the tank car have assumed a very hard condition, as in winter weather, so that it is impossible to insert the tryer, and it becomes necessary to soften the contents of the car by means of the closed steam coil (in nearly all tank cars the closed steam coil leaks) or by means of open steam in order to draw a proper sample, suitable arrangements must be made between buyer and seller for the sampling of the car after it is sufficiently softened, due consideration being given to the possible presence of water in the material in the car as received and also to the possible addition of water during the steaming. The Committee knows of no direct method for sampling a hard-frozen tank car of tallow in a satisfactory manner.

(b) *When contents are liquid.* The sample taken is to be a 50-lb. composite made up of numerous small samples taken from the top, bottom and intermediate points by means of a bottle or metal container with removable stopper or top. This device attached to a suitable pole is lowered to the various desired depths when the stopper or top is removed and the container allowed to fill. The 50-lb. sample thus obtained is handled as under (1).

In place of the device described above, any sampler capable of taking a sample from the top, bottom, and center, or from a section through car, may be used.

(c) *When contents are in semi-solid condition, or when stearine has separated from liquid portions.* In this case, a combination of (a) and (b) may be used or by agreement of the parties the whole may be melted and procedure (b) followed.

BARRELS, TIERCES, CASKS, DRUMS, AND OTHER PACKAGES

All packages shall be sampled, unless by special agreement the parties arrange to sample a lesser number; but in any case not less than 10 per cent of the total number shall be sampled. The total sample taken shall be at least 20 lbs. in weight for each 100 barrels, or equivalent.

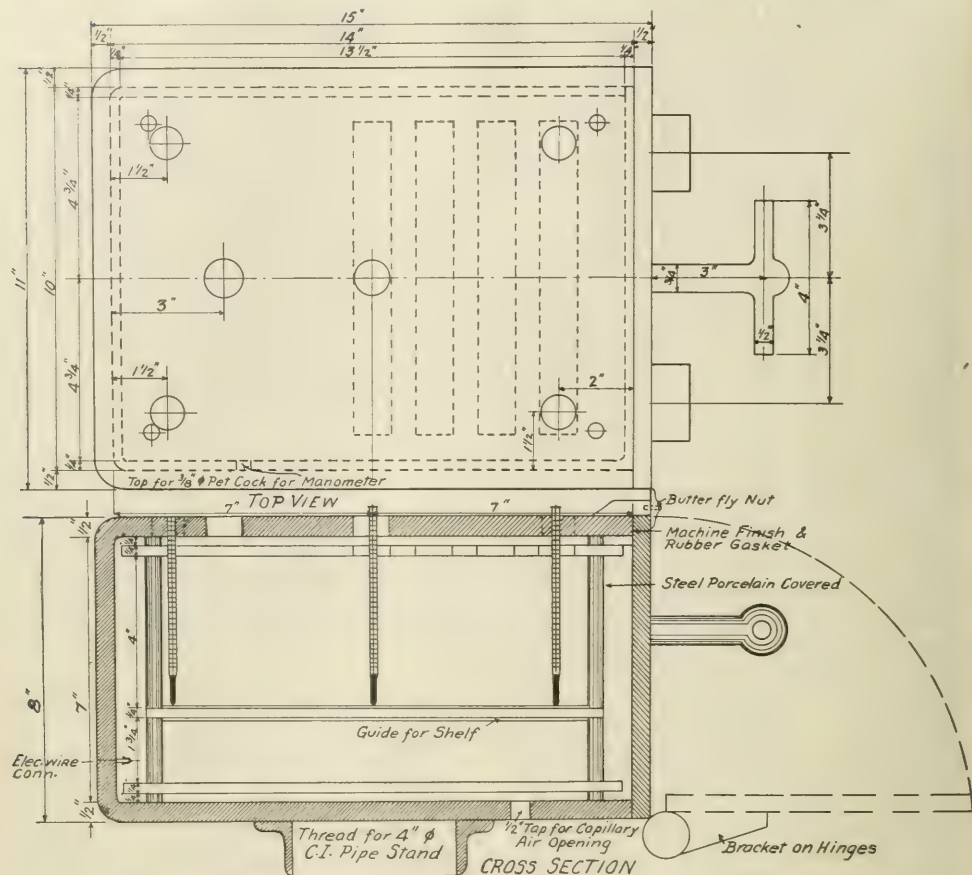
1. **BARRELS, TIERCES AND CASKS**—(a) *When contents are solid.* The small samples shall be taken by a tryer through the bung-hole or through a special hole bored in the head or side for the purpose, with a 1-in. or larger auger. Care should be taken to avoid and eliminate all borings and chips from the sample. The tryer is inserted in such a way as to reach the head of the barrel, tierce, or cask. The large sample is softened, mixed and handled according to TANK CARS (1).

(b) *When contents are liquid.* In this case use is made of a glass tube with constricted lower end. This is inserted slowly and allowed to fill with the liquid, when the upper end is closed and the tube withdrawn, the contents being allowed to drain into the sample container. After the entire sample is taken it is thoroughly mixed and handled according to TANK CARS (1).

(c) *When contents are semi-solid.* In this case the tryer or a glass tube with larger outlet is used, depending on the degree of fluidity.

¹ Live steam must not be turned into tank cars or coils before samples are drawn, since there is no certain way of telling when coils are free from leaks.

² If there is water present under the solid material this must be noted and estimated separately.



STANDARD FAT ANALYSIS COMMITTEE VACUUM OVEN FOR DETERMINING MOISTURE AND VOLATILE MATTER IN FATS AND OILS

(d) *Very hard materials, such as natural and artificial stearines.* By preference the barrels are stripped and samples obtained by breaking up contents of at least 10 per cent of the packages. This procedure is to be followed also in the case of cakes shipped in sacks. When shipped in the form of small pieces in sacks they can be sampled by grab sampling and quartering. In all cases the final procedure is as outlined under TANK CARS (1).

2. **DRUMS**—Samples are to be taken as under (1), use being made of the bung-hole. The tryer or tube should be sufficiently long to reach to the ends of the drum.

3. **OTHER PACKAGES**—Tubs, pails and other small packages not mentioned above are to be sampled by tryer or tube (depending on fluidity) as outlined above, the tryer or tube being inserted diagonally whenever possible.

4. **MIXED LOTS AND PACKAGES**—When lots of tallow or other fats are received in packages of various shapes and sizes, and especially wherein the fat itself is of variable composition, such must be left to the judgment of the sampler. If variable, the contents of each package should be mixed as thoroughly as possible and the amount of the individual samples taken made proportional to the sizes of the packages.

ANALYSIS

SAMPLE

The sample must be representative and at least three pounds in weight and taken in accordance with the STANDARD METHODS FOR THE SAMPLING OF COMMERCIAL FATS AND OILS. It must be kept in an air-tight container in a dark, cool place.

Soften the sample if necessary by means of a gentle heat, taking care not to melt it. When sufficiently softened, mix the sample thoroughly by means of a mechanical egg beater or other equally effective mechanical mixer.

MOISTURE AND VOLATILE MATTER

APPARATUS: *Vacuum Oven*—The Committee Standard Oven. **DESCRIPTION**—The Standard F. A. C. Vacuum Oven has been designed with the idea of affording a simple and compact vacuum oven which will give as uniform temperatures as possible on the shelf. As the figure shows, it consists of an iron casting of rectangular sections with hinged front door made tight by means of a gasket and which can be lowered on opening the oven so as to form a shelf on which samples may be rested. The oven contains but one shelf which is heated from above as well as below by means of resistance coils. Several thermometer holes are provided in order to ascertain definitely the tempera-

ture at different points on the shelf. In a vacuum oven where the heating is done almost entirely by radiation it is difficult to maintain uniform temperatures at all points, but the F. A. C. oven accomplishes this rather better than most vacuum ovens. Larger ovens containing more than one shelf have been tried by the Committee, but have been found to be lacking in temperature uniformity and means of control. The entire oven is supported by means of a 4-in. standard pipe which screws into the base of the oven and which in turn is supported by being screwed into a blind flange of suitable diameter which rests on the floor or work table.

Moisture Dish—A shallow, glass dish, lipped, beaker form, approximately 6 to 7 cm. diameter and 4 cm. deep, shall be standard.

DETERMINATION—Weigh out 5 grams (± 0.2 g.) of the prepared sample into a moisture dish. Dry to constant weight *in vacuo* at a uniform temperature, not less than 15° C. nor more than 20° C. above the boiling point of water at the working pressure, which must not exceed 100 mm. of mercury.¹ Constant weight is attained when successive dryings for 1-hr. periods show an additional loss of not more than 0.05 per cent. Report loss in weight as **MOISTURE AND VOLATILE MATTER**.²

The vacuum-oven method cannot be considered accurate in the case of fats of the coconut oil group containing free acid and the Committee recommends that it be used only for oils of this group when they contain less than 1 per cent free acid. In the case of oils of this group containing more than 1 per cent free acid, recourse should be had temporarily to the routine control method for moisture and volatile matter³ until the Committee develops a more satisfactory method.

The air-oven method cannot be considered even approximately accurate in the case of the drying and semi-drying oils and those of the coconut oil group. Therefore, in the case of such oils as cottonseed oil, maize oil (corn oil), soy bean oil, linseed oil, coconut oil, palm kernel oil, etc., the vacuum-oven method should always be used, except in the case of fats of the coconut group containing more than 1 per cent free acid, as noted above.

¹ Boiling point of water at reduced pressures.

Pressure Mm. Hg	Boiling Point to 1° C.	Boiling Point + 15° C.	Boiling Point + 20° C.
100	52° C.	67° C.	72° C.
90	50	65	70
80	47	62	67
70	45	60	65
60	42	57	62
50	38	53	58
40	34	49	54

² Results comparable to those of the Standard Method may be obtained on most fats and oils by drying 5-g. portions of the sample, prepared and weighed as above, to constant weight in a well-constructed and well-ventilated air oven held uniformly at a temperature of 105° to 110° C. The thermometer bulb should be close to the sample. The definition of constant weight is the same as for the Standard Method.

³ The following method is suggested by the Committee for routine control work: Weigh out 5- to 25-g. portions of prepared sample into a glass or aluminum (Caution: Aluminum soap may be formed) beaker or casserole and heat on a heavy asbestos board over burner or hot plate, taking care that the temperature of the sample does not go above 130° C. at any time. During the heating rotate the vessel gently on the board by hand to avoid spluttering or too rapid evolution of moisture. The proper length of time of heating is judged by absence of rising bubbles of steam, by the absence of foam or by other signs known to the operator. Avoid overheating of sample as indicated by smoking or darkening. Cool in desiccator and weigh.

By cooperative work in several laboratories, the Committee has demonstrated that this method can be used and satisfactory results obtained on coconut oil even when a considerable percentage of free fatty acids is present, and the method is recommended for this purpose. Unfortunately on account of the very great personal factor involved, the Committee cannot establish this method as a preferred method. Nevertheless, after an operator has learned the technique of the method, it gives perfectly satisfactory results for ordinary oils and fats, butter, oleomargarine and coconut oil, and deserves more recognition than it has heretofore received.

INSOLUBLE IMPURITIES

Dissolve the residue from the moisture and volatile matter determination by heating it on a steam bath with 50 cc. of kerosene. Filter the solution through a Gooch crucible properly prepared with asbestos,¹ wash the insoluble matter five times with 10-cc. portions of hot kerosene, and finally wash the residual kerosene out thoroughly with petroleum ether. Dry the crucible and contents to constant weight as in the determination of moisture and volatile matter and report results as **INSOLUBLE IMPURITIES**.

SOLUBLE MINERAL MATTER

Place the combined kerosene filtrate and kerosene washings from the insoluble impurities determination in a platinum dish. Place in this an ashless filter paper folded in the form of a cone, apex up. Light the apex of the cone, whereupon the bulk of the kerosene burns quietly. Ash the residue in a muffle, to constant weight, taking care that the decomposition of alkaline earth carbonates is complete, and report the result as **SOLUBLE MINERAL MATTER**.² When the percentage of soluble mineral matter amounts to more than 0.1 per cent, multiply the percentage by 10 and add this amount to the percentage of free fatty acids as determined.³

FREE FATTY ACIDS

The **ALCOHOL**⁴ used shall be approximately 95 per cent ethyl alcohol, freshly distilled from sodium hydroxide, which with phenolphthalein gives a definite and distinct end-point.

DETERMINATION—Weigh 1 to 15 g. of the prepared sample into an Erlenmeyer flask, using the smaller quantity in the case of dark-colored, high acid fats. Add 50 to 100 cc. hot, neutral alcohol, and titrate with $N/2$, $N/4$ or $N/10$ sodium hydroxide depending on the fatty acid content, using phenolphthalein as indicator. Calculate to oleic acid, except that in the case of palm oil the results may also be expressed in terms of palmitic acid, clearly indicating the two methods of calculation in the report. In the case of coconut and palm kernel oils, calculate to and report in terms of lauric acid in addition to oleic acid, clearly indicating the two methods of calculation in the report. In the case of fats or greases containing more than 0.1 per cent of soluble mineral matter, add to the percentage of free fatty acids as determined 10 times the percentage of bases in the soluble mineral matter as determined.⁵ This addition gives the equivalent of fatty acids combined with the soluble mineral matter.

TITER

STANDARD THERMOMETER—The thermometer is graduated at zero and in tenth degrees from 10° C. to 65° C., with one auxiliary reservoir at the upper end and another between the zero mark and the 10° mark. The cavity in the capillary tube between the zero mark and the 10° mark is at least 1 cm. below the 10° mark, the 10° mark is about 3 or 4 cm. above the bulb, the length of the thermometer being about 37 cm. over all. The thermometer has been annealed for 75 hrs. at 450° C. and the bulb is of Jena normal 16" glass, or its equivalent, moderately thin, so that the thermometer will be quick-acting. The

¹ For routine control work, filter paper is sometimes more convenient than the prepared Gooch crucible, but must be very carefully washed, especially around the rim, to remove the last traces of fat.

² For routine work, an ash may be run on the original fat, and the soluble mineral matter obtained by deducting the ash on the insoluble impurities from this. In this case the Gooch crucible should be prepared with an ignited asbestos mat so that the impurities may be ashed directly after being weighed. In all cases ignition should be to constant weight so as to insure complete decomposition of carbonates.

³ See note on Soluble Mineral Matter following these methods. When the ash contains phosphates the factor 10 cannot be applied, but the bases consisting of calcium oxide, etc., must be determined, and the factor 10 applied to them.

⁴ For routine work methyl or denatured ethyl alcohol of approximately 95 per cent strength may be used. With these reagents the end-point is not sharp.

bulb is about 3 cm. long and 6 mm. in diameter. The stem of the thermometer is 6 mm. in diameter and made of the best thermometer tubing, with scale etched on the stem, the graduation is clear-cut and distinct, but quite fine. The thermometer must be certified by the U. S. Bureau of Standards.

GLYCEROL CAUSTIC SOLUTION—Dissolve 250 g. potassium hydroxide in 1000 cc. dynamite glycerin with the aid of heat.

DETERMINATION—Heat 75 cc. of the glycerol-caustic solution to 150° C. and add 50 g. of the melted fat. Stir the mixture well and continue heating until the melt is homogeneous, at no time allowing the temperature to exceed 150° C. Allow to cool somewhat and carefully add 50 cc. 30 per cent sulfuric acid. Now add hot water and heat until the fatty acids separate out perfectly clear. Draw off the acid water and wash the fatty acids with hot water until free from mineral acid, then filter and heat to 130° C. as rapidly as possible while stirring. Transfer the fatty acids, when cooled somewhat, to a 1-in. by 4-in. titer tube, placed in a 16-oz. salt-mouth bottle of clear glass, fitted with a cork that is perforated so as to hold the tube rigidly when in position. Suspend the titer thermometer so that it can be used as a stirrer and stir the fatty acids slowly (about 100 revolutions per minute) until the mercury remains stationary for 30 seconds. Allow the thermometer to hang quietly with the bulb in the center of the tube and report the highest point to which the mercury rises as the titer of the fatty acids. The titer should be made at about 20° C. for all fats having a titer above 30° C. and at 10° C. below the titer for all other fats. Any convenient means may be used for obtaining a temperature of 10° below the titer of the various fats. The Committee recommends first of all a chill room for this purpose; second, an artificially chilled small chamber with glass window; third, immersion of the salt-mouth bottle in water or other liquid of the desired temperature.

UNSAAPONIFIABLE MATTER

EXTRACTION CYLINDER—The cylinder shall be glass-stoppered, graduated at 40 cc., 80 cc. and 130 cc., and of the following dimensions: diameter about 1 7/8 in., height about 12 in.

PETROLEUM ETHER—Redistilled petroleum ether, boiling under 75° C., shall be used. A blank must be made by evaporating 250 cc. with about 0.25 g. of stearine or other hard fat (previously brought to constant weight by heating) and drying as in the actual determination. The blank must not exceed a few milligrams.

DETERMINATION—Weigh 5 g. (± 0.20 g.) of the prepared sample into a 200-cc. Erlenmeyer flask, add 30 cc. of redistilled 95 per cent (approximately) ethyl alcohol and 5 cc. of 50 per cent aqueous potassium hydroxide, and boil the mixture for one hour under a reflux condenser. Transfer to the extraction cylinder and wash to the 40-cc. mark with redistilled 95 per cent ethyl alcohol. Complete the transfer, first with warm, then with cold water, till the total volume amounts to 80 cc. Cool the cylinder and contents to room temperature and add 50 cc. of petroleum ether.⁶ Shake vigorously for one minute and allow to settle until both layers are clear, when the volume of the upper layer should be about 40 cc. Draw off the petroleum ether layer as closely as possible by means of a slender glass siphon into a separatory funnel of 500 cc. capacity. Repeat extraction at least four more times, using 50 cc. of petroleum ether each time. More extractions than five are necessary where the unsaponifiable matter runs high, say over 5 per cent, and also in some cases where it is lower than 5 per cent, but is extracted with difficulty. Wash the combined extracts in a separatory funnel three times with 25-cc. portions of 10 per cent alcohol, shaking vigorously each time. Transfer the petroleum ether extract to a wide-mouth tared flask or beaker, and evaporate the petroleum ether on a steam bath in an air current. Dry as in the method for MOISTURE AND VOLATILE MATTER. Any blank must be deducted from

the weight before calculating unsaponifiable matter. Test the final residue for solubility in 50 cc. petroleum ether at room temperature. Filter and wash free from the insoluble residue, if any, evaporate and dry in the same manner as before. The Committee wishes to emphasize the necessity of thorough and vigorous shaking in order to secure accurate results. The two phases must be brought into the most intimate contact possible, otherwise low and disagreeing results may be obtained.

IODINE NUMBER—WIJS METHOD

PREPARATION OF REAGENTS—*Wijs Iodine Solution*—Dissolve 13.0 g. of resublimed iodine in one liter of C. P. glacial acetic acid and pass in washed and dried chlorine gas until the original thiosulfate titration of the solution is not quite doubled. The solution is then preserved in amber glass-stoppered bottles, sealed with paraffin until ready for use.

Mark the date on which the solution is prepared on the bottle or bottles and do not use Wijs solution which is more than 30 days old.

There should be no more than a slight excess of iodine, and no excess of chlorine. When the solution is made from iodine and chlorine, this point can be ascertained by not quite doubling the titration.¹

The glacial acetic acid used for preparation of the Wijs solution should be of 99.0 to 99.5 per cent strength. In case of glacial acetic acids of somewhat lower strength, the Committee recommends freezing and centrifuging or draining as a means of purification.

N/10 Sodium Thiosulfate Solution—Dissolve 24.8 g. of C. P. sodium thiosulfate in recently boiled distilled water and dilute with the same to one liter at the temperature at which the titrations are to be made.

Starch Paste—Boil 1 g. of starch in 200 cc. of distilled water for 10 min. and cool to room temperature.

An improved starch solution may be prepared by autoclaving 2 g. of starch and 6 g. of boric acid dissolved in 200 cc. water at 15 lbs. pressure for 15 min. This solution has good keeping qualities.

Potassium Iodide Solution—Dissolve 150 g. of potassium iodide in water and make up to one liter.

N/10 Potassium Bichromate—Dissolve 4.903 g. of C. P. potassium bichromate in water and make the volume up to one liter at the temperature at which titrations are to be made.

The Committee calls attention to the fact that occasionally potassium bichromate is found containing sodium bichromate, although this is of rare occurrence. If the analyst suspects that he is dealing with an impure potassium bichromate, the purity can be ascertained by titration against re-sublimed iodine. However, this is unnecessary in the great majority of cases.

Standardization of the Sodium Thiosulfate Solution—Place 40 cc. of the potassium bichromate solution, to which has been added 10 cc. of the solution of potassium iodide, in a glass-stoppered flask. Add to this 5 cc. of strong hydrochloric acid. Dilute with 100 cc. of water, and allow the N/10 sodium thio-

¹ P. C. McIlhenny, *J. Am. Chem. Soc.*, **29** (1917), 1222, gives the following details for the preparation of the iodine monochloride solution:

The preparation of the iodine monochloride solution presents no great difficulty, but it must be done with care and accuracy in order to obtain satisfactory results. There must be in the solution no sensible excess either of iodine or more particularly of chlorine, over that required to form the monochloride. This condition is most satisfactorily attained by dissolving in the whole of the acetic acid to be used the requisite quantity of iodine, using a gentle heat to assist the solution, if it is found necessary, setting aside a small portion of this solution, while pure and dry chlorine is passed into the remainder until the halogen content of the whole solution is doubled. Ordinarily it will be found that by passing the chlorine into the main part of the solution until the characteristic color of free iodine has just been discharged there will be a slight excess of chlorine which is corrected by the addition of the requisite amount of the unchlorinated portion until all free chlorine has been destroyed. A slight excess of iodine does little or no harm but excess of chlorine must be avoided.

sulfate to flow slowly into the flask until the yellow color of the liquid has almost disappeared. Add a few drops of the starch paste, and with constant shaking continue to add the $N/10$ sodium thiosulfate solution until the blue color just disappears.

DETERMINATION—Weigh accurately from 0.10 to 0.50 g. (depending on the iodine number) of the melted and filtered sample into a clean, dry, 16-oz. glass-stoppered bottle containing 15–20 cc. of carbon tetrachloride or chloroform. Add 25 cc. of iodine solution from a pipette, allowing to drain for a definite time. The excess of iodine should be from 50 per cent to 60 per cent of the amount added, that is, from 100 per cent to 150 per cent of the amount absorbed. Moisten the stopper with a 15 per cent potassium iodide solution to prevent loss of iodine or chlorine but guard against an amount sufficient to run down inside the bottle. Let the bottle stand in a dark place for $1\frac{1}{2}$ hr. at a uniform temperature. At the end of that time add 20 cc. of 15 per cent potassium iodide solution and 100 cc. of distilled water. Titrate the iodine with $N/10$ sodium thiosulfate solution which is added gradually, with constant shaking, until the yellow color of the solution has almost disappeared. Add a few drops of starch paste and continue titration until the blue color has entirely disappeared. Toward the end of the reaction stopper the bottle and shake violently so that any iodine remaining in solution in the tetrachloride or chloroform may be taken up by the potassium iodide solution. Conduct two determinations on blanks which must be run in the same manner as the sample except that no fat is used in the blanks. Slight variations in temperature quite appreciably affect the titer of the iodine solution, as acetic acid has a high coefficient of expansion. It is, therefore, essential that the blanks and determinations on the sample be made at the same time. The number of cc. of standard thiosulfate solution required by the blank, less the amount used in the determination, gives the thiosulfate equivalent of the iodine absorbed by the amount of sample used in the determination. Calculate to centigrams of iodine absorbed by 1 g. of sample (= per cent iodine absorbed).

DETERMINATION, TUNG OIL—Tung oil shows an erratic behavior with most iodine reagents and this is particularly noticeable in the case of the Hanus reagent which is entirely unsuitable for determining the iodine number of this oil since extremely high and irregular results are obtained. The Hübl solution shows a progressive absorption up to 24 hrs. and probably for a longer time but the period required is entirely too long for a chemical determination. The Wijs solution gives good results if the following precautions are observed:

Weigh out 0.15 ± 0.05 g., use an excess of 55 ± 3 per cent Wijs solution. Conduct the absorption at a temperature of $20\text{--}25^\circ\text{C}$. for 1 hr. In other respects follow the instructions detailed above.

SAAPONIFICATION NUMBER (KOETTSTORFER NUMBER)

PREPARATION OF REAGENTS. $N/2$ Hydrochloric Acid—Carefully standardized.

Alcoholic Potassium Hydroxide Solution—Dissolve 40 g. of pure potassium hydroxide in one liter of 95 per cent redistilled alcohol (by volume). The alcohol should be redistilled from potassium hydroxide over which it has been standing for some time, or with which it has been boiled for some time, using a reflux condenser. The solution must be clear and the potassium hydroxide free from carbonates.

DETERMINATION—Weigh accurately about 5 g. of the filtered sample into a 250 to 300 cc. Erlenmeyer flask. Pipette 50 cc. of the alcoholic potassium hydroxide solution into the flask, allowing the pipette to drain for a definite time. Connect the flask with an air condenser and boil until the fat is completely saponified (about 30 minutes). Cool and titrate with the $N/2$ hydrochloric acid, using phenolphthalein as an indicator. Calculate the Koettstorfer number (mg. of potassium hydroxide required to saponify 1 g. of fat). Conduct 2 or 3 blank deter-

minations, using the same pipette and draining for the same length of time as above.

MELTING POINT

APPARATUS—*Capillary tubes* made from 5 mm. inside diameter thin-walled glass tubing drawn out to 1 mm. inside diameter. Length of capillary part of tubes to be about 5 cm. Length of tube over all 8 cm.

Standard thermometer graduated in tenths of a degree. 600 cc. beaker.

DETERMINATION—The sample should be clear when melted and entirely free from moisture, or incorrect results will be obtained.

Melt and thoroughly mix the sample. Dip three of the capillary tubes above described in the oil so that the fat in the tube stands about 1 cm. in height. Now fuse the capillary end carefully by means of a small blast flame and allow to cool. These tubes are placed in a refrigerator over night at a temperature of from 40 to 50°F . They are then fastened by means of a rubber band or other suitable means to the bulb of a thermometer graduated in tenths of a degree. The thermometer is suspended in a beaker of water (which is agitated by air or other suitable means) so that the bottom of the bulb of the thermometer is immersed to a depth of about 3 cm. The temperature of the water is increased gradually at the rate of about 1° per minute.

The point at which the sample becomes opalescent is first noted and the heating continued until the contents of the tube becomes uniformly transparent. The latter temperature is reported as the melting point.

Before finally melting to a perfectly clear fluid, the sample becomes opalescent and usually appears clear at the top, bottom, and sides before becoming clear at the center. The heating is continued until the contents of the tube become uniformly clear and transparent. This temperature is reported as the melting point.¹ It is usually only a fraction of a degree above the opalescent point noted. The thermometer should be read to the nearest $\frac{1}{2}^\circ\text{C}$., and in addition this temperature may be reported to the nearest degree Fahrenheit if desired.

CLOUD TEST

PRECAUTIONS—(1) The oil must be perfectly dry, because the presence of moisture will produce a turbidity before the clouding point is reached.

(2) The oil must be heated to 150°C . over a free flame, immediately before making the test.

(3) There must not be too much discrepancy between the temperature of the bath and the clouding point of the oil. An oil that will cloud at the temperature of hydrant water should be tested in a bath of that temperature. An oil that will cloud in a mixture of ice and water should be tested in such a bath. An oil that will not cloud in a bath of ice and water must be tested in a bath of salt, ice, and water.

DETERMINATION—The oil is heated in a porcelain casserole over a free flame to 150°C ., stirring with the thermometer. As soon as it can be done with safety, the oil is transferred to a 4 oz. oil bottle, which must be perfectly dry. One and one-half ounces of the oil are sufficient for the test. A dry centigrade thermometer is placed in the oil, and the bottle is then cooled by immersion in a suitable bath. The oil is constantly stirred with the thermometer, taking care not to remove the thermometer from the oil at any time during the test, so as to avoid stirring air bubbles into the oil. The bottle is frequently removed from the bath for a few moments. The oil must not be allowed to chill on the sides and bottom of the bottle. This is effected by constant and vigorous stirring with the thermometer. As soon as the first permanent cloud shows in the body of the oil, the temperature at which this cloud occurs is noted.

¹ The melting point of oils may be determined in general according to the above procedure, taking into consideration the lower temperature required.

With care, results concordant to within $1/2^{\circ}\text{C}$. can be obtained by this method. A Fahrenheit thermometer is sometimes used because it has become customary to report results in degrees Fahrenheit.

The oil must be tested within a short time after heating to 150°C . and a re-test must always be preceded by reheating to that temperature. The cloud point should be approached as quickly as possible, yet not so fast that the oil is frozen on the sides or bottom of the bottle before the cloud test is reached.

NOTES ON THE ABOVE METHODS

SAMPLING

The standard size of sample adopted by the Committee is at least 3 lbs. in weight. The Committee realizes that this amount is larger than any samples usually furnished even when representing shipments of from 20,000 to 60,000 lbs., but it believes that the requirement of a larger sample is desirable and will work toward uniform and more concordant results in analysis. It will probably continue to be the custom of the trade to submit smaller buyers' samples than required by the Committee, but these are to be considered only as samples for inspection and not for analysis. The standard analytical sample must consist of 3 lbs. or more.

The reasons for keeping samples in a dark, cool place are obvious. This is to prevent any increase in rancidity and any undue increase in free fatty acids. In the case of many fats the Committee has found in its cooperative analytical work that free acid tends to increase very rapidly. This tendency is minimized by low temperatures.

MOISTURE AND VOLATILE MATTER

After careful consideration the Committee has decided that moisture is best determined in a vacuum oven of the design which accompanies the above report. Numerous results on check samples have confirmed the Committee's conclusions. The oven recommended by the Committee is constructed on the basis of well-known principles and it is hoped that this type will be adopted generally by chemists who are called upon to analyze fats and oils. The experiments of the Committee indicate that it is a most difficult matter to design a vacuum oven which will produce uniform temperatures throughout; and one of the principal ideas in the design adopted is uniformity of temperature over the entire single shelf. This idea has not quite been realized in practice but, nevertheless, the present design approaches much closer to the ideal than other vacuum ovens commonly used. In the drawing the essential dimensions are those between the heating units and the shelf and the length and breadth of the outer casting. The standard Fat Analysis Committee Oven (F. A. C. Oven) can be furnished by Messrs. E. H. Sargent & Company, 125 West Lake Street, Chicago.

The Committee realizes that for routine work a quicker method is desirable and has added one such method and has also stated the conditions under which comparable results can be obtained by means of the ordinary well-ventilated air oven held at 105 to 110°C . However, in accordance with a fundamental principle adopted by the Committee at its first meeting, only one standard method is adopted and declared official for each determination.

The Committee realizes that in the case of all methods for determining moisture by means of loss on heating there may be a loss due to volatile matter (especially fatty acids) other than water. The title of the determination **MOISTURE AND VOLATILE MATTER** indicates this idea, but any considerable error from this source may occur only in the case of high acid fats and oils and particularly those containing lower fatty acids such as coconut and palm kernel oil. In the case of extracted greases which have not been properly purified, some of the solvent may also be included in the moisture and volatile

matter determination, but inasmuch as the solvent, usually a petroleum product, can only be considered as foreign matter, for commercial purposes, it is entirely proper to include it with the moisture.

The Committee has also considered the various distillation methods for the determination of moisture in fats and oils, but since according to the fundamental principles which it was endeavoring to follow it could only standardize one method, it was decided that the most desirable one on the whole was the vacuum-oven method as given. There are cases wherein a chemist may find it desirable to check a moisture determination or investigate the moisture content of a fat or oil further by means of one of the distillation methods.

However, in cooperative work the distillation method in various types of apparatus has not yielded satisfactory results. The difficulties appear to be connected with a proper choice of solvent and particularly with the tendency of drops of water to adhere to various parts of the glass apparatus instead of passing on to the measuring device. When working on coconut oil containing a high percentage of free fatty acids, concordant results could not be obtained by the various members of the Committee when working with identical samples, solvents and apparatus.

On the other hand, the Committee found by individual work, cooperative work and collaborative work by several members of the Committee in one laboratory, that the old, well-known direct heating method (which the Committee has designated the hot plate method) yielded very satisfactory results on all sorts of fats and oils including emulsions such as butter and oleomargarine and even on coconut oil samples containing 15 to 20 per cent free fatty acids and 5 to 6 per cent of moisture. Unfortunately, this method depends altogether on the operator's skill and while the method may be taught to any person whether a chemist or not so that he can obtain excellent results with it, it is difficult to give a sufficiently complete description of it so that any chemist anywhere after reading the description could follow it successfully. The method is undoubtedly worthy of much confidence in careful hands. It is quick, accurate and reliable. It is probably the best single method for the determination of moisture in all sorts of samples for routine laboratory work. On account of this fact the Committee desires to announce its willingness to instruct any person in the proper use of the method who desires to become acquainted with it and who will visit any Committee member's laboratory.

INSOLUBLE IMPURITIES

This determination, the title for which was adopted after careful consideration, determines the impurities which have generally been known as dirt, suspended matter, suspended solids, foreign solids, foreign matter, etc., in the past. The first solvent recommended by the Committee is hot kerosene to be followed by petroleum ether kept at ordinary room temperature. Petroleum ether, cold or only slightly warm, is not a good fat and metallic soap solvent, whereas hot kerosene dissolves these substances readily, and for this reason the Committee has recommended the double solvent method so as to exclude metallic soaps which are determined below as soluble mineral matter.

SOLUBLE MINERAL MATTER

Soluble mineral matter represents mineral matter combined with fatty acids in the form of soaps in solution in the fat or oil. Formerly, this mineral matter was often determined in combination by weighing the separated metallic soap or by weighing it in conjunction with the insoluble impurities. Since the soaps present consist mostly of lime soap, it has been customary to calculate the lime present therein by taking 0.1 the weight of the total metallic soaps. The standard method as given above is direct and involves no calculation. The routine

method given in the note has been placed among the methods for the reason that it is used in some laboratories, but has not been adopted as a standard method in view of the fact that the Committee has made it a rule to adopt only one standard method. It should be pointed out, however, that the method cannot be considered accurate for the reason that insoluble impurities may vary from sample to sample to a considerable extent and the error due to the presence of large particles of insoluble impurities is thus transferred to the soluble mineral matter. The Committee has found one type of grease (naphtha bone grease) which shows most unusual characteristics. The type sample contains 4.3 per cent soluble mineral matter by the Committee method which would be equivalent to 43.0 per cent free fatty acid. The kerosene and gasoline filtrate was particularly clear, nevertheless the ash was found to contain 36.43 per cent P_2O_5 equivalent to 79.60 per cent of $Ca_3(PO_4)_2$ and 9.63 per cent of Fe_2O_3 . The method, therefore, determines the soluble mineral matter in this case satisfactorily but the factor 10 is not applicable for calculating the fatty acids combined therewith. It is necessary, therefore, in order to determine the fatty acids combined with soluble mineral matter in the original sample to determine the actual bases in the soluble mineral matter as obtained by ashing the kerosene and gasoline filtrate. To the bases so determined the factor 10 can then be applied.

FREE FATTY ACID

The fatty acid method adopted is sufficiently accurate for commercial purposes. In many routine laboratories the fat or oil is measured and not weighed, but the Committee recommends weighing the sample in all cases. For scientific purposes the result is often expressed as "acid number," meaning the number of milligrams of KOH required to neutralize the free acids in one gram of fat, but the commercial practice has been, and is, to express the fatty acids as oleic acid or in the case of palm oil, as palmitic acid, in some instances. The Committee sees no objection to the continuation of this custom so long as the analytical report clearly indicates how the free acid is expressed. For a more exact expression of the free acid in a given fat, the Committee recommends that the ratio of acid number to saponification number be used. This method of expressing results is subject to error when unsaponifiable fatty matter is present, since the result expresses the ratio of free fatty acid to total saponifiable fatty matter present.

TITER

At the present time the prices of glycerol and caustic potash are abnormally high but the Committee has considered that the methods adopted are for normal times and normal prices. For routine work during the period of high prices the following method may be used for preparing the fatty acids and is recommended by the Committee:

50 grams of fat are saponified with 60 cc. of a solution of 2 parts of methyl alcohol to 1 of 50 per cent NaOH. The soap is dried, pulverized and dissolved in 1000 cc. of water in a porcelain dish and then decomposed with 25 cc. of 75 per cent sulfuric acid. The fatty acids are boiled until clear oil is formed and then collected and settled in a 150-cc. beaker and filtered into a 50-cc. beaker. They are then heated to 130° C. as rapidly as possible with stirring, and transferred, after they have cooled somewhat, to the usual 1-in. by 4-in. titer tube.

The method of taking the titer, including handling the thermometer, to be followed is the same as that described in the standard method. Even at present high prices many laboratories are using the glycerol-caustic potash method for preparing the fatty acids, figuring that the saving of time more than compensates for the extra cost of the reagents. Caustic soda cannot be substituted for caustic potash in the glycerol method.

UNSAPONIFIABLE MATTER

The Committee has considered unsaponifiable matter to include those substances frequently found dissolved in fats and

oils which are not saponified by the caustic alkalis and which at the same time are soluble in the ordinary fat solvents. The term includes such substances as the higher alcohols, such as cholesterol which is found in animal fats, phytosterol found in some vegetable fats, paraffin and petroleum oils, etc. UNSAPONIFIABLE MATTER should not be confused in the lay mind with INSOLUBLE IMPURITIES OR SOLUBLE MINERAL MATTER.

The method adopted by the Committee has been selected only after the most careful consideration of other methods, such as the dry extraction method and the wet method making use of the separatory funnel. At first consideration the dry extraction process would seem to offer the best basis for an unsaponifiable matter method, but in practice it has been found absolutely impossible for different analysts to obtain agreeing results when using any of the dry extraction methods proposed. Therefore, this method had to be abandoned after numerous trials, although several members of the Committee strongly favored it in the beginning.

IODINE NUMBER.—The iodine number adopted by the Committee is that determined by the well-known Wijs method. This method was adopted after careful comparison with the Hanus and Hübl methods. The Hübl method was eliminated from consideration almost at the beginning of the Committee's work for the reason that the time required for complete absorption of the iodine is unnecessarily long and, in fact, even after absorption has gone on over night, it is apparently not complete. In the case of the Hanus and Wijs methods complete absorption takes place in from 15 minutes to an hour, depending on conditions. Formerly, many chemists thought the Hanus solution rather easier to prepare than the Wijs solution, but the experience of the Committee was that the Wijs solution was no more difficult to prepare than the Hanus. Furthermore, absorption of iodine from the Wijs solution appeared to take place with greater promptness and certainty than from the Hanus and was complete in a shorter time. Results by the Wijs method were also in better agreement in the case of oils showing high iodine absorption than with the Hanus solution and showed a slightly higher iodine absorption for the same length of time. However, the difference was not great. The Committee investigated the question of substitution since it has been suggested that in case of the Wijs solution substitution of iodine in the organic molecule might occur, and found no evidence of this in the time required for the determination, namely, 1/2 hr., or even for a somewhat longer period. One member of the Committee felt that it was not desirable to introduce the Wijs method into these standard methods since the Hanus method was already standardized by the Association of Official Agricultural Chemists, but the Committee felt that it must follow the principle established at the commencement of its work, namely, that of adopting the method which appeared to be the best from all standpoints, taking into consideration accuracy, convenience, simplicity, time, expense, etc., without allowing precedent to have the deciding vote.

IODINE NUMBER, TUNG OIL.—The Committee has made an extensive study of the application of the Wijs method to the determination of iodine value in the case of tung oil with the result that it recommends the method for this oil but has thought it desirable to limit the conditions under which the determination is conducted rather narrowly, although reasonably good results are obtained by the Committee method without making use of the special limitations.

The cooperative work of the Committee and the special investigations conducted by individual members bring out the following points:

Influence of Temperature—From 16° C. to 30° C. there is a moderate increase in the absorption, but above 30° the increase is rather rapid so that it was thought best to limit the temperature in the case of tung oil to 20° to 25° C.

Influence of Time—The absorption increases with the time, but apparently complete absorption, so far as unsaturated bonds are concerned, occurs well within one hour's time. Consequently, one hour was set as the practical limit.

Influence of Excess—The excess of iodine solution also tends to increase the iodine number, hence the Committee thought it necessary to limit this excess rather rigidly to 55 ± 3 per cent, although with greater latitude results were reasonably good.

Influence of Age of Solution—Old solutions tend to give low results although up to 2 mo. no great differences were observed. Nevertheless, it was thought best to limit the age of the solution to 30 days—long enough for all practical purposes.

Amount of Sample—As a practical amount of sample to be weighed out the Committee decided on 0.15 g. with a tolerance of 0.05 g. in either direction according to preference. In other words, the amount of sample to be taken for the determination to be from 0.1 to 0.2 g. in the discretion of the analyst.

The Committee's study of the Hübl method which has been adopted by the Society for Testing Materials in the case of tung oil indicates that this method when applied to tung oil is subject to the same influences as the Wijs method and it has the additional very serious disadvantage of requiring a long period of time for absorption which cannot be considered reasonable for a modern analytical method. When using the Hübl solution, the absorption is not complete in the case of tung oil at 3, 7, 18 or even 24 hrs.

The Hanus method in the case of tung oil gives very high and erratic results, as high as 180 to 240 in ordinary cases for an oil whose true iodine number is about 165.

MELTING POINT

A melting point is the temperature at which a solid substance assumes the liquid condition. If the solid is a pure substance in the crystalline condition the melting point is sharp and well defined for any given pressure. With increased pressure the melting point is lowered or raised, depending on whether the substance contracts or expands in melting. The lowering or raising of the melting point with pressure is very slight and ordinarily is not taken into consideration. Melting-point determinations are commonly carried out under ordinary atmospheric pressures without correction. The general effect of soluble impurities is to lower the melting point, and this holds true whether the impurity has a higher or lower melting point than the pure substance (solvent). Thus if a small amount of stearic acid be added to liquid palmitic acid and the solution frozen, the melting point of this solid will be lower than that of palmitic acid. Likewise the melting point of stearic acid is lowered by the addition of a small amount of palmitic acid. A eutectic mixture results when two components solidify simultaneously at a definite temperature. Such a mixture has a constant melting point and because of this and also because both solid and liquid phases have the same composition, eutectic mixtures were formerly looked upon as compounds. The phenomenon of double melting points has been observed in the case of a number of glycerides. Such a glyceride when placed in the usual capillary tube and subjected to increasing temperature quickly resolidifies only to melt again and remain melted at a still higher temperature. This phenomenon has not yet been sufficiently investigated to afford a satisfactory explanation.

Non-crystalline substances such as glass, sealing wax and various other waxes and wax mixtures, and most colloidal substances do not exhibit a sharp melting point, but under the application of heat first soften very gradually and at a considerably higher temperature melt sufficiently to flow. This phenomenon of melting through a long range of temperature may be due to the amorphous nature of the substance or to the fact that it consists of a very large number of components of many different melting points.

The fats and oils of natural origin, that is, the animal and

vegetable fats and oils, consist of mixtures of glycerides and, generally speaking, of a considerable number of such components. These components are crystalline and when separated in the pure state have definite melting points, although some exhibit the phenomenon of double melting point. For the most part the naturally occurring glycerides are mixed glycerides. In the natural fats and oils there are present also certain higher alcohols, of which cholesterol is characteristic of the animal fats and oils and phytosterol of many of the vegetable fats and oils. In addition to the crystalline glycerides and the higher alcohols present in neutral fats, there are in fats of lower grade, fatty acids, which are crystalline, and also various non-crystalline impurities of an unsaponifiable nature, and the presence of these impurities tends to lower the melting point. They also tend to induce undercooling when the liquid fat or oil is being chilled for purposes of solidification or in determination of titer.

The presence of water, especially when this is thoroughly mixed or emulsified with a fat or oil, also influences the melting point to a marked extent, causing the mixture to melt through a longer range of temperatures than would be the case if the water were absent. This is particularly true of emulsified fats and oils, such as butter and oleomargarine, both of which contain, besides water, the solids naturally present in milk or cream and including casein, milk sugar, and salts. The melting-point method recommended by the Committee is not applicable to such emulsions or other watery mixtures and the Committee has found it impossible to devise an accurate method for making softening-point or melting-point determinations on products of this nature. Not only the amount of water present but also the fineness of its particles, that is, its state of subdivision and distribution, in a fat or oil influences the softening point or melting point and causes it to vary widely in different samples.

As a consequence of the foregoing facts, natural fats and oils do not exhibit a definite melting point, composed as they are of mixtures of various crystalline glycerides, higher alcohols, fatty acids, and non-crystalline substances. Therefore, the term melting point when applied to them requires further definition. They exhibit first a lower melting point (the melting point of the lowest melting component) or what might be called the softening point and following this the fat softens through a shorter or longer range of temperature to the final melting point at which temperature the fat is entirely liquid. This is the melting point determined by the Committee's melting-point method. The range between the softening point and the final melting point varies greatly with the different fats and oils depending on their chemical components, the water associated with them, emulsification, etc. In the case of coconut oil the range between softening point and final melting point is rather short; in the case of butter, long. Various methods have been devised to determine the so-called melting point of fats and oils. Most of these methods, however, determine, not the melting point, but the softening point or the flow point of the fat and the great difficulty has been in the past to devise a method which would determine even this point with reasonable accuracy and so that results could be easily duplicated. It has been the aim of the Committee to devise a simple method for the determination of the melting point of fats and oils, but it should be understood that the term melting point in the scientific sense is not applicable to natural fats and oils.

LECTURES AT WEST POINT AND ANNAPOLIS UNDER THE AUSPICES OF THE AMERICAN CHEMICAL SOCIETY

President Nichols has announced the following list of lecturers to give the courses of lectures on the bearing of chemistry upon military and naval problems.

MILITARY ACADEMY, WEST POINT, N. Y.

DR. WM. H. NICHOLS, 25 Broad St., New York City. *Sulfuric Acid, the Pig Iron of Chemistry.* January 10, 1920.

DR. WM. H. WALKER, Massachusetts Institute of Technology, Cambridge, Mass. **Manufacturing Problems of Gas Warfare.** January 17, 1920.

DR. CHAS. L. PARSONS, 1709 G St., N. W., Washington, D. C. **Nitrogen Fixation and Its Relation to Warfare.** January 24, 1920.

DR. HENRY FAY, Massachusetts Institute of Technology, Cambridge, Mass. **The Amorphous State in Metals.** January 31, 1920.

DR. CHAS. L. REESE, E. I. du Pont de Nemours & Co., Wilmington, Del. **Explosives.** February 7, 1920.

NAVAL ACADEMY, ANNAPOLIS, MD.

DR. HENRY FAY, Massachusetts Institute of Technology, Cambridge, Mass. **Iron and Steel.** November 15, 1919, to post-graduate student officers.

DR. JOHN JOHNSTON, Yale University, New Haven, Conn. **The Utilization of Research.** December 13, 1919, to post-graduate student officers.

DR. ARTHUR D. LITTLE, Charles River Road, Cambridge, Mass. **Natural Resources in Their Relation to Military Supplies.** January 17, 1920, to post-graduate student officers.

DR. WM. H. NICHOLS, 23 Broad St., New York City. **Sulfuric Acid, the Pig Iron of Chemistry.** February 6, 1920, to midshipmen.

DR. WILLIS R. WHITNEY, General Electric Co., Schenectady, N. Y. **Industrial Research.** February 7, 1920, to post-graduate student officers.

DR. W. LEE LEWIS, Northwestern University, Evanston, Ill. **Organic Research in Toxic Gases.** March 6, 1920, to post-graduate student officers.

DR. CHAS. L. REESE, E. I. du Pont de Nemours & Co., Wilmington, Del. **Explosives.** April 2, 1920, to midshipmen. April 3, 1920, to post-graduate student officers.

DR. WILDER D. BANCROFT, Cornell University, Ithaca, N. Y. **Organized Research.** April 30, 1920, to midshipmen, May 1, 1920, to post-graduate student officers.

DR. WM. H. WALKER, Massachusetts Institute of Technology, Cambridge, Mass. **Manufacturing Problems of Gas Warfare.** May 15, 1920.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

The twelfth annual meeting of this organization will be held in Savannah, Ga., December 3 to 6, 1919, with headquarters at the Hotel DeSoto. A series of papers and addresses devoted particularly to such southern industries as the naval stores, cotton, and turpentine and rosin industries has been included in the program, and excursions to the various chemical industries of Savannah and vicinity have been planned. The following schedule has been arranged:

DECEMBER 3, 1919

9.15 A.M.—Meeting at Hotel DeSoto
12.30 P.M.—Auto trip
8.00 P.M.—President's address, A. D. Little

DECEMBER 4, 1919

9.00 A.M.—Steamer trip, including visit to ship building yards, and paper pulp mill
8.30 P.M.—Symphony concert

DECEMBER 5, 1919

9.15 A.M.—Business session and reading of papers
2.00 P.M.—Auto trip to Southern Cotton Oil Company's plant and Fertilizer Plant of American Agricultural Chemical Company
7.00 P.M.—Dinner at Hotel DeSoto

DECEMBER 6, 1919

Special trips to various industries

SOCIETÀ DI CHIMICA INDUSTRIALE

The Società di chimica industriale has been organized at Milan for the purpose of promoting the interests of applied chemistry and chemical industry in Italy. Officers have been elected as follows:

President: Dr. Alb. Pirelli, of Pirelli & Co.

Vice Presidents: Prof. Aug. Menozzi and Dr. Giov. Morselli, of the Società Elettrochimica del Caffaro.

The first issue of the *Giornale di chimica industriale*, which is published under the auspices of the new society, appeared in August 1919. The subscription price is 40 lire, and the address of publication via San Paolo 10, Milan.

NOTES AND CORRESPONDENCE

SOME REMARKS ON STANDARD METHODS OF SOAP ANALYSIS

Editor of the Journal of Industrial and Engineering Chemistry:

In the August number of the *Journal of Industrial and Engineering Chemistry* I noticed the title "Tentative Standard Methods for the Sampling and Analysis of Commercial Soaps and Soap Products," by a Committee of the SOCIETY, of well known and capable men.

The subject interested me, for I have been connected with the manufacture and analysis of soaps, glycerin, and allied products for the past thirty-two years, and am still actively engaged along the same lines.

I do not see how it is possible to have any "Standard Method for Soap Analysis," except along the lines of a scheme of qualitative analysis which would start out somewhat in this fashion:

The soap is liquid. Pass on to page 57.

The soap is a solid. See page 60.

Turning to page 60 we might find:

It is a pure sodium soap. Pass on to page 71.

It contains sodium carbonate, but no other foreign matters. Pass on to page 73.

It contains alkaline silicates as well as sodium carbonate. Pass to page 74.

It contains sodium hydroxide, as well as carbonate, silicate, etc. Pass to page 75.

Etc., etc.

It is only by such a scheme, which would include all branches of inorganic and organic analytical chemistry, that it would be possible to give orderly directions for the analysis of many soaps. All schemes, without exception, that I have seen for the analysis of soaps appear to have been reasoned or thought out and put

down on paper without actual trial to see whether they worked as expected.

For instance, for moisture, one is generally directed to weigh out a certain amount of the soap and then, either directly or after dissolving in alcohol, to evaporate to approximate dryness and finish drying to constant weight in an air oven at 100° C. to 105° C., or some other limit. Such a method ignores several things, some of them serious, if accuracy is desired.

1—Volatile matters other than water will be wholly or partially lost.

2—Caustic alkalies will be changed, probably entirely, to carbonates.

3—Oxidation products of the soaps themselves and organic matters in the soaps will surely be formed.

4—Sodium carbonate will not lose all its moisture at such temperatures.

5—Sodium silicate will not lose its moisture short of a temperature that would burn up all organic matters present.

And still this method is given time after time. We can show by actual tests that the above things happen, and often seriously affect the moisture determination.

Again for the determination of Free Caustic Alkali you are generally directed to dissolve the soap in strong alcohol, protecting from the air (often omitted) as much as possible, filter through some efficient filtering material, and from hereon it is assumed that:

Matters such as sodium carbonate, silicate, starch, clay, etc., are insoluble in the liquid present and remain upon the filter, while

The soap and caustic alkali are to be found in the filtrate. Salt is sometimes looked for in the residue on the filter, but if

sufficient wash alcohol has been used it will be entirely in the filtrate.

Now as a matter of fact, some of the sodium carbonate will be in the filtrate, for we make use of aqueous alcohol and the moisture in the soap also helps to dilute it further, and sodium carbonate dissolves to some extent, as can easily be found out by concentrating the filtrate (keeping it strong in alcohol) when a precipitate will form, which will be found to be sodium carbonate. Sodium silicate is pretty insoluble in the liquids; small amounts will usually be found in the filtrate, apparently due either to colloidal solution or to mechanical entrapment in the filtration process. But the most serious thing is that sometimes little or none of the free caustic alkali will be found in the filtrate. Ignoring the fact that it may have been carbonated, and so tend to remain upon the filter, there is a more serious reason in the presence of silicate. The silicate used in soap manufacture is a highly acid silicate and is capable of forming four or five definite silicates of sodium, and this is one reason for adding it to soaps, that it unites with any excess of free caustic alkali and binds it loosely.

Some of these silicates of sodium are beautifully crystalline and can be easily formed and separated from the solution by the proper mixture of sodium hydroxide solution and silicate solution.

One at least of these compounds can be filtered off or taken out by centrifugal action, and then forms a pure white crystalline powder, almost permanent in the air. This can be handled with bare hands without injury, and yet when dissolved in water undergoes hydrolysis, leaving the effect of free caustic alkali. Now when a soap containing silicate and caustic alkali is treated with strong alcohol, a combination of the free caustic and silicate takes place, if it has not previously done so, and forms a compound that is not entirely decomposed by neutral alcohol, at the boiling temperature, and so such a compound remains upon the filter, and if sufficient silicate is present, practically all the caustic remains combined with it, on the filter. This point is always overlooked. But we have formed this compound and we have determined the practical composition of the compound of silicate and caustic that remains upon the filter. Again starch and caustic alkalies form combinations, and such combinations are used commercially as detergents, such as cornmeal ground up with strong caustic soda solution, which is dried and made into a soap powder. Such compounds show *no free caustic*.

In the determination of total fatty acids usually no reference is made to the fact that even on heating with water some fatty acids will be converted partially into anhydrides. That the neutralizing value and saponifying value of fatty acid is rarely exactly the same, is due principally to this cause. Precautions are not usually taken to prevent oxidation and volatilization of the fatty acids while drying. Fatty acids (those usually met with in soaps) easily lose weight in a current of air when heated to 100° C.; they also are subject to oxidation. Petroleum ether is recommended as a solvent by many who seem to prefer this substance to ether on account of its supposed cheapness. When properly purified it is not as cheap as it seems at first. Petroleum ether is a poor solvent for oxidized or hydroxylated fatty matters, and is favored, commercially, in many cases for this reason. It is a very useful solvent for many purposes, but it should be used intelligently and not assumed to be the equal of ether for total fatty matters. Further than this, petroleum ether not only is apt to leave a residue very hard to volatilize when being evaporated from a substance like fatty acids or soaps, but, more serious, it often, for some unknown reason, acts as a catalyzer in causing rapid oxidation of the fatty acids or soaps during evaporation in air. Direct experiment shows this.

The determination of unsaponifiable matters was long a very

bothersome operation, but at the present time we have very excellent commercial methods. There are two published methods that give good results, and one unpublished method (our own) that we believe gives better results.

Twitchell's¹ method makes use of either to extract a diluted alcoholic solution of the soap. It results in always leaving more or less free fatty acids, of unknown combining weight, in the final weighed residue. He titrates and assumes oleic acid to be present, and deducts the amount found from the weighed residue. In many cases this works nicely, in others it results in great errors. We used the process for a long time, and often found the free fatty acids left were largely in excess of the actual unsaponifiable matters.

The method of the Committee on the Tentative Standard Methods for the Sampling and Analysis of Commercial Fats and Oils² employed petroleum ether for the extraction of a soap solution containing considerable alcohol. It is a better method than Twitchell's and evidently the authors of the method thought that no free fatty acids were left with the final residue, for no provision or advice is given for correcting for them. However, in our hands, on various substances, free fatty acids are always left in the final residue, but not nearly as much as with Twitchell's process. We modify the committee's method slightly, with the results that our residues, while containing all the unsaponifiable matter possible by this method, contain either none or the smallest amounts of free fatty acids. While very concordant results are easily obtained nowadays for unsaponifiable matters, there is still a question whether we get them all, and also a serious question, in trying to purify them by re-solution and recovery after another saponification, whether we destroy or change some of these matters, or whether we really had impurities in the first place. Such residues are very apt to lose seriously in weight on resaponification and recovery and this may continue through several repetitions before anything like constancy is attained. The final substances in such cases appear purer substances, and we are inclined to think some true unsaponifiable substances are changed by boiling with alcoholic alkali, and so lost to subsequent extraction.

Twitchell's method for rosin was a blessing when it appeared. It has been well tested out and used for years and gives fair results, very good results when one knows what he is dealing with. But it does not recover by weight all the ingredients of the rosin originally present. We found years ago that we got better results by paying no attention to the rosin matters, but recovering the fatty acids. If the mixture of fatty acids and rosin or rosin acids is weighed, to start with, one gets the fatty ethers at one stage. If these are recovered, saponified, and the fatty acids recovered and weighed, there is all the data necessary for knowing how much rosin was present originally, and it does not make any difference how much of the resinous products was lost during the process. As one starts with fatty and rosin acids and ends up with the same fatty acids, less the rosin acids, the amount lost must have been the rosin acids, etc. In the analysis of soaps, as with alloys, the determination of one ingredient is so dependent upon the presence of other ingredients that it is impossible to give a standard method. The chemist has to use all his knowledge and ability, both mentally and mechanically, to arrive approximately at the truth. It is possible, and desirable, to have standard methods to apply to any one kind of soap, where all the ingredients are known. This is the best covered by specifications where directions to operate in a certain manner are given and it makes no difference whether the result is a true one (for a certain ingredient) or not; the specification states the limits within which the result must come to be acceptable.

The difficulties of a soap analysis may be better appreciated

¹ THIS JOURNAL, 7 (1915), 217.

² *Ibid.*, 10 (1918), 315; 11 (1919), 69.

if it is considered that an ordinary bar of laundry soap generally will contain:

Fatty anhydrides
Rosin anhydrides
Sodium oxide, combined as soap with the above
Unsaponifiable matters, from both the fatty and rosin matters, mineral oil, etc.
Perfume, or essential oils
Sodium carbonate, as filler and hardener
Sodium hydroxide, free or free and combined with silicate
Sodium silicate, free or hardener, and neutralizer of caustic
Sodium chloride
Sodium sulfate
Unsaponified matter, particularly in cold soaps, rarely in laundry soaps
Lime, magnesia, aluminum, iron, or other metallic salts in small amounts
Water
Glycerin, always present to some extent
Naphtha, borax, ammonium chloride, etc., always possibilities

This does not begin to exhaust the list, but covers those things usually present, and in getting up a scheme of analysis the effect of these things on one another and towards the reagents must always be borne in mind.

We have methods to determine with considerable accuracy any of the above ingredients, but we would hesitate to try to get up a standard method by which they could all be found in turn. It takes special methods and special apparatus for many of them.

THE CUDAHY PACKING COMPANY
OMAHA, NEBRASKA
September 5, 1919

WILSON H. LOW

TWO LETTERS ON THE TREATMENT OF LOW-GRADE NICKEL ORES

Editor of the Journal of Industrial and Engineering Chemistry:

It was with much pleasure and interest that I read the article by Mr. C. W. Davis [THIS JOURNAL, 11 (1919), 644] relative to the treatment of low-grade oxide nickel ore.

While appreciating his courtesy in mentioning my name in his acknowledgment in connection with a reduction test on nickel ore of North Carolina, I wish to emphasize that the reduction was done on my own request and initiative, Mr. Davis being kind enough to supply me the ore sample. Moreover, the idea of rendering the refractory nickel ore soluble by means of a reducing roast with gas, without fusing the ore, preventing reoxidation by cooling, originated with me. The results of this reduction test confirmed my theory. No doubt Mr. C. W. Davis, a friend of mine, must have not purposely forgotten this point in his acknowledgment, and it is therefore with friendly feelings that I bring this matter to his attention.

5 WILHELMINA LAAN
WELTEKVEDEN, JAVA (N. E. I.)
August 31, 1919

M. H. CARON

Editor of the Journal of Industrial and Engineering Chemistry:

Referring to the above criticism of the paper which was published in the July issue of your journal, Mr. M. H. Caron is correct in stating that the idea as well as the actual reduction of the nickel ore was his. I regret exceedingly that this point was not covered in my acknowledgment in that paper, for I had no thought of claiming to be the originator of a method of ore treatment which has been patented by Mr. Caron.

CHARLES W. DAVIS

BUREAU OF MINES EXPERIMENT STATION
GOLDEN, COLORADO
November 3, 1919

A SELECTIVE BIBLIOGRAPHY ON WASTE UTILIZATION AS AFFECTED BY THE WAR

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SPECIFICATIONS FOR REAGENTS

Editor of the Journal of Industrial and Engineering Chemistry:

In the belief that a valuable service can be rendered both to the manufacturers and to the users of reagents and apparatus, through standardization, the AMERICAN CHEMICAL SOCIETY appointed a committee which is now organized and at present is collecting data regarding the quality of reagents now on the market.

It seems that in general the experience of users agrees with that of the Bureau of Chemistry as reported by Mr. H. E. Buc at the Philadelphia meeting of the Society (p. 1140, this issue). The chief complaints appear to be in regard to the lack of reliability of the analyses rather than unsatisfactory purity of the reagents themselves. It is also evident that in many instances impurities which have caused dissatisfaction could have been removed by exercising sufficient care in production.

Insufficient knowledge on the part of the producer, both as to requirements and acceptable methods for testing, has been one cause for dissatisfaction relative to reagents. Some makers have signified a willingness to follow standard specifications and methods of testing, and the committee therefore proposes to begin work on the specifications for sulfuric, nitric and hydrochloric acids, and ammonia. This will be followed with specifications for other reagents.

It is requested that suggestions be sent to the secretary of the

committee, W. D. Collins, Bureau of Chemistry, Washington, D. C., indicating the specifications which would be acceptable, the uses to which the reagents are put in any special case and the methods which are satisfactory in determining the purity of the reagents and the presence and amount of objectionable impurities.

In the near future coöperation in the standardization of laboratory apparatus will be sought.

W. D. BIGELOW, *Chairman*
Committee on Guaranteed
Reagents and Standard Apparatus

WASHINGTON, D. C.
October 27, 1919

PLATINUM THEFTS

Thefts of platinum have occurred recently in the chemical laboratories of several universities.

Iowa State Teachers College, Cedar Falls, Iowa, reports the loss of over 300 grams of platinum ware, including 6 crucibles, 3 dishes, wire and sheet platinum, and a few grams of gold.

At Michigan Agricultural College, East Lansing, Michigan, 1700 grams of platinum were stolen from the laboratory, including 26 crucibles and 40 dishes.

CHEMICAL WARFARE SERVICE

The Board of Directors of the American Electrochemical Society has approved and ordered sent to members of Congress and the officials of the War Department the following resolution concerning the Chemical Warfare Service:

WHEREAS, The development of science and research is of paramount importance not only to the military establishment of the United States, but to the welfare and security of the entire nation; and

WHEREAS, The bill introduced into Congress for the reorganization of the Army (Senate 2715—66th Congress) is not only clearly destructive of the Chemical Warfare Service, but is so drawn as to belittle all scientific and technical work in the Army and make it subordinate to the unscientifically trained officer:

Therefore, be it Resolved, That the American Electrochemical Society urges strongly that any legislation for the reorganization of the Army shall provide for the continuing of the Chemical Warfare Service as a separate staff bureau as at present; shall provide for the commissioning of staff officers in the corps and departments in which they are to serve; and shall in general accord to the technical man full recognition and opportunity throughout every grade and department of the military establishment.

PROBLEMS AND METHODS IN AGRICULTURAL RESEARCH—CORRECTION

In the article under the above heading [THIS JOURNAL, **11** (1919), 1056] the following corrections should be made on page 1056:

First column, first paragraph, last line, the word "importance" should read "opportunity." Third paragraph, eighth and ninth lines, "Muntz" and "Deherain" should be "Müntz" and "Dehërain;" same paragraph, last line, "Voelecker" should read "Voelcker."

Second column, first paragraph, seventh line, "McCullon" should be "McCullum." H. J. WHEELER

WASHINGTON LETTER

By J. B. McDONNELL, Union Trust Building, Washington, D. C.

Congress, when it convenes in regular session in December, will face the task of disposing of several measures of importance to the chemical industry of the country.

Debate on the Treaty of Peace was an effective barrier to final action on many measures and many others were held up because of the refusal of Republican leaders in the Senate to

consider tariff legislation at this session. Included among the measures which must be further considered before they are written into law are the Longworth dyestuffs bill, the army reorganization bill, and tariff measures dealing with sulfur and pyrites, potash, barium chemicals, wood chemicals, starch, talc and soapstones, and chromium compounds.

Some of these measures have gone no farther than the first step of introduction and reference to the House Ways and Means Committee. Some have been reported out and passed by the House, and now are before the Senate Finance Committee. Among these latter is the Longworth dye bill, which provides increased import duties and vests in the U. S. Tariff Commission control by license of import of coal-tar products.

Action on the Longworth bill was prevented in the Senate by the opposition to the licensing plan. In order to prevent the American dye industry from facing foreign competition with the present law as its only bulwark while the Senate considered new protective legislation, Senator Penrose, chairman of the Senate Finance Committee, introduced a joint resolution continuing the authority of the War Trade Board to control imports of coal-tar products until January 15, 1920. By that date it is expected the Senate will have acted upon the Longworth bill. As originally introduced in the Senate by Senator Penrose the resolution would have practically placed an embargo against all dye imports, except those for which War Trade Board licenses already had been granted when the resolution was adopted. This was later amended in committee, however, and as finally passed to-day, the resolution simply continues the authority to control imports, which now exists after the formal coming of peace. Representative Green, of Iowa, brought the resolution up in the House and a short time after its passage, Senator Penrose obtained unanimous consent for its consideration in the Senate where it was quickly adopted. Objections advanced by several members of the Senate delayed consideration of the resolution there, and it appeared possible that these objections would continue until too late for the House, which wished to adjourn early, to act. To avoid this situation, Representative Longworth called a meeting of the House Ways and Means Committee and after conferences with Republican and Democratic leaders, it was decided to bring the resolution up first in the House, leaving the Senate action to come later. The resolution, S. J. Res. 125, provides: "That notwithstanding the prior termination of the present war, the provisions of the Trading with the Enemy Act, approved October 6, 1917, and of any proclamation of the President, issued in pursuance thereof, which prohibit or control the importation into the United States of dyes or other products derived directly or indirectly from coal tar, are continued until January 15, 1920."

Introduction of the resolution came after a flurry of conferences in which dye manufacturers, consumers and importers voiced their support or objection to the Longworth bill to various senators. Practically the same ground is being gone over in the Senate that was covered in the House. Dye importers and those consumers who are opposed to the measure in its present form still are determined to do their utmost to prevent enactment of the licensing provision. The fight in the Senate will be the same as in the House—over the licensing feature.

While it is indeed early to predict the outcome of the fight over the licensing provision in the Senate, it is probable that when the dye bill finally is enacted into law it will provide for licensing of dye imports. At the present time, however, the opposition is as strong, if not stronger, than the supporters of the provision. Should it remain so and the licensing provision be beaten in the Senate, the fight for it will be renewed in the House by Representative Longworth when the bill goes back there for agreement to the Senate amendments.

The potash bill also contains a licensing system for imports. This measure, however, still is in the House Ways and Means Committee, and it is somewhat doubtful whether it will come out without material changes. The licensing system is opposed in principle by some Democrats and by most of the Republicans, who profess to see in it an effort to get around the tariff as the principal means of protecting American industry. Frankly, the dyestuffs industry is receiving special consideration at the hands of Congress, and it must be confessed that the potash interests have not made as nearly a good case for themselves and have not as broad and as important reasons for special protection. It was because of disagreement among the members of the Ways and Means Committee that the potash measure was not reported to the House some time ago. Chairman Fordney, who is one of the opponents of the licensing feature in the dyestuffs bill, has expressed himself as being in favor of such a system when the potash bill has been under consideration.

The House cleared its calendar of all tariff measures which were reported out by the Ways and Means Committee, and these now are pending in the Senate Finance Committee, where action on most of them probably will be delayed for some months.

The U. S. Tariff Commission has in preparation a handbook on the acids of Paragraph I and related materials provided for in the Tariff Act of 1913. Among the acids dealt with in this paragraph are boric, citric, formic, gallic, lactic, oxalic, pyrogalllic, tannic and tartaric. These acids have not been discussed

in Congress with a view to any tariff legislation, however. The report of the Tariff Commission is expected to show that increased duties should be granted to the producers of at least some of these, although, of course, the Commission will not depart in any way from its practice of making absolutely no recommendations regarding rates, leaving that subject entirely to Congress. The handbook is part of the general material which the Commission is preparing for the information of Congress when it takes up consideration of the tariff law.

Revision of this law will be of especial interest to the chemical industry. The general changes brought about in the industry during the war are such as to give us as a nation an entirely new viewpoint. The changed situation has received recognition in the several tariff bills which have been introduced dealing with various phases of the industry. The attitude of the executive branch of the Government also shows that the growth of the chemical industry has been recognized and that the wisdom of fostering it is seen. President Wilson specifically mentioned the dyestuffs industry in one of his messages to Congress urging the necessity for its protection against foreign competition; and the Department of the Interior has endorsed and urged protection of the American potash industry.

Investigation of the cost of production in the domestic dyestuffs industry, which has been undertaken by the Tariff Commission, is expected to show abnormal production costs and practically chaotic conditions existing in the industry. This investigation will cover the production costs of dye manufacturers in the last half of the year 1918 and the first quarter of 1919. Efforts are being made to have the results in shape for presentation to Congress in time to give them weight in the consideration of the dye bill by the Senate. It is believed that an investigation of production costs for succeeding months, which probably will be undertaken some time in the future, will show marked improvement in the production and lowering of costs. This reduction, however, is met with a constant demand, on the other hand, for costly experiments and investigations which are essential if the industry is to continue its development, but which advance the total production costs.

The Bureau of the Census of the Department of Commerce is preparing to undertake a census of dyestuffs. This census should bring to light figures of intense interest to the chemical world. At the present time the progress of American dye manufacturers is known only in general terms. The census to be taken will include the number of establishments in the industry, their output, its value, the number of persons employed and the capital invested.

Dr. Charles H. Herty, who was sent abroad by the War Trade Board to represent the United States in the distribution of German dyestuffs under the provisions of the Treaty of Peace is due to arrive in this country about the middle of November. Details of the results of his mission are not known here. It has been learned, however, that he succeeded in obtaining the full six months' supply of dyestuffs for the importation of which the War Trade Board has granted licenses to consumers. Unable to obtain the full quantity desired through the Reparations Commission, Dr. Herty, it is reported, took out personal options upon the remaining dyes needed, dealing directly with the German chemical cartel. Only 30 per cent of the dyes for which licenses have been granted could be obtained through the interallied commission, and the remaining 70 per cent has been secured by means of an offer for direct purchase from the German manufacturers. These dyes probably will be imported under the licenses granted to consumers, very likely in the same manner as those obtained through the Reparations Commission are imported—through the Textile Alliance, Inc.

While there has as yet been no definite action taken by the Senate Military Committee's sub-committee which was appointed to consider the army reorganization bill, it is understood that the majority of the members of the sub-committee, of which Senator Wadsworth is chairman, favor continuing the Chemical Warfare Service as a separate and distinct department of the Army. In the measure which was prepared under the direction of Chief of Staff March, this important service was placed in a subordinate position and made a part of the engineer department. Congress is not kindly disposed toward the Chief of Staff, however, as it has shown on several occasions, and if present intentions of the sub-committee do not miscarry, the original bill S. 2715 will be practically rewritten, and the important Chemical Warfare Service will be made permanently a separate and distinct department of the Army. * * * *

In a public statement on November 15 Representative Kahn, chairman of the House Committee on Military Affairs, stated that in the legislation to be reported to the House provision will be made of a chemical warfare section.

November 18, 1919

INDUSTRIAL NOTES

Of the area of the Philippine Islands, about 120,000 square miles, only 14,000 square miles is cultivated land which includes rice, 2,189,000 acres; abaca, or Manila hemp, 1,236,000 acres; corn, 1,070,000 acres; coconuts, 680,000 acres; sugar cane, 444,000 acres; tobacco, 145,000 acres; maguey, 78,000 acres; cacao, 26,000 acres; coffee, 2,000 acres.

Land awaiting development include commercial forests, 61,000 square miles; non-commercial forests, 11,000 square miles; unexplored and other small islands, 14,000 square miles, not to mention a variety of mineral resources.

A preliminary investigation has been made of certain fish oils obtained from the Commissioner of Fisheries, Department of Commerce, with a view to determining their value in the paint and varnish industry. These oils have heretofore found application in other industries and may be used in the manufacture of soap, leather dressings, core oils, and for hydrogenation. It is probable that they will become available in greater quantities and be of use in the manufacture of certain types of coatings. So far, however, they have not proved satisfactory as drying oils when used alone, and it is probable, according to a circular of the Paint Manufacturers' Association of the U. S., that they will find application only in admixture with real drying oils.

The Forest Products Laboratory in recent experiments has succeeded in producing by all three pulping processes (the soda, sulfate, and sulfite) pulps which meet all surveillance tests for the use of wood pulp in the production of cannon powder. At certain steps in the process of manufacturing nitrocellulose, wood pulp cannot be handled as easily as cotton, but at other points it yields to treatment more readily.

Columbia University has received a gift of \$6,000 for research work in food chemistry.

The Department of Agriculture has investigated the damage to crops attributed to the use of fertilizer containing high borax-potash, and has traced in important instances this potash to the product of Searies Lake. In order to permit the safe use of this product in future, the Department has, under authority of the Control Act of August 10, 1917, decided to place such restrictions on the use of potash salts containing borax as will guarantee the use of an application of not more than two pounds of anhydrous borax per acre. Instructions have been issued to the producers of potash salts at Searies Lake and to all brokers, fertilizer manufacturers and mixers not to sell potash salts direct to farmers as straight goods when they contain more than five-tenths of one per cent of borax, and not to sell mixed fertilizers containing more than two pounds of borax per ton unless the amount of borax contained is plainly shown upon the container. The Department feels that such restrictions will make the use of potash salts from Searies Lake as safe under all conditions of agriculture as the use of nitrate of soda, acid phosphate, and other fertilizer constituents.

The War Trade Board Section of the Department of State has issued the following form of application for allocations for the importation of German dyes, other than vat dyes:

Date.....

Applicants reference number.....

To Bureau of Imports,

War Trade Board Section, Department of State,
Washington, D. C.

We hereby certify that the dyes hereinbelow described are the estimated requirements for consumption in our plant during the six months' period, November 15, 1919, to May 15, 1920; and we hereby make application for an allocation of the same.

We further certify that said dyes are:

(1) Unobtainable from United States sources, or

(2) Though obtainable from United States sources, are obtainable only on the terms as to price, quality and delivery set forth in a letter which accompanies this application, which terms we do not consider reasonable for the reasons stated in said letter.

We undertake and agree that all dyes of German origin which may be secured by us pursuant to the rules and regulations of the War Trade Board Section will be used by us and not be sold or otherwise disposed of except with the approval of the Bureau of Imports.

Designation of Dye (Schultz Number) Pounds.

(Name of corporation, firm or individual.)

(Name of officer authorized to act for applicant.)

The Bureau of Fisheries reports that excellent progress in the tanning of fish leather is to be recorded, and a number of the difficulties that have retarded the development of the industry have been overcome by tanners in this field. One company which is tanning fish skins has established a station in North Carolina and another in Florida for the capture of sharks and porpoises, and is meeting with success in its fishery for sharks. It is understood that the number of stations will be increased as rapidly as possible. Another company which has recently acquired a site for a tannery in Washington plans to tan the hides of sharks, beluga, hair seals, etc.

The possibility of utilizing liquid sulfur dioxide from the stack gases of smelters for the manufacture of sulfite acid for the paper industry has been suggested by the Forests Products Laboratory. Liquid sulfur dioxide has many advantages over sulfur for this purpose. The smelter product is free from all foreign material except perhaps a very small amount of moisture. It might be produced in quantities far exceeding the demands of the sulfite industry.

The seventh National Foreign Trade Convention will be held in San Francisco, May 12-15, 1920. It is expected that this will be the greatest gathering of American foreign traders ever brought together.

The British government has acquired from Germany, in exchange for food, 40,000 tons of potash salts for use as fertilizers throughout the United Kingdom. The British Potash Company has been appointed to undertake the sale under the control of the Government Potash Committee, and the following maximum prices per ton, net cash, in bags, delivered at the farmer's nearest railway station in Great Britain and Ireland, in lots of not less than 4 tons, have been fixed: Potash salts, 30 per cent K_2O , £12 10s. (\$60.83 at normal exchange); muriate of potash, 80 per cent KCl , £20 12s. 6d. (\$100.37); sulfate of potash, 90 per cent K_2SO_4 , £23 2s. 6d. (\$112.54).

The Salters' Institute of Industrial Chemistry of England has awarded grants in aid to thirty young persons occupied in chemical factories in or near London to assist them in improving their knowledge of chemistry.

The fourth annual report of the Committee of the Privy Council for Scientific and Industrial Research has just been issued in England, covering the period from August 1, 1918, to July 31, 1919. During the past year the work of the Department of Scientific and Industrial Research has steadily grown in usefulness and in amount. Encouraging progress is recorded in several directions. Thus a marked change is observed to be taking place in the attitude of industry towards scientific research. Something also has been done to increase the number of trained research workers, the demand for whose services has risen rapidly not only in industries, but also in the universities and government departments.

A bill for a national university, which failed of final action in the Sixty-fifth Congress, has been reintroduced at this session. The present bill is H. R. 9353: "To create a national university at the seat of the federal Government." The institution, to be known as the "National University of the United States," is to be governed by a board of trustees, consisting of the U. S. Commissioner of Education and twelve appointed members; the acts of the board are subject to approval by an advisory council, consisting of one representative (usually the president of the State University) from each State. No student is to be admitted unless he shall have obtained the degree of master of science or master of arts from an institution of recognized standing. No academic degrees are to be conferred. An initial appropriation of \$500,000 is provided. The bill was referred to the Committee on Education.

A reorganization of considerable magnitude has been taking place within the Newport Chemical Works. The manufacturing company is now the Newport Company, recently organized, which operates the works at Carrollville, Wis., and controls the property. The Newport Chemical Works of Delaware, with main offices at Passaic, N. J., will operate the Passaic branch and do the selling, with the exception of the sale of intermediates, which will continue from the New York office at 120 Broadway. This reorganization involves no change in the personnel of the company and is for the purpose of business facility.

The National Safety Council and the University of Cincinnati are cooperating in carrying out a program of instruction to medical students and graduate physicians in industrial relations, including sanitation, accident prevention and safety work.

¹ If number is not found in Schultz dye table, 1914 edition, classify if possible under proper group as given by Schultz.

The consolidation of the business operations of the Edible Oil Co., the Buttercup Oil & Tar Co., and the Louisville Soap Co. under the name of the Louisville Food Products Co., all at Louisville, Ky., has been completed with F. W. McKee as president. Mr. McKee retains his interests in the Marden, Orth & Hastings Corporation of New York, as vice president, but will spend a considerable part of his time in Louisville.

Of the 400,000 tons of fat which, before the war, were used in Germany for industrial or non-edible purposes, about 250,000 tons were used for soap making and 6000 to 8000 tons for candles, says *The Economist* of London. The concentration of the industry in the hands of a few large firms has not proceeded so rapidly in Germany as in England. At the outbreak of the war there were 34 large, 85 medium and 549 small soap works, with a total capital of about 300,000,000 marks. During the war the fat available for soap making was reduced to 18,000 tons per annum, and most of the works had to close. In 1917 the whole industry was brought under the control of one syndicate; it was, in fact, one of the earliest examples of compulsory syndication. The future is uncertain, although it is expected that syndication will reduce the cost of manufacture and of distribution.

The total value of the minerals produced in the United States in 1918 was about \$5,526,000,000, more than half a billion dollars in excess of the value recorded for 1917, but the total quantity produced was less. The output of fuels was greater than in 1917, though somewhat less anthracite coal was marketed. The increase in the quantity of coal marketed was about 5 per cent, but the increase in value, due to higher prices, was more than 17 per cent. It is significant that though the increase in the quantity of petroleum marketed was only a little more than 4 per cent, the increase in value was over 32 per cent.

Officials of the Bureau of Chemistry, U. S. Department of Agriculture, say that the slow rate at which figures on the production, consumption and stocks of turpentine and rosin are being received from the producers and consumers to whom the department has sent questionnaires and follow-up letters, is most discouraging. It is pointed out that this lack of co-operation on the part of the trade is causing indefinite delay in the publication of the naval stores statistics, therefore those concerned are urged to comply with the department's letters at once so as to expedite the complete publication.

The rights, properties and good will of the Corn Products Refining Company at Granite City, Ill., were sold recently to the Best Clymer Manufacturing Company of St. Louis, manufacturers of all kinds of preserves, jellies, syrups and other food products. The deal involved a consideration of approximately \$6,750,000.

The Coca-Cola Company has acquired the H. P. Pratt Laboratory, the largest manufacturer of carbonic gas, Epsom salts and other chemicals in the South. The Pratt Company has been organized for fifteen years, and operations for the last three years have averaged \$100,000 a year. Officers of the company are J. B. Campbell, chairman of the board; S. Y. Boykin, president; W. D. Heath, vice president, and C. M. Bergstrom, secretary and treasurer.

Total production of refined potassium salts during 1918 amounted to 33,503,017 lbs., valued at \$17,491,414; the sales amounted to 43,674,844 lbs., valued at \$15,634,125, according to a report by the United States Geological Survey. In addition there were produced 62,972,000 lbs. of potassium chloride, more or less refined, and 13,652,000 lbs. of potassium sulfate.

Fire in the plant of the Standard Guano Company, at Curtis Bay, near Baltimore, recently destroyed the electric plant shop, the pier, the old factory, the timekeeper's quarters and the pump building. Two lighters at the pier, many loaded freight cars and a quantity of fertilizer were burned, the loss amounting to \$1,500,000. Sparks from the grinding machine caused the blaze.

The United States Industrial Alcohol Company and the United States Chemical Company have awarded a contract for the erection of a plant at Curtis Bay, Baltimore, for the production of alcohols, a substitute for gasoline as a motor fuel. The cost is estimated at \$250,000.

The manufacturing and selling of chemicals, perfumery, fats, oils, soaps, etc., are additional objects of the Paterson Brewing and Malting Company, of Paterson, N. J., which has filed a certificate in New Jersey.

Even before the war the manufacture of pharmaceutical and chemical preparations was highly developed in Switzerland. During the war, says the *Swiss Exporter*, Swiss exports in this line reached a very high figure, 5,000,000 francs in 1913, and for the first nine months of 1918 amounted to 10,000,000 francs.

A bill to increase the present import tariff on talc has been introduced into the House of Representatives by Mr. Fordney, chairman of the Ways and Means Committee. The principal provisions of this bill are as follows: Talc, steatite, soapstone, and French chalk, crude and unground, 1/5c. per pound: when ground, washed, pulverized, or powdered, 1c. per pound: when cut or sawed, or in the form of blanks, crayons, or cubes, 2c. per pound: and 50 per cent ad valorem on manufactures of talc, talcum, steatite, soapstone, and French chalk, wholly or partly manufactured, if not decorated: if decorated, 60 per cent ad valorem. The present tariff on talc and soapstone admits crude and unground material, free of duty: talc or steatite, cut, powdered, washed, or pulverized, 15 per cent ad valorem.

According to the National Foreign Trade Council there is a new activity on the part of the American Chamber of Commerce in London which should prove of the greatest value to American foreign trade. Investigators, representing the dye and chemical trade group of the Chamber, have left London for Germany and Austria and possibly certain districts of Russia, to make a practical study of German methods of production and the possibilities of Germany's import and export trade in dyes and chemicals. The question of future business will be studied, especially from the financial side, to see how Germany intends to carry on her exports of chemicals. Information will also be obtained for use in preventing the dumping of German dyestuffs direct or through neutral countries. The reports of these investigators should be available in the course of a few months and may be obtained from the American Chamber of Commerce in London.

The Universal Conservation Company, of Los Angeles, has asked permission to make a scientific salvage of the garbage of the city of Oakland, Cal., and has offered to erect a \$100,000 reduction plant.

John Lucas & Company, Inc., Philadelphia, manufacturer of paints, oils and varnishes, has acquired the W. W. Lawrence & Co., Pittsburgh, Pa., capitalized at \$200,000. The purchase includes a large nine story factory covering an entire city block in Pittsburgh.

Announcement has recently been made of the organization of the Rollin Chemical Corporation, with a capital of \$2,500,000, which takes over the chemical plants of the Rollin Chemical Co., Charleston, W. Va., and the chemical works and mines of the Clinchfield Products Corporation, located at Johnson City, Tenn., and Evinston, Va. New capital has been brought into the company and extensions are being planned. Changes will also be made in order to improve and centralize the manufacture of certain products, so that these can be turned out with the greatest facility.

The French Chamber of Deputies has adopted a new detailed tariff schedule for dyestuffs and chemicals, including pharmaceuticals, providing for free importation and government distribution of German products covered in Reparation Annex VI of the Peace Treaty, and licensing all German imports of those products in excess of treaty amounts. The bill has been referred to a committee of the Senate.

Announcement has been made by the Newark College of Technology, Newark, N. J., of the establishment of a special course on "corporation chemistry," covering the relation of business economics to industrial chemistry. The course will be of particular interest to factory superintendents, supervising engineers, sales managers, and the like, and will consist of thirty lectures under five subdivisions, arranged so as to have special application to the problems of projected chemical plants. The instructions will be under the direction of Dr. Frederick Danerth, a local consulting chemist.

A report on the German chemical market states, according to *Drug and Chemical Markets*, that a majority of the works are only covering their most urgent requirements. There has been a considerable decline in prices for products which can be imported and of which quantities have already arrived, such as tartaric products and caustic soda. On the other hand, the German works were obliged to make a further advance, owing to the scarcity of raw materials and fuel and demands for higher wages.

The Garrigues Industrial Corporation, New York, has just received from the Norsk Hydro-Elektrisk Kvaestofaktieselskab, Norwegian manufacturers of nitrite of soda, one of the largest shipments ever brought into this country. Approximately one million pounds of nitrite were received.

The Federal Trade Commission has issued an order directing F. E. Atteaux and Co., of Boston, manufacturers of dyestuffs and chemicals, to discontinue the practice of commercial bribery in the form of gifts to employees of customers.

PERSONAL NOTES

Mr. James A. Branegan, of Philadelphia, was elected vice president of The Heyden Chemical Co. of America at a recent meeting of the Directors.

The American Society of Mechanical Engineers has invited the members of the American Chemical Society to attend its meeting in New York City, December 2 to 5, 1919.

Mr. R. L. Howard, for the past two years instructor in the State University of Iowa, is at present associate professor of chemistry at Richmond College, Richmond, Va., where he has charge of the organic chemistry and the chemistry of food and nutrition.

Prof. Marston T. Bogert has received his honorable discharge from the Chemical Warfare Service and has returned to his professorship at Columbia University, resuming charge there of the subject of organic chemistry.

Mr. L. E. Saunders, of the Norton Company, has been transferred from the Niagara Falls plant to the executive offices of that company at Worcester, Mass., as manager of the research and abrasive plants.

Mr. Louis J. Gurevich has resigned from the U. S. Bureau of Standards as assistant physicist in metallurgy to accept a position as metallurgist with the research department of the Hydraulic Pressed Steel Co., of Cleveland, Ohio.

Mr. H. W. Curry, after ten years of service as chief chemist of the Ozark Smelting and Mining Co., of Coffeyville, Kansas, resigned recently from that position and is now with the American Zinc, Lead and Smelting Co., Oxide Department, at Hillsboro, Ill.

Mr. William Stericker, who for the past two years has been a chemist at the Westinghouse Lamp Co., Bloomfield, N. J., is now an industrial fellow at the Mellon Institute of Industrial Research, University of Pittsburgh, Pittsburgh, Pa.

Mr. Norville C. Pervier, recently discharged from the U. S. Army, has returned to the Standard Chemical Company, Inc., Des Moines, Iowa, where he is chief chemist.

Dr. V. S. Babasianian has returned to his duties as associate professor of organic chemistry at Lehigh University, Bethlehem, Pa., after a leave of absence of one year, during which time he did research on poison gases at the American University, Washington, D. C., and was also research chemist at the Jackson Laboratory of E. I. du Pont de Nemours & Co., Wilmington, Del.

Dr. David Klein, recently returned from France and Serbia as Major, Sanitary Corps, has resigned as state analyst, State of Illinois, and has accepted the position of associate professor of biochemistry, Johns Hopkins University, School of Hygiene and Public Health, Baltimore, Md.

Dr. S. C. Brooks, formerly research fellow, Harvard School of Tropical Medicine, Boston, Mass., is now associate professor of biochemistry and physiology at Bryn Mawr College, Bryn Mawr, Pa.

Mr. Edgar R. Wagner, who has been with the Wyoming Chemical Co., Pittston, Pa., since his discharge from the Army, has resumed his duties as instructor in chemistry at Syracuse University, Syracuse, N. Y.

Mr. J. R. Lorenz, formerly in the research laboratory of William F. Mosser Co., at Chicago, Ill., is tanning chemist for the Northeastern Leather Co., Salem, Mass.

Mr. Glenn S. Skinner, who, following his discharge from the Chemical Warfare Service, taught in the University of Illinois, is in charge of organic chemistry at Oberlin College, Oberlin, Ohio.

Mr. Edward P. Phelps, for the past two years instructor in general chemistry at Syracuse University, N. Y., is an instructor in organic chemistry at New York University, New York City.

Mr. J. Hallett Hodges, formerly in the Chemical Warfare Service, is instructor in general chemistry at the University of Michigan, Ann Arbor, Michigan.

Mr. H. D. Gibbs has resigned his position as chemist-in-charge of the color laboratory of the U. S. Bureau of Chemistry, in order to accept a research position with E. I. du Pont de Nemours & Co., at their Jackson Laboratories, Wilmington, Del.

Mr. Guilford A. Morse, formerly in the Chemical Warfare Service, has accepted a position with the Boise Payette Lumber Co., of Emmett, Idaho, as research chemist.

Dr. Charles K. Francis, formerly of Tulsa, Okla., is manager of refineries for the Transcontinental Oil Co., with headquarters at Fort Worth, Texas.

Mr. Frank W. Sherwood recently resigned from the Jackson Laboratory of E. I. du Pont de Nemours & Co., Wilmington, Del., is first assistant chemist at the North Carolina Agricultural Experiment Station, West Raleigh, N. C.

Mr. Alfred H. White, formerly Lieutenant Colonel and Chief of the Research Section of the Nitrate Division of the Ordnance Department, has returned to his former position as professor of chemical engineering at the University of Michigan, but is retaining connection with the nitrogen fixation work as consulting engineer of the Ordnance Department.

Mr. R. M. Ladd, formerly special analyst for the Aetna Works, Aetna Explosives Co., Inc., and more recently operator at the naphthalene plant of the Illinois Steel Co., Gary, Ind., is now chief chemist and factory manager of the Egg-O Baking Powder Co., Ltd., Hamilton, Ont., Canada.

Dr. Arthur B. Ray, recently Captain in the Chemical Warfare Service, has joined the staff of the research laboratories of the National Carbon Co., Inc., Cleveland, Ohio.

Mr. W. W. Lake, recently discharged from the U. S. Army as Second Lieutenant in the Infantry, is head of the science department, El Paso High School, El Paso, Texas.

Dr. Harry A. Curtis has resigned his position at the Fixed Nitrogen Research Laboratory in order to accept a professorship in chemistry at Northwestern University, Evanston, Ill.

Mr. Charles A. Glabau, previously technical advisor for the Campbell System, Inc., scientific operators of bakeries, Kansas City, Mo., is at present connected with the American Trade Publishing Company as technical editor of *Bakers Weekly*, New York.

Dr. Walter C. Schumb, formerly assistant gas chemist at the American University Experiment Station, Washington, D. C., has been appointed assistant professor in chemistry at Vassar College, Poughkeepsie, N. Y.

Mr. George P. Shingler, Jr., formerly professor of chemistry in Emory College, Oxford, Ga., and in the field service of the American Red Cross, is now establishing an independent laboratory at Donaldsonville, Ga., for industrial and clinical work.

Mr. Benjamin Levitt, for several years associated with the Swift and Company Soap Works, E. Cambridge, Mass., has accepted a position as chemist for Charles W. Young and Company, at Philadelphia, Pa.

Mr. William Pines, formerly chief army chemist, U. S. A., Ordnance Department, at Parlin, N. J., is now chief chemist of the Faultless Rubber Co., Ashland, Ohio.

Mr. Frederick Vossler is instructor in chemistry at Waite High School, Toledo, Ohio, having resigned from the instructorship in chemistry at Poughkeepsie High School, Poughkeepsie, N. Y.

Mr. Bert Russell has resigned from the Patent Office staff to accept a position with Prindle, Wright and Small, patent attorneys, New York City.

Dr. C. D. Andrade, consulting chemist in the Guayaquil Custom House, Guayaquil, Ecuador, has been appointed by the City Council of Guayaquil, director (chief chemist) of the city laboratory.

Mr. William J. Cotton, formerly with the color laboratory of the Bureau of Chemistry, Washington, D. C., is now with the research division of the National Aniline and Chemical Company, Buffalo, N. Y.

Mr. W. H. Macmillan has severed his connection with the Remington Typewriter Company, Ilion, N. Y., as chief chemist, and has accepted a position in the metallurgical laboratory of the Halcob Steel Co., Syracuse, N. Y.

Mr. William A. Turner, previously in the Army as First Lieutenant in the Sanitary Corps, attached to the Section of Food and Nutrition of the Surgeon General's Office, and for some time camp nutrition officer at Camp Jackson, S. C., is at present located at Wesleyan University, Middletown, Conn., as assistant professor of chemistry.

Mr. Lloyd H. Reyerson has accepted a position as instructor in the School of Chemistry, University of Minnesota, Minneapolis, Minn., having formerly been a student in chemistry at Johns Hopkins University, Baltimore, Md.

Dr. Edward S. Johnson, who for a number of years has been connected with the Solvay Process Co., has accepted the position of director of manufacture and chief chemist of the U. S. Color and Chemical Co., with main office in Boston and plant at Ashland, Mass.

Mr. Elliott E. Geisinger has resigned his position as chemist in the Pfaunder Company to take one as industrial engineer with the Firestone Tire and Rubber Company of Akron, Ohio.

Mr. J. A. Le Clerc, formerly chemist-in-charge of the laboratory of plant chemistry of the Bureau of Chemistry, Washington, D. C., is now with the Miner-Hillard Milling Co., of Wilkes-Barre, Pa.

Mr. H. E. Cleaves, formerly chemist with the Metal and Thermit Corporation, Jersey City, N. J., is with the Charleston Chemical Co., Charleston, W. Va., as chief chemist.

Mr. Bruner M. Burchfiel has resigned his position as junior fellow on the Refractories Manufacturers Association Fellowship at Mellon Institute, Pittsburgh, Pa., and has accepted an assistantship in the department of chemistry at the University of California, Berkeley, Cal., where he will be engaged in graduate research in physical chemistry.

Mr. R. Edman Greenfield, formerly Captain in the Sanitary Corps, has returned to the Illinois State Water Survey Division, Urbana, Ill., as bacteriologist, in which department he was employed prior to his service in the U. S. Army.

Mr. Eugene A. Giard, recently released from active duty in the U. S. Naval Reserve Force, is now on the research staff of the National Lamp Works of Nela Park, Cleveland, Ohio.

Miss Florence N. Schott, formerly assistant in chemistry at the University of Illinois, is now instructor in chemistry at the Municipal University of Akron, Akron, Ohio, having the organic and household chemistry courses for the women majoring in home economics.

Mr. Charles W. Clifford, who has been assistant chemist in the Polarimetric Division, U. S. Bureau of Standards, since leaving the Chemical Warfare Service as First Lieutenant last December, has accepted a position with the Great Western Sugar Company and will be located at the Fort Collins, Colorado, factory.

Mr. George L. Clark, formerly associate professor at DePauw University, Greencastle, Ind., has become associate professor in charge of physical chemistry at Vanderbilt University, Nashville, Tenn.

Mr. Arthur R. Cade, formerly instructor in chemistry at the University of Minnesota, Minneapolis, Minn., has accepted a position as research chemist with the National Carbon Company, of Fremont, Ohio.

Dr. Edward Bartow, formerly Lieutenant Colonel in the Sanitary Corps, connected with the Water Supply Service of the A. E. F., has resumed his former work as chief of the Illinois Water Survey Division.

Mr. Charles A. Mann, formerly of Ames, Iowa, has been appointed associate professor of industrial chemistry, School of Chemistry, University of Minnesota, Minneapolis, Minn.

Mr. Numa P. G. Adams, associate professor of chemistry and head of the department of chemistry of Howard University, has resigned after seven years of service in that institution and will devote his time to the study of medicine at Chicago, Ill.

Mr. Edgar S. Ross, formerly chief chemist for the Charlotte Chemical Laboratories and Columbite Reduction Co., Charlotte, N. C., is now located at New Hampshire College, Durham, N. H., where he is to carry out special research in the rare earths.

Mr. Francis H. Thurber, formerly instructor in chemistry at Washington State College, Pullman, Washington, is now in the College of Chemistry of the University of California.

On October 1, the Washington office of **Dr. L. I. Shaw**, grand recorder-treasurer of the Alpha Chi Sigma Fraternity (the national professional chemical fraternity), was moved from 1208 G Street, N. W., to 1709 G Street, N. W., Washington, D. C. This change will give the fraternity much needed additional space for carrying on its work. The new location is directly across the corridor from the new offices of the Secretary of the AMERICAN CHEMICAL SOCIETY.

Mr. E. Colonna de Giovellina, who received his discharge from the Canadian Expeditionary Forces last February, has been appointed research chemist at the Mill Creek plant of the Whalen Pulp & Paper Mills, Ltd., Vancouver, B. C.

Mr. W. F. Gericke, who has been in the service of the National Research Council on investigations in plant nutrition, at the laboratory of plant physiology of the Johns Hopkins University, has returned to the University of California, Berkeley, Cal., to take up his work in the division of soil chemistry and bacteriology.

Mr. A. W. Bull, formerly student and assistant in chemistry at Cornell University, is now instructor in chemistry at Haverford College, Haverford, Pa.

Mr. P. G. Savage has become resident manager of the Niagara Falls, New York, and the Chippawa, Ont., plants of the Norton Company of Worcester, Mass.

Mr. Arthur L. Greeley, who has been in the Chemical Warfare Service and who later was instructor in chemistry at Tufts College, Boston, Mass., is now connected with Union College, Schenectady, N. Y., as instructor in chemistry.

OBITUARY

THOMAS J. PARKER

The chemists of this country have seldom been called upon to bear a greater loss than when, on October 9, 1919, Thomas J. Parker joined the ranks of those who have solved all earthly problems.

Mr. Parker's name will always remain linked with the development of chemical industry in this country. The AMERICAN CHEMICAL SOCIETY, as its representative body, was to him a proud and glorious structure and he was one of its strongest and staunchest pillars. He was at all times a real worker in its behalf, and few have given to a cause as freely and as unselfishly as he, or with a more whole-hearted devotion.

To his brother chemists he was an ever-ready friend and counsellor, and many of the younger generation will remember his sympathetic consideration and the great skill with which "Commodore" Parker steered them safely, time and again, through the troubled waters which most chemists must navigate before reaching a quiet haven.

His many and notable technical achievements, beginning with his work at the Bayonne Chemical Works, the Bergen Point Chemical Works of the Standard Oil Company and culminating in his important work for the Martin Kalbfleisch Chemical Company and the General Chemical Company, reflected but one side of Mr. Parker's character—its professional side.

The dominating note of his life was a rare loyalty to his friends and to the causes he espoused. Among the latter was the AMERICAN CHEMICAL SOCIETY, the New York Section of the Society of Chemical Industry, of which he was a founder, and the Chemists' Club in particular, of which he likewise was a charter member. To all these he gave his time and his best efforts; many were the sacrifices which he made in their behalf. Nothing pleased him more during his protracted illness than word of the rapidly increasing membership of the AMERICAN CHEMICAL SOCIETY, or the assurance that all was well with the Chemists' Club.

His interest was not limited to matters chemical, but extended to public affairs in general and his indefatigable efforts in that direction led, among other things, to the establishment of a free library in his home town, Bayonne, N. J.

If at his desk he sometimes appeared stern and uncompromising, those who knew him best recognized as the cause his dominant sense of justice. His sense of humor, his wit and gift of repartee were a keen and constant delight to all.

His fellow chemists will remember his services and his worth, but his friends will, above all, keep him in memory as a lovable, staunch, and loyal gentleman.

T. B. WAGNER

GOVERNMENT PUBLICATIONS

By R. S. McBaroz, Bureau of Standards, Washington

NOTICE—Publications for which price is indicated can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. Other publications can usually be supplied from the Bureau or Department from which they originate. Commerce Reports are received by all large libraries and may be consulted there, or single numbers can be secured by application to the Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington. The regular subscription rate for these Commerce Reports mailed daily is \$2.50 per year, payable in advance, to the Superintendent of Documents.

UNITED STATES TARIFF COMMISSION

Information Concerning the Domestic Potato-Product Industries, Potato Flour; Dried or Dehydrated Potatoes; Potato Starch; Potato Dextrine. Unnumbered pamphlet printed for use of Committee on Ways and Means, House of Representatives. 28 pp. In 1918 five potato flour factories were operating, their combined production being 2,500,000 lbs. Three of these factories are controlled by a large corporation which is surveying the field with a view to erecting others in regions of large production. The first domestic plant was established in Idaho in 1917; four others are operating in Nebraska, Michigan, Wisconsin, and Minnesota.

WAR INDUSTRIES BOARD

The Planning and Statistics Division of the War Industries Board has issued the following parts of its "History of Prices during the War."

Prices of Coal-Tar Crudes, Intermediates, and Dyes. W. N. JONES and F. W. CASSEBEER. 32 pp. W. I. B. Price Bulletin 53.

Prices of Drugs and Pharmaceuticals. W. LEE LEWIS and F. W. CASSEBEER. 24 pp. W. I. B. Price Bulletin 54. Paper, 5 cents.

Prices of Essential Oils, Flavoring and Perfumery Materials. W. B. MELDRUM. 21 pp. W. I. B. Price Bulletin 50. Paper, 5 cents.

Prices of Fibers and Fiber Products. JANE COATES. 29 pp. W. I. B. Price Bulletin 32. Paper, 5 cents.

Prices of Glass. VIVA B. BOOTH in consultation with CARROLL W. DOTEN. 11 pp. W. I. B. Price Bulletin 42. Paper, 5 cents.

Prices of Mineral Acids. H. L. LEWENBERG. 18 pp. W. I. B. Price Bulletin 45. Paper, 5 cents.

Prices of Miscellaneous Inorganic Chemicals. W. B. MELDRUM. 24 pp. W. I. B. Price Bulletin 47. Paper, 5 cents.

Prices of Miscellaneous Organic Chemicals. ARTHUR MINNICK. 18 pp. W. I. B. Price Bulletin 57. Paper, 5 cents.

Prices of Natural Dyestuffs and Tanning Chemicals. P. W. CARLETON. 15 pp. W. I. B. Price Bulletin 52. Paper, 5 cents.

Prices of Oats, Rice, Buckwheat, and Their Products. HARLEY R. WILLARD. 23 pp. W. I. B. Price Bulletin 11. Paper, 5 cents.

Prices of Paints and Varnishes. ARTHUR MINNICK. 25 pp. W. I. B. Price Bulletin 44. Paper, 5 cents.

Prices of Petroleum and Its Products. JOSEPH E. POGUE, assisted by ISADOR LUBIN. 55 pp. W. I. B. Price Bulletin 36. Paper, 5 cents. Prepared in cooperation with Fuel Administration. Also issued without series title as a Fuel Administration publication.

Prices of Soaps and Glycerin. H. L. TRUMBULL. 20 pp. W. I. B. Price Bulletin 49. Paper, 5 cents.

Prices of Sugar and Related Products (with bibliography). FRANK F. ANDERSON. 23 pp. W. I. B. Price Bulletin 13. Paper, 5 cents.

International Price Comparisons (with bibliography). WESLEY C. MITCHELL, assisted by Margaret L. Goldsmith and Florence K. Middaugh. 395 pp. W. I. B. Price Bulletin 2.

Paper, 25 cents. Prepared in cooperation with Commerce Department. Also issued without series title as a Commerce Department publication.

Prices in Button Industry. JOHN M. CURRAN. 22 pp. W. I. B. Price Bulletin 29. Paper, 5 cents.

Prices of Barley, Hops, Rye, and Their Products. LLOYD W. MAXWELL. 17 pp. W. I. B. Price Bulletin 12. Paper, 5 cents.

Prices of Cement. HOMER HOYT. 11 pp. W. I. B. Price Bulletin 41. Paper, 5 cents.

Prices of Corn and Corn Products. HARRY F. BRUNING. 19 pp. W. I. B. Price Bulletin 10. Paper, 5 cents.

Prices of Edible Vegetable Oils. 16 pp. W. I. B. Price Bulletin 15. Paper, 5 cents.

Prices of Feed and Forage. LLOYD W. MAXWELL. 21 pp. W. I. B. Price Bulletin 8. Paper, 5 cents.

Prices of Fruits, Nuts, and Wine. 15 pp. W. I. B. Price Bulletin 16. Paper, 5 cents.

Prices of Hair, Bristles, and Feathers. J. LINDEN HEACOCK. 19 pp. W. I. B. Price Bulletin 28. Paper, 5 cents.

Prices of Hatter's Fur and Fur Felt Hats. J. LINDEN HEACOCK. 13 pp. W. I. B. Price Bulletin 27. Paper, 5 cents.

Prices of Heavy Chemicals. H. L. LEWENBERG. 20 pp. W. I. B. Price Bulletin 46. Paper, 5 cents.

Prices of Matches. MARY L. DANFORTH. 9 pp. W. I. B. Price Bulletin 37. Paper, 5 cents.

Prices of Proprietary Preparations. W. LEE LEWIS and F. W. CASSEBEER. 13 pp. W. I. B. Price Bulletin 55. Paper, 5 cents.

Prices of Quarry Products. HOMER HOYT. 15 pp. W. I. B. Price Bulletin 40. Paper, 5 cents.

Prices of Sand and Gravel. W. J. KOTSRAN. 8 pp. W. I. B. Price Bulletin 39. Paper, 5 cents.

Prices of Spices and Condiments. DEBORA E. WOOD. 12 pp. W. I. B. Price Bulletin 17. Paper, 5 cents.

GEOLOGICAL SURVEY

Magnesium in 1918. R. W. STONE. From Mineral Resources of the United States, 1918, Part I. 9 pp. Issued July 28, 1919.

The output of metallic magnesium in 1918 was 284,188 lbs., valued at \$615,217, an increase of 145 per cent in quantity and 163 per cent in value over the output of 1917. The production of magnesium on a commercial scale began in the United States so recently as 1915 and has reached these noteworthy proportions in four years because of unusual conditions.

The average price per pound of metallic magnesium in sticks ranged in 1918 from \$1.60 to about \$2. Magnesium powder brought a higher price, because of the additional fabrication required, and varied in price according to the quantity sold and the fineness of the material.

The variation in price of magnesium during the last few years is interesting to note, because the magnesium industry in the United States is virtually a "war baby." Imported magnesium quoted at about \$1.65 a lb. supplied the domestic market until the war cut off the foreign supply. Prices rose to \$5 or even \$6 a lb. for sticks and to \$6.50 a lb. for powdered material. These prices continued through 1915. During 1916 the price fell off, and, at the beginning of 1917, 99 per cent pure bar magnesium was selling for \$2.50 to \$3 a lb. This price gradually declined, and at the end of 1917 magnesium in bars was selling for \$1.85 to \$2 a lb., according to the quantity bought. In 1918 the price of domestic material returned approximately to the pre-war price of imported magnesium.

Ground Water in the San Jacinto and Temecula Basins, California. GERALD A. WARING. Water Supply Paper 429. 113 pp. Paper, 40 cents. Prepared in cooperation with the Department of Engineering of the State of California.

Oil Shale in Western Montana, Southeastern Idaho, and Adjacent Parts of Wyoming and Utah. D. DALE CONDIT. Bulletin 711-B, from Contributions to Economic Geology, 1919, Part II. 25 pp. Issued September 27, 1919.

The results of the investigation may be briefly summarized as follows: In the Dillon-Dell area, where the Phosphoria oil shale is at its best, the richest beds of 3 ft. or more in thickness yield 25 to 30 gal. of oil to the ton. The phosphate beds associated with the shale are thinner and contain considerably less phosphorus pentoxide than those mined near Montpelier, Idaho, and those known to occur in the Melrose and Garrison fields of Montana. Samples of the shales associated with the high-grade phosphate rock in the southeastern Idaho area yielded on distillation little more than a trace of oil.

In connection with the investigation of the phosphatic shales of the Phosphoria formation, attention was also given to bituminous shales of other formations that were convenient to the route of travel. Samples were taken at a number of localities of outcrop of the black shale in the Threeforks formation (Devonian) and Quadrant formation (Pennsylvanian and late Mississippian) of west-central Montana; the Tertiary beds in the intermountain basins south of Dillon, Mont.; the Green River shale at Fossil, Wyo.; and Mississippian shales in northeastern Utah. No new localities that seem especially promising were discovered. The results are set forth in detail.

A Reconnaissance of the Pine Creek District, Idaho. EDWARD L. JONES, JR. Bulletin 710-A, from Contributions to Economic Geology, 1919, Part I. 36 pp. Issued August 27, 1919. The discussion refers to deposits, mines, and prospects for lead, zinc, antimony, and siderite.

Mining and Mineral Deposits in the Cook Inlet-Susitna Region, Alaska. Bulletin 692-D. Separate from Mineral Resources of Alaska, 1917-D. This includes the following six reports:

- (1) **Gold Lode Mining in the Willow Creek District, Alaska.** STEPHEN R. CAPPS. 9 pp.
- (2) **Mineral Resources of the Western Talkeetna Mountains, Alaska.** STEPHEN R. CAPPS. 20 pp.
- (3) **Mineral Resources of the Upper Chulitna Region, Alaska.** STEPHEN R. CAPPS. 25 pp.
- (4) **Platinum-Bearing Gold Placers of the Kahiltna Valley, Alaska.** J. B. MERTIE, JR. 31 pp.

Placer gold is the only mineral that has been exploited on a commercial scale in the valley of Kahiltna River up to the present time. Other minerals of value, however, including principally platinum, cassiterite (tin oxide), and scheelite (calcium tungstate), have been found in the placer sands, and it is possible that some of these may later be produced in commercial amounts. Provision should be made for the recovery of platinum in the gold placers, where it is found in any considerable amount, and the district should be further prospected for workable deposits of placer platinum. Heavy concentrates of cassiterite from the placer sands were noted at certain localities, and search should be made for their bedrock sources. The presence of scheelite in the placers, although it is not plentiful, indicates the presence of tungsten ore south of the Alaska Range and should be remembered when prospecting for lode deposits. The Eocene coal deposits have already been used locally as a source of fuel and power.

(5) **Chromite Deposits in Alaska.** J. B. MERTIE, JR. 3 pp. The chromite of southwestern Kenai Peninsula occurs in lens-shaped bodies that range in thickness from a few inches to 20 ft. and that lie in attitudes ranging from horizontal to vertical. None of the lenses appear to be more than 150 ft. long, and most of them measure considerably less. The ore is not of uniform grade. Some of it averages 50 per cent of chromic oxide, and some is a mixture of chromite and peridotite, the leanest part of which may yield only 5 to 10 per cent of chromic oxide. All gradations between these extremes are found.

(6) **Geologic Problems at the Matanuska Coal Mines.** G. C. MARTIN. 12 pp.

Sulfur Deposits and Beach Placers of Southwestern Alaska. Bulletin 692-E. Separate from Mineral Resources of Alaska, 1917-E. This report includes the following two articles:

(1) **Sulfur on Unalaska and Akun Islands and Near Stepovak Bay, Alaska.** A. C. MADDREN. 15 pp.

(2) **The Beach Placers of the West Coast of Kodiak Island, Alaska.** A. C. MADDREN. 20 pp.

Mining in Fairbanks, Ruby, Hot Springs, and Tolstoi Districts, Alaska. Bulletin 692-F. Separate from Mineral Resources of Alaska, 1917-F. This report includes the following five articles:

(1) **Mining in the Fairbanks District.** T. CHAPIN. The mineral production of the Fairbanks district in 1917 included placer gold, valued at \$1,310,000; lode gold, valued at \$47,781; placer silver, valued at \$6,904; lode silver, valued at \$1,827; and lead, tungsten, and antimony, valued at \$58,257. The total value of the mineral output in 1917 was \$1,424,769, as against \$2,039,744 in 1916. The decrease was due in large part to a general retrenchment on the part of operators owing to the high cost of supplies, which prevented the working of low-grade ground. Failures were recorded in 1917 on ground which in previous years netted a good profit, and but for the general retrenchment other failures would doubtless have resulted.

(2) **A Molybdenite Lode on Healy River.** T. CHAPIN. 1 p.

(3) **Mining in the Hot Springs District.** T. CHAPIN. 6 pp. The chief mineral product of the Hot Springs district is placer gold. In a portion of the district a considerable amount of cassiterite (tin oxide) occurs with the gold, but the amount recovered is insignificant in value compared with the gold. There are no independent tin placers, but the tin content of many of the gold placers is sufficient if recovered to add considerably to the total value of the output.

(4) **Tin Deposits of the Ruby District.** T. CHAPIN. 1 p. Evidently the amount of tin recovered from even the richest tin placers now known is so small that even the shallow gravels can not be worked profitably for the tin alone. At best it adds but little to the profit derived from the gold. It is also evident that the tin ore is so disseminated that it will be very difficult to recover any large quantity, although a few tons may be saved each year by the placer gold miners.

(5) **The Gold and Platinum Placers of the Tolstoi District.** G. L. HARRINGTON. 12 pp. About \$50,000 in gold was taken out in 1917, the result of the operations of about 25 men on five plants, most of the production being on Boob Creek. Boob Creek is the only creek in the district that produced platinum. The platinum was not separated from the gold but was sold with it to the bank in Iditarod. The platinum in the gold was said to amount to about one per cent, so that about 30 ounces of platinum was produced in 1917.

Analysis of Silicate and Carbonate Rocks. W. F. HILLEBRAND. Bulletin 700. A revised edition of the well-known Bulletin 422 is in press and will soon be available for the use of analytical chemists.

BUREAU OF THE CENSUS

Leather Statistics: Leather Stocks, Boots and Shoes, and Other Manufactures of Leather. 19 pp. Report shows results of inquiries by Census Bureau as to leather stocks and manufactures of leather. Data shown are for leather stocks reported to Census Bureau as on hand or in transit in United States at end of each month from May to December 1918, inclusive, and for quantities of boots and shoes, gloves, harness and saddlery, and other leather goods manufactured during each month and stocks of these on hand or in transit at end of each month from June to December 1918.

BUREAU OF MINES

The Vapor Pressure of Lead Chloride. E. D. EASTMAN and L. H. DUSCHAK. Technical Paper 225. 16 pp. Paper, 5 cents. Issued June 1919. A method for the measurement of vapor pressures at high temperatures is described. The details of its application and the experimental results for lead chloride at temperatures between 500° C. and 850° C. are given. The melting point of lead chloride has been determined as 495° C. and the boiling point as 945° C. at a pressure of 754 mm. of mercury. An average melting point of 498° C. was adopted as the best average of all determinations.

Explosives and Miscellaneous Investigations. Bulletin 178-D. 18 pp. Paper, 5 cents. Issued August 1919. This is an advance chapter from Bulletin 178, War Work of the Bureau of

Mines. It deals with explosives research, regulation of explosives and platinum, marine-boiler tests, underground sound ranging, training in first aid and rescue work, census of mining engineers and chemists, preparation of alloy steels, lighting aviation fields, coöperation with Capital Issues Committee.

BUREAU OF STANDARDS

Experimental-Retort Tests of Orient Coal. R. S. MCBRIDE AND I. V. BRUMBAUGH. Technologic Paper 134. 10 pp. Issued September 26, 1919. This publication comprises a series of five experimental-retort tests made at various temperatures.

A Relation Connecting the Derivatives of Physical Quantities. M. D. HERSEY. Scientific Paper 331. 9 pp. Paper, 5 cents. Issued September 25, 1919. In this paper it is shown how the theory of dimensions may be used in a differential form; a procedure which appears fruitful particularly in investigating the effect of given sources of error on the performance of measuring instruments.

A Standardized Method for the Determination of Solidification Points, Especially of Naphthalene and Paraffin. R. M. WILHELM AND J. L. FINKELSTEIN. Scientific Paper 340. 12 pp. Paper, 5 cents. Issued September 12, 1919.

Reflecting Power of Stellite and Lacquered Silver. W. W. COBLENTZ AND H. KAHLER. Scientific Paper 342. 3 pp. Paper, 5 cents. Issued September 11, 1919.

Spectral Photoelectric Sensitivity of Silver Sulfide and Several Other Substances. W. W. COBLENTZ AND H. KAHLER. Scientific Paper 344. 18 pp. Paper, 5 cents. Issued September 19, 1919.

Bibliography of Scientific Literature Relating to Helium. Circular 81. 21 pp. Paper, 5 cents. Issued September 10, 1919. This was prepared by E. R. Weaver.

DEPARTMENT OF AGRICULTURE

A Report on the Retail Prices of Unmixed Fertilizer Material as of June 1, 1919. Department Circular 57. 11 pp. Issued July 1919. With comparative prices for May 1.

BUREAU OF FOREIGN AND DOMESTIC COMMERCE

Economic Position of the United Kingdom. W. A. PATON. Miscellaneous Series 96. 160 pp. Paper, 15 cents. First of series of economic studies of countries during war, compiled in Bureau of Research and Statistics, War Trade Board.

COMMERCE REPORTS—SEPTEMBER 1919

The Rossi process of retting flax as now employed in France is described in detail. It depends upon the action of aerobic bacteria which are introduced with the flax and water into large concrete tanks through which air is blown. The operation is carried out at 28–30° C. Among the advantages claimed are that the fiber is not injured even by extended action of the bacteria; and the effluent is not noxious or dangerous to fish when emptied into streams. (Pp. 1147–51)

Among the subjects recently investigated at the Bureau of Standards are incandescent lamps, dry batteries, storage batteries, lubricating oils, and dental amalgams. (P. 1181)

Among the industrial notes from Germany it is stated that there is a very great demand for cement, but a scarcity of coal for the cement factories. A syndicate of nitrogen producers has been formed to increase the agricultural use of nitrogen compounds. A process has been devised for the manufacture of synthetic asphalt. (Pp. 1185–7)

The vegetable oil industry of Hull, England, has increased greatly during the war. The demands for oil for edible purposes were so great that little oil was allowed for industrial purposes. All linseed oil used for industrial purposes was "split" in order to obtain the glycerin for munitions. Large supplies of oil nuts formerly sent from British West Africa to

Germany and Holland are now shipped to England. The principal raw materials now used in England are castor beans, cottonseed, linseed, rapeseed, sesame, soy beans, copra, ground nuts and palm kernels. There has been an enormous increase in the growth of the margarine industry. (Pp. 1198–1205)

The limited importation of German vat dyes into the United States is permitted for a period of six months from October 1, 1919.

In extracting candelilla wax from shrubs in Mexico, the shrubs are placed in water which is heated to boiling, after which a small amount of sulfuric acid is added. The wax which separates is refined by a subsequent treatment with steam and sulfuric acid. (P. 1350)

The chemical industries of the Netherlands are very seriously hampered by unsettled trade conditions, so that their output in 1919 is much below that of 1918. (P. 1434)

In a report of a special British Interdepartmental Committee upon "power alcohol," it is urged that steps be taken to foster the manufacture of alcohol and its use with benzol as a motor fuel. Among the most promising sources are (1) by synthesis from the ethylene to be extracted from the gas from coke ovens and gas retorts. It is estimated that from this source at least 60,000,000 gal. could be produced annually in Great Britain at a cost of about 30 cents per gallon. (2) From vegetable sources. In view of the present value of potatoes, artichokes, etc., as food, it is felt that sources of alcohol must be found in tropical and sub-tropical plants, e. g., the flowers of the malva tree. It is recommended that so far as possible all taxes and restrictions upon the manufacture of power alcohol be removed and that an organization should be established by the Government to conduct research and development work upon the manufacture and use of power alcohol. (Pp. 1460–2)

The annual platinum output of Colombia is about 30,000 troy ounces, most of which is exported to the United States. (P. 1508)

Statistics of the American cottonseed industry show that only about one-sixth as much seed was received by the mills for crushing in August 1919 as in August 1918. (P. 1553)

Progress in the tanning of fish leather in the United States is reported to be very satisfactory. (P. 1558)

In a survey of the mining industry of Siberia it is pointed out that the dredges, etc., formerly used in platinum mining, and since destroyed, were inefficient. If replaced by modern machinery the output could be greatly increased. (P. 1577)

Among the "key" industries listed in a recent report of the British Board of Trade are dyes and intermediates, synthetic drugs, perfumes and flavorings, analytical reagents and fine chemicals, optical glass, scientific glassware, illuminating glassware, laboratory porcelain, scientific and optical instruments, potassium compounds, tungsten and ferro-tungsten, zinc oxide and lithopone, thorium nitrate and gas mantles, magnetos, hosiery needles and gauges. Importation of such materials is prohibited except under license. (Pp. 1578–9)

The Bureau of Standards has developed a method for the production of pure *D*-mannite at a reasonable cost. It will be available for use in the differentiation of bacteria. (P. 1581)

With the reduced demand for Malay tin, the government of Malay is purchasing the output. (P. 1582)

STATISTICS OF EXPORTS TO THE UNITED STATES

CANTON, CHINA— Sup. 528	SANTO DOMINGO— (P. 1590)	FRANCE—Sup. 5a
Gall nuts		Chemicals
Glass	Castor beans	Lakes
Hides	Divi-divi	Hides
Aniseed oil	Hides	Paper
Cassia oil	Rosin	Perfumery
Wood oil	Beeswax	Soap
Molybdenite		Pottery
Tungsten ore		Glass

BOOK REVIEWS

Lecture Demonstrations in Physical Chemistry. By HENRY S. VAN KLOOSTER, Ph.D., Rensselaer Polytechnic Institute, Troy, N. Y. vi + 196 pp. 83 illustrations. The Chemical Publishing Co., Easton, Pa., 1919. Price, \$2.00.

The scope of this handy little volume is perhaps best indicated by the titles of its chapters: General Properties of Matter in the Liquid and Solid State, Diffusion; Osmosis, Vapor Pressure and Determination of Molecular Weight; Chemical Equilibrium and the Law of Mass Action; Catalysis; Electrochemistry and Ionic Theory; Solubility and Its Changes; Colloids and Adsorption; Actino-chemistry; Flame; Combustion and Explosion; Liquid Air Experiments. In practically every case the apparatus required is simple enough to be made by an amateur glass blower with the aid of materials usually found in a very modest supply room. A variety of demonstrations is offered under each particular heading to enable the lecturer to choose illustrations adapted to his class or textbook. The directions are sufficiently detailed and so clearly written that most of the experiments may be set up in a very short time and without referring to the original articles from which the description was taken. In all cases the source of the experiment is stated, so that additional information may be obtained if desired.

On reading the book, one has the comfortable feeling that the experiments will "work," or, to state the matter more elegantly, that they are not for the most part sensitive to slight changes in external conditions or dependent on the manipulative skill of the lecturer. The experiments are frequently well adapted to purposes other than those given as well as to the case in hand. For example (page 51), the velocity of hydrolysis of methyl formate is illustrated by adding a quantity of it to each of several indicator solutions simultaneously, when it will be found that first one indicator changes color, later another, still later a third, and so on. What a fine experiment to illustrate the behavior of the indicators after the mechanism of hydrolysis has been taught.

Many of the experiments are familiar to courses of beginning chemistry, but they may be shown again to a class in physical chemistry with advantage. For those who think a book review incomplete without some adverse criticism it may be said that the index is not very good.

E. B. MILLARD

Sewage Disposal. By LEONARD P. KINNICUTT, C. E. A. WINSLOW AND R. WINTHROP PRATT. 2d Edition, rewritten. xv + 547 pp. John Wiley & Sons, Inc., New York, 1919. Price, \$4.00 net.

While the fundamental principles of sewage disposal are presented in this second edition in the same logical and progressive manner characteristic of the first edition, the scope of the subject matter has been greatly enlarged. A chapter on two-story tanks, which were just beginning to come into general use at the time of publication of the first edition, has been added, together with a discussion of some of the difficulties which have arisen in recent years in the operation of this type of tank.

A chapter on screening includes a brief discussion of the Riensch-Wurl screen. A rather complete summary of a year's test of this screen at Cleveland is presented, but results obtained at some of the other permanent installations in this country are not given.

A clear discussion of the development of the activated-sludge process shows the effect of each discovery as reflected in the succeeding investigations in this country and England.

The chapters on chemical precipitation and the disposal of sewage sludge contain the most recent experimental results on the treatment of sewage by the Miles acid process, acidification by means of sulfur dioxide.

One new chapter on general considerations includes a very instructive discussion of the variable conditions which affect the choice of a process, and the necessity for a preliminary survey of these conditions by the construction and operation of an experimental station.

The unique value of this book lies in the clear presentation of theories and fundamental principles as affecting the trend of practical development in the construction of sewage treatment plants. As a textbook it is probably of more value than any of the recent works on sewage disposal which are inclined to emphasize engineering details rather than the history of the development of modern methods and the discovery of basic principles which underlie these processes.

F. W. MOHLMAN

Annual Reports of the Society of Chemical Industry on the Progress of Applied Chemistry. Vol. III. 495 pp. Issued by the Society of Chemical Industry, 46-47 Finsbury Square, London, E. C., 2, 1919. Price, to members, 5s. 6d.; to non-members, 10s. 6d.

The present volume constitutes Volume III of the Annual Reports of the Society of Chemical Industry. The reviewer has nothing but praise for this excellent resumé of the advances in applied chemistry during 1918. In this day of common emphasis on nationalism it is pleasing to note the avoidance of any effort to minimize work carried out in other countries and the frank recognition of world facts and economic questions rather than the confining of the discussion to matters of interest solely to the British Empire.

Of the twenty-two chapters in the present volume, two were not included in the previous reports, one being on Agricultural Chemistry and the other on Foods. In recognition of the need for prompt publication it is pleasing to note that the editor did not delay publication owing to the fact that two compilers were slow in getting in their copy. Editors too often sacrifice prompt publication owing to a delay of some sub-editor.

In conclusion, the writer would urge on chemists in the field of both pure and applied science the perusal of these relatively inexpensive annual reports as the easiest and best method of keeping in touch with the important advances in applied chemistry.

RALPH H. MCKER

Chemical Calculations. By R. HARMON ASHLEY, Ph.D., Professor of Chemistry, Tufts College Medical and Dental School, Boston, Mass. 2nd Ed., revised. v + 276 pp. D. Van Nostrand Co., New York, 1918. Price, \$2.00 net.

The text of the second edition is substantially unchanged from the first edition except for corrections in certain of the problems. The book includes a very large number of practice problems (516) and emphasizes especially the application of chemical arithmetic to technical operations. Much attention is paid to problem of interpolation, the use of specific gravity tables, and to such industrial questions as the composition and production of coal gas, sulfur dioxide, and the like. In the chapter on volumetric calculations numerous problems on "mixed acids" are given. An appendix contains logarithms, specific gravity, temperature correction, and similar tables.

It is to be regretted that a book so satisfactory in many respects does not give somewhat more space to explanation of the fundamental principles of the calculations of analytical chemistry and also that many of the problems are based directly on data given in Van Nostrand's Annual. The fact that a second edition has been necessary after three years indicates that the book has met a real need.

R. S. WILLIAMS

Metallurgy of Lead. By H. O. HOFMAN, E.M., Met.E., Ph.D., Professor of Metallurgy, Massachusetts Institute of Technology and Harvard University. First Edition. McGraw-Hill Book Company, Inc., New York, 1918; Hill Publishing Co., Ltd., 6 & 8 Bouverie St., London, E. C., 1918.

This work by Professor Hofman is explained by him in his preface to be based on his treatise, "The Metallurgy of Lead and the Desilverization of Base Bullion." He states that in undertaking to prepare a new edition of this work, he found it necessary to rewrite most of the book, so that the book under review appears as a first edition, having a wider scope than the older book, but omitting some of the material which he states has been thoroughly discussed in other publications.

Any work coming from the hands of Professor Hofman is sure to be found complete and, in the main, reliable. To review a work of this kind is not a simple matter, but we can unhesitatingly state in general terms that this work is a substantial contribution to the subject and should be read by everyone having practical interest in the subject.

There is a general question that we believe deserves some consideration here, *i. e.*, what is the purpose of the book? Careful scrutiny of the book will disclose the fact that its purpose is primarily that of compiling information in regard to the state of the art. This Professor Hofman has diligently done, and the book is full of numerous references to the experiences and opinions of others. There is very little in the book which is laid down in the form of authoritative opinions of the author. This scheme has its advantages and its disadvantages. The advantages are that the work conveys a large quantity of valuable information and statements which must be taken by the reader on his own valuation, basing his values on the evidence presented and the authority of those presenting the evidence. The disadvantage is that the reader in some cases is confused by conflicting statements and finds it difficult to determine which statements he shall accept as authoritative. This, of course, only applies in some cases. The book will frequently be referred to as authoritative, and, where there are no conflicting statements, the single statement, derived from an outside authority, is apt to be accepted as final. The advantages and disadvantages of a work of this kind, therefore, constitute its strength and its weakness. We must emphasize the advantage and strength of this book, but we are compelled to do this in general terms, by stating that the subject is well handled, is comprehensively treated, and that there is hardly any branch of the subject that does not receive a consideration proportioned to its importance. We offer some criticisms in detail.

On page 8, speaking of the physical properties of lead, he states "The tensile strength is low, 2600-3300 lbs. per square inch; the elastic limit 0.5 lb." Professor Hofman must have been wrongly advised in putting the elastic limit as low as this. It must be admitted, however, that we have much to learn with regard to the elastic limit of lead and similar soft metals. It seems probable that this elastic limit is very variable according to condition of test. If, however, we consider the elastic limit to be equivalent to the yield point, it is manifest that the tensile strength cannot be five thousand times as great as the elastic limit.

On page 11, considering the chemical properties of lead and its resistance to the action of nitrous sulfuric acid, the reader is left in doubt as to whether a pure lead is better than a lead containing certain impurities. It seems, however, to be pretty well established that chemical manufacturers prefer a pure lead, considering the matter only from the standpoint of resistance to chemical action.

On page 15, he rightly states that coloring lead must be very pure to produce a product having the required whiteness, but there is no evidence that this affects the covering power of the white lead.

On page 25 there is a table giving the composition of some industrial lead alloys. Many of these are antiquated and of really little value. It might be difficult for Professor Hofman to get correct information as to the composition of lead alloys as sold in the American market, but it would seem as though a more up-to-date table could be prepared. Many of the alloys, however, are receiving consideration by the Nonferrous Metals Committee of the American Society for Testing Materials and in their publications more authoritative data may be obtained. Furthermore, during the war there has been a considerable standardization inspired by the Government, results of this standardization being available.

On page 34, the old distinction between massicot and litharge is retained. At the present time there is no commercial distinction between massicot and litharge and it is questionable whether there is a real difference between them other than may be indicated by difference in fineness. There is no difference in chemical composition and no one ever orders massicot as distinct from litharge; both products are known as litharge.

These examples are given solely to indicate the point we have made that the value of information obtained by compilation must be determined by the reader and it must not be assumed that the author is speaking authoritatively.

The larger part of the book, as is natural, is given over to smelting and refining operations. Here we find a very valuable compilation of information as to present practices, also much information comparing the value of different practices.

G. W. THOMPSON

Industrial Electrometallurgy. By ERIC K. RIDEAL, Ph.D. xii + 247 pp., 26 illustrations. Baillière, Tindall & Cox, 8 Henrietta St., Covent Garden, London. Price, 7s. 6d. net.

This is a volume of the series on Industrial Chemistry edited by S. Rideal. Its aim is to give more industrial information than is contained in the usual textbooks, and to discuss costs and commercial conditions as well as the applications of physico-chemical principles. The eight sections deal successively with electrolysis in aqueous solutions, in fused electrolytes, preparation of the rarer metals, electrothermal processes, carborundum, carbides, nitrogen fixation, iron and the ferro-alloys. Within the limits of such a small book the subject is wonderfully well handled. The author's points and observations are usually very well taken, and the treatment is illuminating. The few defects are mostly the inevitable result of trying to cover too much ground in too little space. The author shows such a thorough command of the subject that we hope he will write the second edition twice as large, in which case the few defects and omissions would correct themselves, and the industry be under still greater obligations to the author for his masterly analysis of the subject.

JOSEPH W. RICHARDS

Outlines of Industrial Chemistry. By FRANK HALL THORP, assisted in revision by WARREN K. LEWIS. Third revised and enlarged edition. xxv + 665 pp. 137 figures. The Macmillan Company, New York, 1918. Price, \$3.75.

This reprint of the third revised edition of "Thorpe" has been corrected as much as possible without enlargement along the lines indicated by the reviewer in his consideration of the first impression issued in May 1916.¹ Always a useful book because of its demonstrated pedagogic excellence, the advent of this reimpression will be welcomed by teachers of industrial chemistry, since it is highly important that a textbook of this character should be as accurate in description as the size will permit.

W. A. HAMOR

¹ Hamor, *This Journal*, 9 (1916), 863.

NEW PUBLICATIONS

By CLARA M. GUPPY, Librarian Mellon Institute of Industrial Research, Pittsburgh

- Bacteriology and Mycology of Foods.** F. W. TANNER. 8vo. 592 pp. Price \$5.00. John Wiley & Sons, Inc., New York. (Publisher's name corrected.)
- Beverages: A Practical and Scientific Treatise on the Manufacture of Pure, High Class Carbonated Beverages and Bottlers, Soluble Extracts, Ginger Ale Paste, Colors, Fruit Acids, Mineral Salts, Etc.** S. A. TUCKER. 63 pp. Price, \$100.00. S. A. Tucker, 3030 Emerald St., Philadelphia. (Price corrected.)
- Carbohydrates: The Simple Carbohydrates and the Glucosides.** E. F. ARMSTRONG. 3d Ed. 8vo. 250 pp. Price, 12s. Longmans, Green & Co., London.
- Catalysis in Theory and Practice.** E. K. RIDEAL and H. S. TAYLOR. 496 pp. Price, 17s. Macmillan & Co., Ltd., London.
- Chemical Industries: Kelly's Directory of Chemical Industries of the United Kingdom.** 844 pp. Price, 25s. Kelly's Directories, Ltd., 182-184, High Holborn, London.
- Chemical Physiology: Essentials of Chemical Physiology.** W. D. HALBURTON. 10th Ed. 8vo. 335 pp. Price, 7s. 6d. Longmans, Green & Co., London.
- Chemistry: Quantitative Analysis.** G. M. SMITH. 8vo. 206 pp. Price, \$1.75. The Macmillan Co., New York.
- Chemistry: Textbook of Chemistry, Inorganic and Organic, with Toxicology.** R. A. WITTHAUS. 7th Ed. Revised. 8vo. Price, 20s. Bale, Sons & Danielsson, Ltd., London.
- Chemistry: Textbook of Chemistry Intended for the Use of Pharmaceutical and Medical Students.** S. P. SATTLER, VIRGIL COBLENTZ and JEANOT HOSTMANN. 5th Ed. Revised and Rewritten. 8vo. 765 pp. Price, \$5.50. J. B. Lippincott Co., Philadelphia.
- Coal Tar: Some Constituents of Coal Tar and their Properties.** P. E. SPIELMANN. 8vo. 35 pp. Printed for Coke Oven Managers' Association by Benn Brothers, Ltd., London.
- Concrete Construction: Principles of Reinforced Concrete Construction.** F. E. TURNHAUSE and E. R. MAURER. 3d Ed. Revised and Enlarged. 485 pp. Price, \$3.75. John Wiley & Sons, Inc., New York.
- Essential Oils: Tables of Refractive Indices.** Vol. 1. Essential Oils. Compiled by R. KAMTHACK. Edited by J. N. GOLDSMITH. 148 pp. Price, 15s. Adam Hilger, Ltd., London. (Reviewed in this JOURNAL, 11 (1919), 614.)
- Forest Products: Their Manufacture and Use.** N. C. BROWN. 471 pp. Price, \$3.75. John Wiley & Sons, Inc., New York.
- Hydrogen: Chemistry and Manufacture of Hydrogen.** P. L. TEED. 8vo. 152 pp. Price, \$2.40. Longmans, Green & Co., New York.
- Materials of Engineering: Strength of Materials; A Textbook for Technical and Industrial Schools.** J. P. KOTTCAMP. 193 pp. Price, \$4.50. John Wiley & Sons, Inc., New York.
- Minerals and Ores of the Rarer Elements. Analysis of.** W. R. SCHREIBER and A. R. POWELL. 239 pp. Price, 16s. Charles Griffin & Co., London.
- Petroleum: Treatise on British Mineral Oil.** A Foreword by Sir Boverton Redwood. J. A. GREENE, Editor. 8vo. 24 pp. Price, 21s. Charles Griffin & Co., London.
- Physical Chemistry of the Metals.** RUDOLPH SCHENCK and R. S. DEAN. 239 pp. Price, \$3.00. John Wiley & Sons, Inc., New York.
- Plant Products and Chemical Fertilizers.** S. H. COLLINS. 8vo. 236 pp. Price, \$3.00. D. Van Nostrand Co., New York.
- Varnishes: The Manufacture of Varnishes and Kindred Industries.** Vol. 1. The Crushing, Refining and Boiling of Linseed and Other Varnish Oils. A. LIVACHE and J. C. MCINTOSH. 3d Ed. Revised. 498 pp. Price, 17s. 6d. Scott, Greenwood & Son, London.
- Clay: Phenomena of Clay Plasticity Explained; A Technical Description of the Causes for the Above as well as Other Physical Characteristics of Clay upon the Addition or Expulsion of Fluids.** R. F. MACMICHAEL. *Brick and Clay Record*, Vol. 55 (1919), No. 8, pp. 677-680.
- Clay: Tests to Determine Uses for Clay.** R. F. MACMICHAEL. *Brick and Clay Record*, Vol. 55 (1919), No. 9, pp. 762-767.
- Coal: Deterioration in the Heating Value of Coal during Storage.** H. C. PORTER. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 18, p. 346r.
- Cotton Industry: Research a Necessity to the Cotton Industry.** H. E. HOWE. *Manufacturers Record*, Vol. 76 (1919), No. 18, pp. 114-115.
- Dehydration of Formic Acid Solutions.** D. C. JONES. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 19, pp. 3621-3631.
- Electrolytic Hydrogen Generator for the Laboratory.** L. D. WILLIAMS. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 17, pp. 3551-3561.
- Fuel: Methods for More Efficiently Utilizing our Fuel Resources.** S. S. WYER. *General Electric Review*, Vol. 22 (1919), No. 10, pp. 760-766.
- Fuel: Problems in the Utilization of Fuels. Part I. Economic Use of the Poorer Grades of Coal and Oils.** R. F. BACON and W. A. HAMOR. *Scientific American Supplement*, Vol. 83 (1919), No. 2283, pp. 222-223.
- Glucina: L'Industrie de la Glucine.** H. COPAUX. *Chimie et Industrie*, Vol. 2 (1919), No. 8, pp. 914-916.
- Graphitization in Iron-Carbon Alloys Giving Results of a Number of Experiments Undertaken to Determine the Actual Mechanism of the Formation of Graphite in Iron-Carbon Alloys.** KUNICHI TAWARA and GENSICHI ASAHARA. *The American Drop Forge*, Vol. 5 (1919), No. 10, pp. 509-513.
- Leather: Analysis of Different Tannages of Strap Harness and Side Leather.** L. M. WHITMORE. *Journal of the American Leather Chemists Association*, Vol. 14 (1919), No. 10, pp. 567-576.
- Leather: Extraction of Leather Stuffing Oils and Greases from Sand.** F. P. VEITCH and M. C. HUNT. *Journal of the American Leather Chemists Association*, Vol. 14 (1919), No. 9, pp. 507-511.
- Leather: Notes on the Determination of Water Solubles in Leather.** R. W. FREY and I. D. CLARKER. *Journal of the American Leather Chemists Association*, Vol. 14 (1919), No. 9, pp. 488-499.
- Leather: Oils Used in Making Leather; Standardization and Chemical Supervision Now Considered Essential in a Modern Tannery.** C. V. BACON. *Drug and Chemical Markets*, Vol. 5 (1919), No. 58, pp. 7-8.
- Leather: Valuation of Pyroxylin Solvents and Leather Solution.** J. R. LORENZ. *Journal of the American Leather Chemists Association*, Vol. 14 (1919), No. 10, pp. 548-566.
- Leather Belting: Leather Link-Belts and Work for Which They are Adapted.** H. C. SHIELDS. *Belting*, Vol. 15 (1919), No. 8, pp. 21-22.
- Leather Measuring Machines.** F. J. SCHLINK. *The Leather Manufacturer*, Vol. 30 (1919), No. 10, pp. 331-334, 354.
- Musk: Its Origin and Export. Annual Slaughter of a Hundred Thousand Deer to Furnish the World with Perfume.** A. J. CLEMENTS. *Scientific American Supplement*, Vol. 88 (1919), No. 2283, pp. 226-227.
- Mustard Gas.** W. J. POPE. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 18, pp. 334-345r.
- Paper Barrels and the Like.** A. H. SEARLES. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 17, pp. 3371-3381.
- Phosphate: Economic Analysis of the World Shortage in Phosphate.** I. B. ANDERSON. *The American Fertilizer*, Vol. 51 (1919), No. 7, pp. 47-59.
- Potash: A New Potash Supply.** E. G. BRYANT. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 19, pp. 3601-3621.
- Potash Industry of the United States and Its Possibilities for Future Production.** A. E. WELLS. *The American Fertilizer*, Vol. 51 (1919), No. 9, pp. 63-64, 87.
- Refractories: Effect of Heat on Refractories.** C. E. NABBITT and M. L. BELL. *The Iron Trade Review*, Vol. 65 (1919), No. 17, pp. 1112-1114.
- Refractory Materials and High Temperature Measurements.** C. W. KANOLT. *Journal of the Franklin Institute*, Vol. 188 (1919), No. 4, pp. 489-505.
- Root-Beers: Notes on So-Called Root-Beers.** C. H. LAWALL and HENRY LEFFMANN. *Journal of the Franklin Institute*, Vol. 188 (1919), No. 4, pp. 545-546.
- Rubber: Ageing Experiments on Vulcanized Plantation Para Rubber.** B. J. EATON and F. W. F. DAY. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 17, pp. 3391-3471.
- Shipping Containers: Liners for Shipping Containers.** B. ARKELL. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 17, p. 3371.
- Steam from Low-Grade Fuel, Production of.** P. PARRISH. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 17, pp. 3271-3281.
- Steel Tubing: Forming Light-Wall Tubing; Methods of Manufacturing.** H. J. FRENCH. *The Iron Trade Review*, Vol. 65 (1919), No. 15, pp. 982-985.

RECENT JOURNAL ARTICLES

- Acetylene: Commercial Synthesis of Organic Compounds.** M. J. MARSHALL. *Canadian Chemical Journal*, Vol. 3 (1919), No. 8, pp. 254-257; *The Chemical Age* (London), Vol. 1 (1919), No. 16, pp. 434-437.
- Acetylene: General Properties of Acetylene and Its Application as a Tool in Industry.** R. A. WITHERSPOON. *Canadian Chemical Journal*, Vol. 3 (1919), No. 8, pp. 250-253.
- Ball-Bearings: Lubrication of Ball-Bearings.** H. R. TROTTER. *Mechanical Engineering*, Vol. 41 (1919), No. 10, pp. 811-815.
- Belting: Statistics on the Belting Needs of the American Farmer.** J. M. IAVELLE. *Belting*, Vol. 15 (1919), No. 7, pp. 21-23.
- Carbide: The Canadian Carbide Company, Limited; A Brief History of the Carbide Industry and a Description of Its Growth and Development.** J. C. KING. *Canadian Chemical Journal*, Vol. 3 (1919), No. 8, pp. 262-264.
- Catalysts for the Fixation of Nitrogen.** E. K. RIDEAL and H. S. TAYLOR. *The Chemical Age* (London), Vol. 1 (1919), No. 18, pp. 488-490.
- Chlorine Gas: Electrolytic Production of Chlorine Gas.** C. A. BORRA-BAILLE. *Chemical Age*, Vol. 1 (1919), No. 5, pp. 222-224.

MARKET REPORT—NOVEMBER, 1919

WHOLESALE PRICES PREVAILING IN THE NEW YORK MARKET ON NOVEMBER 15, 1919

INORGANIC CHEMICALS

Acetate of Lime, Basis 80%.....	100 Lbs.	2.00	2.05
Alum, ammonia, lump, U. S. P.....	100 Lbs.	4.25	4.50
Aluminum Sulfate, (iron free) Works.....	Lb.	22 1/2	24 1/2
Ammonium Carbonate, domestic.....	Lb.	12 1/2	13 1/2
Ammonium Chloride, white.....	Lb.	19	20
Aqua Ammonia, 26°, drums.....	Lb.	8 1/2	9
Arsenic, white.....	Lb.	10 1/4	10 1/2
Barium Chloride.....	Ton	65.00	85.00
Barium Nitrate.....	Lb.	12	14
Barytes, prime white.....	Ton	30.00	35.00
Bleaching Powder, 35 per cent, Works.....	100 Lbs.	2.50	3.00
Blue Vitriol.....	Lb.	8 1/4	8 1/2
Borax, crystals, in bags.....	Lb.	8 1/4	10 1/2
Boric Acid, powdered crystals.....	Lb.	13 1/4	14
Brimstone, crude, domestic.....	Long Ton	28.00	35.00
Bromine, technical, bulk.....	Lb.	75	
Calcium Chloride, lump, 70 to 75% fused.....	Ton	20.00	24.00
Caustic Soda, 76 per cent.....	100 Lbs.	3.50	3.55
Chalk, light precipitated.....	Lb.	nominal	
China Clay, imported.....	Ton	18.00	23.00
Feldspar.....	Ton	8.00	15.00
Fuller's Earth, foreign, powdered.....	Ton	nominal	
Fuller's Earth, domestic.....	Ton	20.00	30.00
Glauber's Salt, in bbls. Technical.....	100 Lbs.	14	14 1/2
Green Vitriol, bulk.....	100 Lbs.	2.00	2.25
Hydrochloric Acid, commercial, C. P.....	Lb.	10	11
Iodine, resublimed.....	Lb.	4.50	4.55
Lead Acetate, white crystals.....	Lb.	14	15
Lead Nitrate, C. P.....	Lb.	85	
Litharge, American.....	Lb.	9 1/4	10
Lithium Carbonate.....	Lb.	1.50	
Magnesium Carbonate, U. S. P.....	Lb.	21	22
Magnetite, "Calcined".....	Ton	60.00	65.00
Nitric Acid, 40°, 100 pounds.....	Lb.	6.60	6.75
Nitric Acid, 42°, 100 pounds.....	Lb.	7.35	7.45
Phosphoric Acid, 48/50%.....	Lb.	24	26
Phosphorus, yellow.....	Lb.	35	40
Plaster of Paris.....	100 Lbs.	2.00	2.50
Potassium Bichromate.....	Lb.	27	28
Potassium Bromide, granular.....	Lb.	1.25	1.30
Potassium Carbonate, calcined, 80 @ 85%.....	Lb.	24	26
Potassium Chlorate, crystals, spot.....	Lb.	19c	
Potassium Cyanide, bulk, 98-99 per cent.....	Lb.	nominal	
Potassium Hydroxide, 88 @ 92%.....	Lb.	30	33
Potassium Iodide, bulk.....	Lb.	3.50	3.60
Potassium Nitrate.....	Lb.	13 1/4	16
Potassium Permanganate, bulk, U. S. P.....	Lb.	59	60
Quicklime, slack.....	75 Lbs.	90.00	95.00
Red Lead, American, dry.....	100 Lbs.	11.00	13.00
Salt Cake glass makers'.....	Ton	12.00	15.00
Silver Nitrate.....	Oz.	75 1/2	76 1/2
Soapstone, in bags.....	Ton	10.00	12.50
Soda Ash 58%, in bags, ex-store.....	100 Lbs.	2.10	2.25
Sodium Acetate, broken lump.....	Lb.	6 1/4	7
Sodium Bicarbonate, domestic.....	100 Lbs.	2.25	2.40
Sodium Bichromate.....	Lb.	15	15 1/4
Sodium Chlorate.....	Lb.	15	
Sodium Cyanide.....	Lb.	29	30
Sodium Fluoride, commercial.....	Lb.	13	14
Sodium Hyposulfite.....	100 Lbs.	3	4
Sodium Nitrate, 95 per cent, spot.....	100 Lbs.	3.25	3.35
Sodium Silicate, liquid, 40° Bé.....	Lb.	2 1/2	2 1/4
Sodium Sulfide, 60%, fused in bbls.....	Lb.	4 1/4	5
Sodium Bisulfite, powdered.....	Lb.	5	7
Strontium Nitrate.....	Lb.	25	30
Sulfur.....	100 Lbs.	3.30	3.40
Sulfuric Acid, chamber 66° Bé.....	Ton	19.00	20.00
Sulfuric Acid, oleum (fuming).....	Ton	23.00	24.00
Talc, American, white.....	Ton	18.00	22.00
Terra Alba, American, No. 1.....	100 Lbs.	1.25	
Tin Bichloride, 50°.....	Lb.	18	20
Tin Oxide.....	Lb.	60	63
White Lead, American, dry.....	Lb.	8 1/4	9 1/4
Zinc Carbonate.....	Lb.	18	20
Zinc Chloride, commercial.....	Lb.	12	13

ORGANIC CHEMICALS

Acetanilid, C. P., in bbls.....	Lb.	50	51
Acetic Acid, 56 per cent, in bbls.....	100 Lbs.	5.75	6.00
Acetic Acid, glacial, 99 1/2%.....	100 Lbs.	12.50	13.00
Acetone, drums.....	Lb.	13 1/2	14
Alcohol, denatured, 180 proof.....	Gal.	52	53

Alcohol, Ethyl, non-beverage, 190 proof.....	Gal.	4.70	4.95
Alcohol, wood 98 per cent, refined.....	Gal.	1.43	1.46
Amyl Acetate.....	Gal.	3.75	3.84
Aniline in drums extra.....	Tb.	32	34
Benzoin Acid-acetolui.....	Lb.	90	100
Benzene, pure.....	Gal.	36	
Camphor, refined in bbls.....	Lb.	3.55	3.60
Carbolic Acid, U. S. P., in drums.....	Lb.	17	
Carbon Bisulfide.....	Lb.	9	10
Carbon Tetrachloride.....	Lb.	11	12
Chloroform, U. S. P.....	Lb.	30	31
Citric Acid, domestic, crystals.....	Lb.	92	95
Cresote, beechwood.....	Lb.	2.00	2.10
Cresol, U. S. P.....	Lb.	17	18
Dextrine, corn (carloads, bags).....	Lb.	6 1/4	6 1/2
Dextrine, imported potato.....	Lb.	15	15 1/2
Ether, U. S. P. 1900.....	Lb.	26	
Formaldehyde, 40 per cent.....	Lb.	28	30
Glycerin, dynamite drums extra.....	Lb.	21	21 1/2
Oxalic Acid, in sacks.....	Lb.	24	25
Pyrogallol Acid, resublimed, bulk.....	Lb.	2.37 1/2	
Salicylic Acid, U. S. P.....	Lb.	55	
Starch, corn (carloads, bags) pearl.....	100 Lbs.	4.97	
Starch, potato, Japanese.....	Lb.	9	9 1/2
Starch, rice.....	Lb.	25	27
Starch, sago flour.....	Lb.	7 1/2	9
Starch, wheat.....	Lb.	9	
Tannic Acid, commercial.....	Lb.	60	65
Tartaric Acid, crystals.....	Lb.	71	73

OILS, WAXES, ETC.

Beeswax, pure, white.....	Lb.	63	65
Black Mineral Oil, 29 gravity.....	Gal.	22 1/4	
Castor Oil, No. 3.....	Lb.	18	18 1/4
Ceresin, yellow.....	Lb.	16	17
Corn Oil, crude.....	Lb.	18	18 1/4
Cottonseed Oil, crude, f. o. b. mill.....	Lb.	20c	
Cottonseed Oil, p. s. y Nov. option.....	100 Lbs.	22.50	
Menhaden Oil, crude (southern).....	Gal.	1.00	
Neat's-foot Oil, 20°.....	Gal.	2.30	
Paraffin, crude, 118 to 120 m. p.....	Lb.	7 1/2	8
Paraffin Oil, high viscosity.....	Gal.	38	40
Rosin, "R" Grade, 280 lbs.....	Bbl.	17.50	
Rosin Oil, first run.....	Lb.	89	
Shellac, T. N.....	Lb.	nominal	
Spermaceti, cake.....	Lb.	31	33
Sperm Oil, bleached winter, 38°.....	Gal.	1.98	2.00
Spindle Oil, No. 200.....	Gal.	38	40
Stearic Acid, double-pressed.....	Lb.	29	29 1/2
Tallow, special loose.....	Lb.	16 1/4	
Tar Oil, distilled.....	Gal.	58	59
Turpentine, spirits of.....	Gal.	1.58	

METALS

Aluminum, No. 1, ingots.....	Lb.	33	
Antimony, ordinary.....	100 Lbs.	9.00	9.25
Bismuth, N. Y.....	Lb.	nominal	
Copper, electrolytic.....	Lb.	20 1/4	21
Copper, lake.....	Lb.	21 1/2	21 1/4
Lead, N. Y.....	Lb.	6.75	6.90
Nickel, electrolytic.....	Lb.	55	56
Platinum, refined, soft.....	Oz.	135.00	
Silver.....	Oz.	1.26 1/2	
Tin.....	Lb.	53 1/2	54 1/2
Tungsten (WOs).....	Per Unit	7.00	10.00
Zinc, N. Y.....	100 Lbs.	8.20	

FERTILIZER MATERIALS

Ammonium Sulfate nominal.....	100 Lbs.	5.35	
Blood, dried, f. o. b. New York.....	Unit	7.25	
Bone 3, 50, ground, raw.....	Ton	40.00	
Calcium Cyanamide.....	Unit of Ammonia	nominal	
Calcium Nitrate, Norwegian.....	100 Lbs.	—	
Castor Meal.....	Unit	—	
Fish Scrap, domestic, dried, f. o. b. works.....	Unit	7.50 & 10c	—
Phosphate Rock, f. o. b. mine.....	Ton	nominal	
Florida land pebble, 68 per cent.....	Ton	nominal	
Tennessee, 78-80 per cent.....	Ton	11.00	11.50
Potassium "muriate," basis 80 per cent.....	Ton	nominal	
Pyrites, furnace size, imported.....	Unit	16 1/2	17
Tankage, concentrated, f. o. b. Chicago.....	Unit	6.10	6.25

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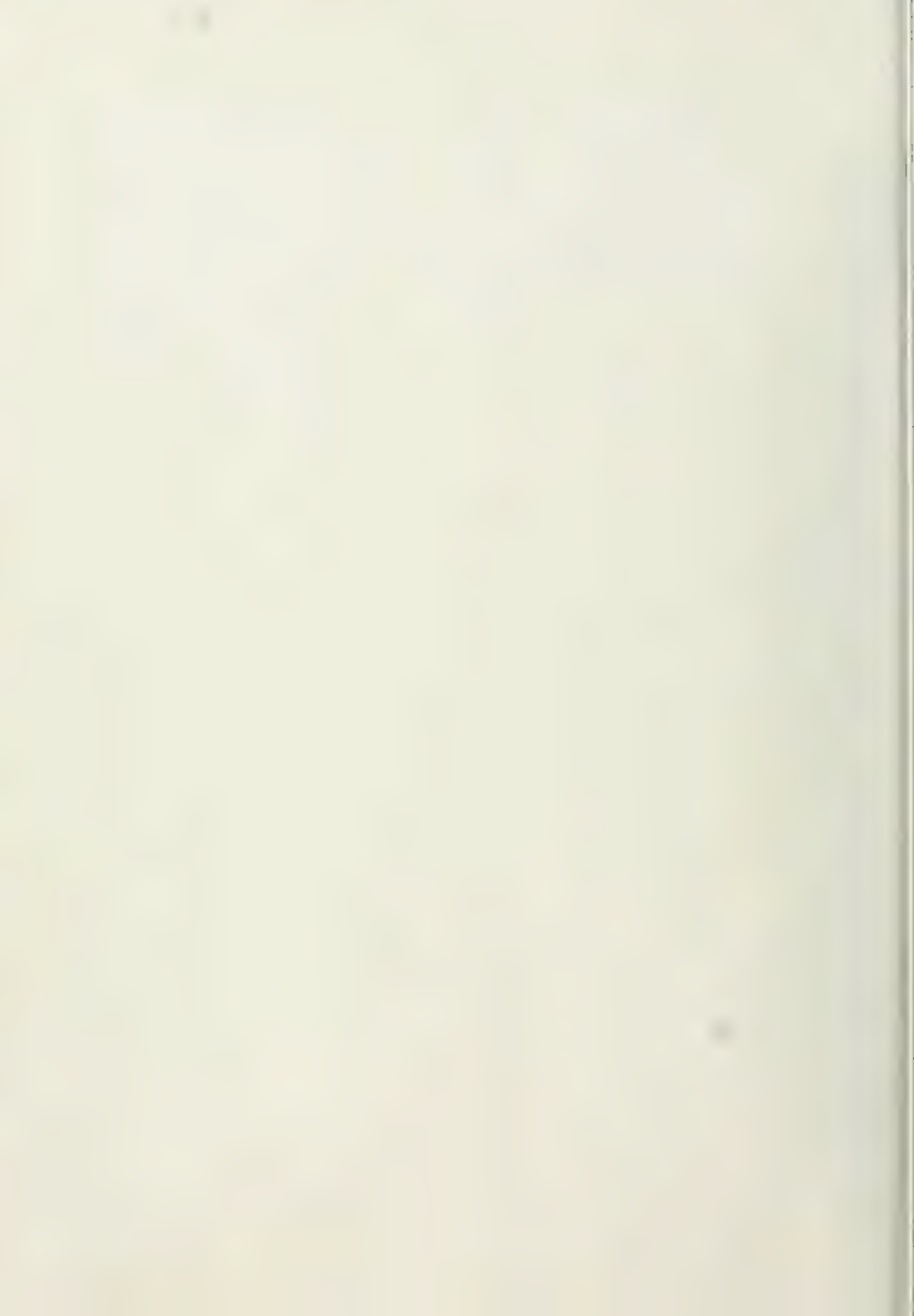
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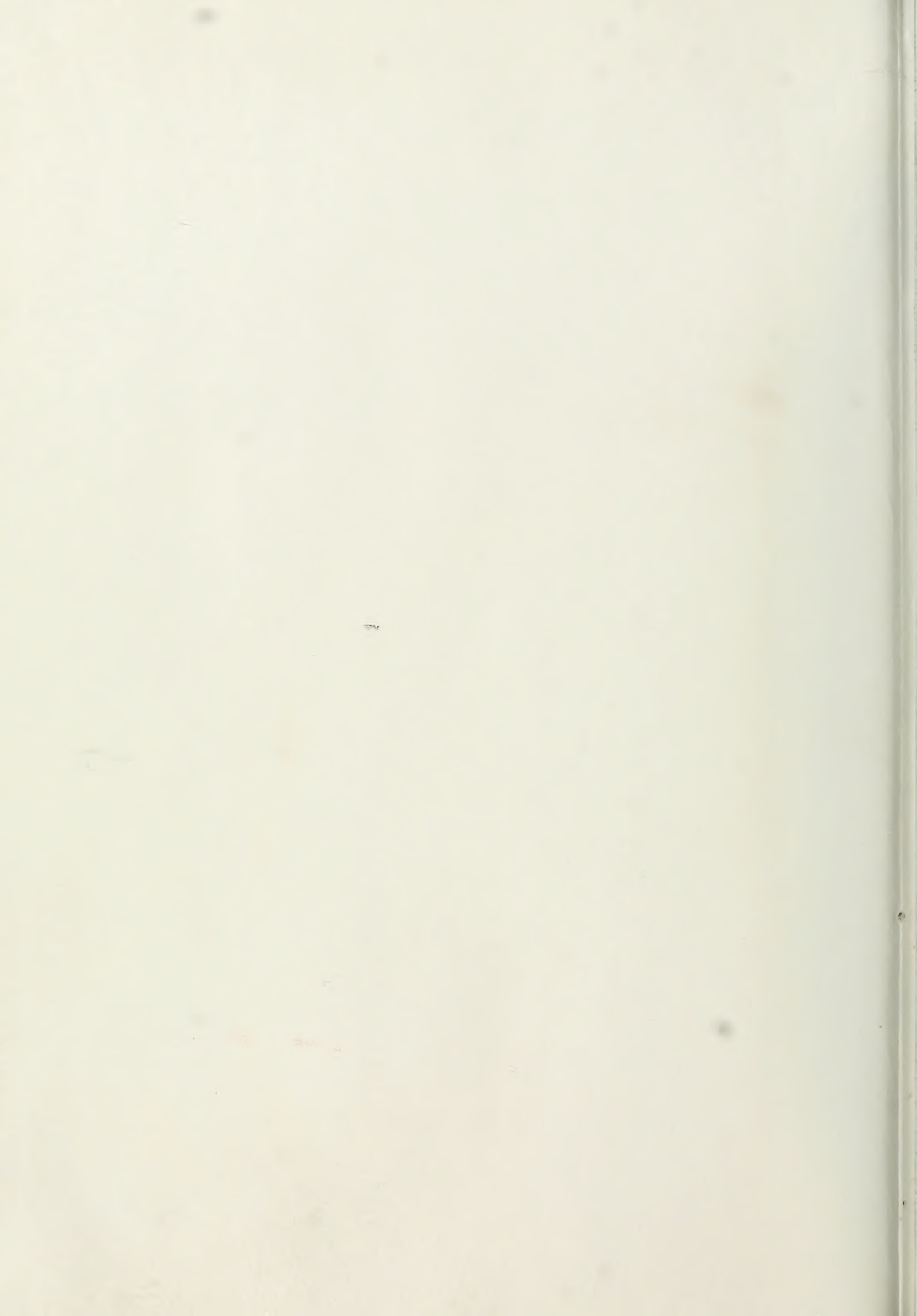
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